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THE

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# THE AMERICAN EDITION

OF THE NEW

# EDINBURGH ENCYCLOPÆDIA.

## GRAMMAR.

GRAMMAR is that knowledge of words which qualifies the possessor for speaking and writing with propriety. PARTICULAR GRAMMAR comprehends the rules of particular languages, as founded on the practice of those who have that sort of conspicuousness in society which is considered as entitling them to fix the standard in each. Every language has thus a grammatical system of its own. All languages, however, possess some circumstances in common. Prevalent analogies are developed in their origin and history, and certain leading principles are found to obtain in the application of them to the purposes of speech. The general doctrines discovered by the comparison of different languages form the important science of PHILOSOPHICAL, or UNIVERSAL GRAMMAR.

### UNIVERSAL GRAMMAR.

THIS science unfolds the principles by which man is directed in the contrivance of the varieties of words. Its utility is extended by the opportunities which it gives of tracing the connection which the phenomena of language, considered as a production of the human mind, have with the other principles of our nature.

As the term Grammar has been currently applied to a much inferior department of knowledge, some have thought proper to give Universal Grammar the apparently more elegant designation of the THEORY OF LANGUAGE. This latter designation, however, comprehends all the general branches of inquiry connected with language, which are treated under various articles of this work, such as ALPHABET, ETYMOLOGY, PHILOLOGY, and LANGUAGE. Its most interesting branch consists of those inquiries which, under the name of UNIVERSAL GRAMMAR, we here propose to lay before our readers.

Language being the leading instrument by which men communicate their thoughts to one another, it is to it that we undoubtedly owe the most important improvements of which our intellectual character is susceptible. It might therefore have been expected that an inquiry into its nature would necessarily imply an elucidation of all the laws of thought. But its province does not extend altogether so far; and, by keeping it within its due bounds, we shall do greater justice both to this science and to those with which it is connected. We shall find that the points of view in which man appears in thinking and in speaking are not so perfectly identical as has been imagined. It is not true that Universal Grammar implies the whole theory of human thought; yet it implies a great and important part of it: and the habit which the study of it gives us of investigating the subject, and the analogies which it furnishes for the prosecution of the rest, may, under judicious management, contribute materials towards a perfect knowledge of the general philosophy of mind.

We have intimated that this science originates in the comparison of different languages. It is not indeed very flattering to the pride of human intellect, and it will appear to many inaccurate, as well as undignified, to ascribe the discovery of the principles of Universal Grammar to a circumstance which might be regarded as accidental, viz. the multiplicity of languages existing among mankind. Its principles must operate in the formation of each individual language; and the science might therefore appear to admit of being investigated with sufficient certainty, by a direct inquiry into the operations of the human mind, or by the obvious analysis of any single language. This might be thought sufficient to distinguish all that is requisite to the purposes of speech from every thing whimsical or peculiar, that is, from those turns of words and of phraseology which ought to be reckoned idiomatic. It might, at least, seem reasonable to expect that the principles would be discovered by paying attention to the variations and analogies existing among those words of any language which are not immediately and evidently borrowed from a foreign source. It might even be thought possible to collect them by recording the early operations of a child in learning the use of his native language. That the principles of this science *could* have been so discovered, it would be rash to deny. But the well known obstructions opposed to science by the delicacy and proneness to error which mark the human faculties, and the various external biases which the mind receives, operate in all ages to prevent scientific inquiry from being made, and in corrupting the accuracy of the results obtained. Hence we are sometimes indebted to fortunate accidents for an introduction to the right path of inquiry, and for the discovery of truths which had otherwise a chance of remaining for ever unknown. One of these fortunate accidents, as relating to the subject of our present article, is the existence of various languages in the world, and the access which individuals have to compare them together. The success which philosophers have met with in these inquiries has arisen from the study of languages the most diversified from each other in their structure. Those of ancient Greece and Rome have, for example, been compared with those of modern Europe, and both these with the languages of the East, and the great differences apparent in their origin and structure have afforded a valuable opportunity of tracing, with a scientific hand, the general operations of man in this conspicuous department of his active efforts. An extensive erudition in literature confers emancipation from that enthralling influence, which any single language exercises over those whose knowledge is confined to it. The errors which the habits of one would produce receive correction from the attention exacted by the varying genius of another. These inquiries might even lead us a step higher. They might enable us to discover whether or not there are any circumstances in which the habits common to all languages mark a prevailing erroneous bias in our nature, and might lead us to improve and purify in this department the perspicacity of our intellect.

The difficulty of the subject renders it at least prudent to avail ourselves of all the aids which can be afforded by diversities in the structure of languages. These, indeed, are of themselves elegant subjects of study. No person who cultivates them can be indifferent about Universal Grammar, or insensible to the intimate connection which exists between the two pursuits. A very limited fact in philology not unfrequently suggests an important doctrine in the philosophy of grammar, which is afterwards confirmed by multiplied evidences, and, though formerly overlooked, exhibits, when known, a character of internal truth, and throws a broad light over the whole extent of the subject.

In no circumstance does the difficulty of this subject appear more conspicuous than in the diversity of sentiment which prevails on it. This diversity is indeed capable of being represented as chiefly, if not entirely, verbal. But, where verbal differences are pertinaciously adhered to, some misconceptions with regard to the subject itself are undoubtedly more or less prevalent. It cannot be said to be clearly understood among all who cultivate it, unless they either agree in the choice of the words by which their theories are expressed, or concur in acknowledging their differences of phraseology to be immaterial.

This is not at present the case. The cultivators of the science are divided into parties, which seem so distant from one another, that the philosophical analysis of language may be considered as still in its infancy. The account which we shall now give of it will not arrogate to itself the rank of a system matured for indiscriminate adoption. It will only be offered for deliberate consideration, as an attempt to advance the progress of this interesting branch of study, by exhibiting explanations which will show to partial systems several of their leading defects, and reconcile a variety of disputes without compromising the spirit of investigation.

## CHAP. I.

### *On the Object or Universal Office of Language.*

In order to investigate the characteristic differences by which words are distinguished, it is essential that we entertain correct ideas of the OBJECT or PURPOSE of language. Grammarians have hitherto satisfied themselves, with describing it as consisting in the COMMUNICATION OF OUR THOUGHTS. Yet it does not appear certain that they have always entertained the same views of what is meant by this communication. Vague notions of the office of language have in consequence been entertained, and a confusion arising from this cause has impeded the inquiries which were made into the origin and distinctions of the various parts of speech. Mr Harris describes it as consisting in "an exhibition of the energies or motions of the soul." These he divides into perception and volition; and he considers every sentence as either "a sentence of assertion," or "a sentence of volition." Some consider the object of language as simply consisting in the exhibition of a connection betwixt one idea and another, and therefore make the act of AFFIRMATION its universal office. These opinions, though slightly varying, agree in stating the communication of our thoughts to be the object of language.

That we may divest the subject of ambiguity, we shall enquire in what respects thought is ever communicated by language; what are the circumstances that lead to such communication; and whether or not the importance of this object entitles it to be regarded as the sole and definite purpose for which it is formed and employed.

Men may evince, by various signs, that particular thoughts occupy their minds. This is not only done by pantomimical language, but by oral sounds constituting the materials of verbal discourse. We sometimes shew by involuntary exclamations that we are affected by certain impressions called passions, which, though they originate from outward causes, do not necessarily point to such causes in our mode of expressing them. At other times, words are employed as the signs of external objects which are known to the person addressed. The effect of the employment of these is to recal to his recollection ideas formerly possessed by him. We show, at the same time, that they occupy our own minds. The meaning of the words being formerly known, they exhibit nothing new, except their connection with some present occasion. Old ideas thus recalled, however, do not constitute exactly the same state of thought which accompanied the former employment of the words. The mental exercises excited by the same word at different times are not strictly the same. They cannot be identical, because they are separate instances of mental exercise. But they are not even perfectly similar. Amidst the varying movements of the human mind, in which one thought impels another, and in which external and internal causes modify the state of the percipient being, the appropriate affection produced by any particular word can never be separately obtained. It is always modified, either by humour, by degrees of activity in the mind, or by the kinds of exercise in which it has been previously engaged.

The most important modifications of the mental effects of words arise from their connection with one another. By changes in this connection, new conjunctions of ideas are presented to the mind of the person addressed. The signs of thoughts formerly known to him are so exhibited as to excite impressions possessing the most striking novelty, and imparting the most important character, both to the immediate thoughts of the individual, and to those which are liable to occur on numerous future occasions. This is the case when, by means of words well understood, and therefore conveying in their separate state no idea that is new, we communicate information to one another, and exercise an influence on human opinions. On this office of language depends the whole benefit which mankind derive from the records of literature and science.

Engrossed by this most dignified application of language, authors have been induced to consider it as consisting entirely in assertion; that is, in expressing the connection of one idea with another, and conveying by these means new information. But, it may be called in question how far this account is strictly applicable to all language, or may be trusted for our guidance in tracing the steps of its earliest history.

It has been hastily assumed, that language arises from an original and universal inclination to impart our thoughts gratuitously to one another. From this cause it has sometimes been erroneously concluded, that it is nothing else than a faithful transcript of the successions of human thought. This, however, is not its character. A man does not speak simply because he thinks. It is not a necessary result of the possession of a thinking faculty, nor does the inclination to speak regularly accompany its operations. It is the effect of a range of thoughts, which must be considered as limited when compared to the whole phenomena of mind. Speech, like every other voluntary act of man, is founded on the presence of particular motives. It originates in his social nature taking advantage of his social state; and it depends on the knowledge which each has of various links of connection existing betwixt himself and other thinking beings.

It is not natural to man to communicate all his thoughts. Supposing, therefore, that a complete analysis of the origin of thought were in our possession, this would not necessarily bring along with it a perfect theory of the origin and character of language; nor would the most perfect history of the formation of language lead us in the opposite direction to a perfect analysis of the nature of thought.

But, allowing that we do not by means of language communicate *all* our thoughts, that we make a selection among them suited to our several occasions, it might still be contended that we do *nothing else* by means of language than communicate our thoughts; that this is its universal office; and that this position might be assumed as fundamental in entering on the subject of universal Grammar.

Some considerations will, we conceive, warrant us in hesitating before we concede even this point. We shall not stop to enquire if there is any acceptation in which this theory is true; but it is certainly susceptible of a meaning which is erroneous, and which has tended in some cases to distort philological enquiry. On the supposition now mentioned, language would still be considered as properly an exhibition of human thought.*

The first observation which we have to make on this account of the subject is, that, if it were correct, language ought always to have a definite reference to our sentiments, and ought in fact to express them with fidelity. But we find that, when we desire a person to perform any act, our motives for it are kept out of view, and are not intended to be contemplated by the individual spoken to. The motives which are expected to operate on him are ideas of a different sort which we endeavour to excite. Even in the use of the plainest affirmations, we do not necessarily exhibit our own thoughts. We may excite thoughts completely the reverse of them. This is always the case when we procure reception to a false proposition. The thought conveyed by our words has indeed been revolved in the mind as a contrivance for operating on another. In that other, however, we mean to produce a particular belief. This is certainly a thought; yet it is not the belief, consequently not the thought, which, in so far as truth is concerned, we ourselves entertain.

It might indeed be replied, that this employment of language is unnatural; that it is as much a deviation from its original purpose, in the right use of our faculties, as any act of drivelling folly committed by means of language, which ought not to be regarded as entering into its original character. But it is to be remembered that this use of language, though disingenuous, is still characteristic of intellect and address.

It might also be said, that in this use of language we closely *imitate* the sentences in which our own ideas are *bona fide* communicated, and that our success in falsehood depends on the closeness of this imitation. This fact only shows that dissimulation does not affect language in its structure. But its *object* must imply the real motives of the speaker. This account of it, therefore, must be deficient. If we can form a general theory on the subject which will embrace these as well as all other occasions on which it is used, a material advantage will undoubtedly be obtained.

The existence of false sentences is not our only reason for declining to regard the communication of thought, at least that communication which consists in assertion, as the universal office of language. We shall find that *Imperative sentences* cannot, without great awkwardness, be reduced to affirmations or communications of our knowledge. But, reserving that argument for the next Chapter, we shall now endeavour to unfold, in a more detailed manner, some of the intricacies in which this part of the subject is involved.

Different circumstances concur to impress the philosophical inquirer with an idea, that the communication of our thoughts is the object of language. One, at which we have already hinted, is, that this communication is the object of a *great part* of language, perhaps by far the greatest. This is most especially the case in polished and literary communities. It is the object of the greater part of the language of men of philosophical habits, the only persons who concern themselves with analytical inquiries on the subject; and it recommends itself as exhibiting the most important species of influence which language has exerted on society.

There are also some particulars in which all human speech agrees with the office of communicating thought, and which have led to an acquiescence in that account of its general object. One is, that the use of it always proceeds from some thoughts existing in the mind. Another is, that language consists of the signs of thought. A third, that the thoughts corresponding to these signs are contemplated by the individual using them. And the last is, that language terminates in exciting thoughts in the person addressed. But, though these points of coincidence are real, a closer attention will, we think, convince our readers, that they do not of themselves constitute a communication of our thoughts.

The mere circumstance that the employment of lan-

* For a more varied illustration of this and some other views nearly coinciding with those which are here expressed, we refer to a paper on "the theory of language," contained in the 7th volume of the Transactions of the Royal Society of Edinburgh.

guage is in every instance the effect of previous thought is by no means peculiar to this department of human exertion. All our voluntary actions are as much the effect of our mental operations as the uttering or the writing of sentences. In the use of language, as in other exertions, we indeed execute our own designs; but the enquiry is still equally open as before, what is our specific design in using language?

The second circumstance essential to language, which has perhaps tended to confirm the notion that its specific object is to communicate our thoughts, is, that the signs of human thought form the materials of which language consists. Such signs are always the media employed when we communicate our thoughts to one another. Yet it may be inquired, whether they admit of being also applied to other uses, and whether the object of language is, on that account, still more general?

The third circumstance of which we took notice, that the thoughts of which our words are the signs are entertained by the individual using them, is little more than a condensation of the two former, and requires no separate observation.

The truth will evolve itself in the clearest light when we discuss the last particular in which language has one common character with the communication of thought, that it produces appropriate thoughts in the mind of the person addressed. This is always the intention of the speaker, and if it is used by him in a skilful manner, the production of such thoughts is the consequence. This object is much more general than the communication of our own thoughts; but it is not too general to be stated as the real object of language. The conveyance of our sentiments, volitions, and opinions, is only an important part of it. The definite object of language consists in THE PRODUCTION OF THOUGHT BY MEANS OF ORAL SIGNS.

By adopting this more comprehensive view of the subject, we avoid all difficulty about the nature of such sentences as are the reverse of the belief of the speaker. We avoid the necessity of any inquiry into the propriety of considering them as in some sense exhibitions of the thoughts which he entertains for the moment, or as partial representations of his habitual thoughts. We consider them, in common with all sentences, in a point of view in which they maintain the same unquestionable ground; that is, as instruments fabricated to execute our designs; and our universal design in language is, to produce in one another such mental impressions as we please. Its ulterior purposes, being considerably diversified, admit of subdivision.

## CHAP. II.

### *The General Nature of Sentences.*

According to the author of the Diversions of Purley, two parts of speech are necessary to language, the noun and the verb, and every sentence must contain both. The reason assigned for this is, that one part of speech is required as the sign of the idea, and another as the instrument of communication. The views which this author entertained of the characteristic nature of the verb, and the act of communication as distinct from the exhibition of the signs of ideas, are not fully developed in his writings. We have not, therefore, sufficient data for appreciating their merits. The opinion maintained by some of his most acute followers is, that affirmation is the proper character of all sentences. This is considered as closely connected with the doctrine which makes the object of language to consist in the communication of our thoughts; and by this communication seems to be understood, the act of conveying to our neighbours the same connections betwixt ideas, (formerly known to both,) which they possess in our own minds. This conveyance, and the act of affirmation, are reckoned equivalent. Affirmation, from *ad firmare*, means the establishing of a connection betwixt one idea and another. The doctrine which resolves language into assertion does not depend on the truth of the theory, that its object is the communication of our thoughts. Our readers will perhaps agree with us in denying that sentences intended to deceive are communications of the thoughts of the speaker. It must, however, be allowed by all, that these sentences are assertions, and the inquiry still remains open, whether or not assertion is the proper character of sentences? To this inquiry the present Chapter is devoted.

A sentence of assertion includes two ideas expressed by two signs, and another sign to indicate the affirmation, or the establishment of their mutual connection. In the sentence "man is rational," "man" expresses one idea, the first two syllables of the word "rational" another, and the last syllable of "rational" along with the word "is" constitutes a sign expressing the connection betwixt the two. These different signs are not always expressed in separate words. Sometimes two of them are contained in one, as in the last word of the sentence "John walks." Sometimes all the three are contained in a single one, as in the Latin word *loquitur*, for "he speaks;" or *rubet*, for "he is red."

On a full consideration, however, of the variety of arrangement which words assume in the use of language, and the various kinds of words employed, assertion does not appear essential to it. We may produce thought without making any assertion. We may, for instance, merely call the attention of another person to an object formerly known to him. A very extensive department in the uses to which it is applied is that of exciting the person addressed to the performance of voluntary acts. This is done by *Imperatives*, which certainly differ from assertions. Attempts have indeed been made to reduce them under this head, and to regard them in the same light with those affirmations in which an abbreviation is produced by condensing a plurality of signs into one. This attempt succeeds in so far as it appears to establish a fact, that, according to the habits of speaking and understanding one another which we now possess, the same meaning may be conveyed by an affirmation and by an imperative sentence. The sentence, *I nunc et versus tecum meditare canoros*, is of the same import with the affirmative sentence, *Jubeo te nunc ire et tecum meditari versus canoros*. But the question recurs, which of these modes of expression is likely to have been the original one in the contrivance of words?

We formerly observed that the contrivances of language are founded on the known relations existing, on different occasions, betwixt the speaker and the person addressed, and are so adapted as to enable the former to avail himself of these relations for accomplishing some definite purpose. An answer to the inquiry, what forms of sentences are likely to be the earliest and the simplest, is not obtained by determining what connections of thoughts are simplest in relation to the mind of the solitary individual, but by finding what those purposes are which he is likely soonest to have in view in employing the influence which language gives him over others.

The first objects that strike the attention of man in becoming acquainted with his fellows are their motions. In other respects, one man is not more interesting to another than any piece of dead unchangeable matter. He first observes voluntary motions of the most palpable kind, and then gradually becomes acquainted with more delicate phenomena, such as the motions and changes of the human countenance, from which he infers the existence of thoughts in other persons, and judges of their nature. In acquiring this knowledge, he is guided by experience, and by a comparison betwixt the motions of others and those of which he is conscious, as the natural accompaniments of his own thoughts.

The helplessness of man as an individual, and the support which he is capable of deriving from the services of his fellows, create perpetual occasions on which he wishes for their assistance; and one of the earliest as well as the most frequent objects of his wishes is, to influence them to perform those motions for which he finds occasion. These necessities are prior to the mere luxury of a mutual communication of knowledge and opinion. This fact seems to point out imperative sentences as the earliest forms of language.

On this account, it is not historically correct to consider the imperatives *I*, *veni*, *fac*, and *dic*, as brief modes invented in the progress of language for expressing thoughts originally conveyed by means of such affirmative sentences as *jubeo* or *precor te ire*, *venire*, *facere*, and *dicere*. The act of commanding, or requesting, does not require to be mentioned. It is actually exhibited. *Jubeo te ire* is something more than *I*. It is a pleonasm in the form of an affirmative sentence; and has the same relation to this imperative which the sentence "I affirm that man is mortal," has to the shorter one, "Man is mortal." When we speak, there is no meaning in affirming that we speak; and in like manner, when we give a command, or make a request, there is no meaning in telling that we do so, unless we intend to enforce a compliance with our wishes by an additional idea contained in the verb prefixed, as by addressing ourselves particularly to the fears of another in the verb *jubeo*, or to his kindness in the verb *precor*. A command ought, in strict propriety, to be given, before it can become the subject of an affirmation.

As the imperative is an immediate consequence of our wishes, advantage might be taken of that circumstance to represent it as an "assertion that such wishes exist." But the circumstance of being the consequence of our wishes is common to it with all our actions, as well as all our words. It is rather, however, to be considered as an execution of our wishes, than an assertion of their existence. It is a call of attention; a mode of influencing the volitions of other persons, and thus producing, on their part, certain trains of action.

In corroboration of this view of the subject, we find that words signifying voluntary motion exist in the shortest form in the imperative of the verb. This is the case in all the languages, ancient and modern, which we have had access to examine. Exemplifications of this in the Latin language are afforded in the words already named, *I*, *veni*, *fac*, *dic*, and *duc*; or the common examples of the conjugations in elementary grammars, *ama*, *doce*, *lege*, *audi*. The same comparative brevity takes place in the English language, as in the words, "go," "come," "do," "say," "bring," "love," "teach," "read," and "hear," which never stand by themselves except in the imperative mood. Even when the idea expressed by any verb, in either language, is introduced as an object regarding which an assertion is to be made, the word employed is longer than the imperative. In Latin, the syllable *re* is in this case added to those which constitute the imperative. From *ama* we have *ama*-RE, and from the other imperatives, *doce*-RE *lege*-RE, and *audi*-RE; also, *i*-RE, *veni*-RE *dic*-ERE, *fac*-ERE, *duc*-ERE. In English, we prefix the word TO, or add the syllable ING; as, "*To* read, or read-*ing*, is an improving occupation." "Men of intellectual refinement delight in read-*ing*, or delight *to* read." In some instances, the word is equally short in its application to other uses as in the imperative. Of this the noun "love" is an example, being equally short, and indeed the same word, with the imperative of the corresponding verb. Such instances, however, are rare. Brevity, therefore, appears to be an original character of imperatives; a circumstance conformable with the theory, that they ought to be considered as original modes of speech, and not as abbreviations of affirmative sentences. The affirmative form, instead of illustrating the imperative mood, renders it cumbersome, and destroys its characteristic animation.

To those who have not previously considered this subject, the brevity of imperatives may appear, in point of fact, liable to some exceptions. The Chinese language is said to have no imperatives. That language, however, in so far as we can judge from our scanty knowledge of its structure, seems to owe this apparent defect to affectation and refinement, which have induced men in speaking to prepare the hearer by means of distant and respectful circumlocutions, instead of using direct imperatives, in order to avoid the apprehended indelicacy of dictating an abrupt change of direction to his thoughts. This modification probably took place after men had learned to keep their own objects and their own influence out of view, and to appear solely attentive to the convenience and pleasure of others. In a light nearly similar we are to consider those forms in the languages of modern Europe, originating in ceremony, by which single persons are addressed in the plural number.

Another question may here be asked, Why does this alleged brevity of the imperative not extend to the third person, and the plural number? Why are the words, *amato*, *amate*, *amatote*, and *amanto*, comparatively long? Would not this fact seem to intimate that the circumstance of being imperative does not of itself determine this brevity of form? To this we answer, that the word called the third person of the imperative, is not properly an imperative as directed to the person addressed; it expresses either a simple wish, or specifies some *consequence* of an action which the speaker wishes him to perform. The command is then learned by inference, and not conveyed in the word. The imperative in the second person of the plural number is, indeed, a real imperative; but it is to be observed, that it is not of so early natural origin as the imperative singular. It requires a particular arrangement to render it applicable. It implies not merely a wish that a certain action should be performed, but a knowledge that it is capable of being performed by a plurality of people, and that their concurrence in it will promote the same object, or fulfil a variety of objects that are alike desirable. Hence it probably deserves to be considered as equally remote from the original imperative with the other uses of the signs of locomotion.

Since, then, imperatives are not to be considered as contracted affirmations, it remains to inquire in what relation they stand to sentences of the latter kind? Whether these are originally two distant species of sentences, merely agreeing in the general character which is common to all language, that of being intended to produce appropriate thoughts in the person addressed?

In tracing the nature and origin of human language, it appears to us, on the whole, most strictly agreeable to the natural history of our species, to consider all language as IMPERATIVE; that is, as always implying the imperative of a verb.

Even when we merely mention an object by making use of a noun, an imperative is implied, desiring the person addressed to think of it. Some more particular intentions on the part of the speaker may be left to be inferred from the occasion on which it is uttered, or may be expressed by some circumstances of manner, or conveyed by means of some further verbal sign; but the noun itself, in the moment of utterance, always implies the general act of demonstration, that is, the imperative of the verb "look," or "think."

Assertions may be advantageously reduced to the imperative form, and may be considered as originally and essentially partaking of that character. Imperatives, we have remarked, are deprived of their characteristic animation when reduced to assertions. Assertions, on the contrary, preserve more completely that interest which originally belongs to them, when viewed as imperative directions for regulating the volitions and active thoughts of others. Our opinions proceed from impelling causes which bear a resemblance in their nature to the motives which prompt us to action, and assertions resemble the exhibition of such motives to other persons.

But if each single word possesses an imperative power, it may be asked, in what respects that power can be ascribed to the copula "is?"—When the intention of assertions is considered, this copula will be found equivalent to the imperative of the verb "believe." An opinion asserted by means of it does not retain the simple character of one which remains quiescent. Hence it is always expected to be of a nature fitted to interest the person addressed, and possessing a just claim on his attention. Without this, the declaration is regarded as unmeaning. Keeping this circumstance in view, we shall find nothing forced or exaggerated in representing the "is," in English as equivalent to "believe," and the *est* in Latin to *crede*.

When sentences constructed by means of this copula are not intended for conveying information, but for exhibiting pleasing objects already known, or objects of imagination, as in poetic description or fictitious narrative, the copula has the power of the imperative "contemplate."

One objection might be made to this theory, that *est* being placed betwixt two nominatives, cannot be equivalent to a word which governs nouns in the accusative. If such an objection should occur, it is sufficient to observe that the cases of nouns are refinements of language, intended for marking in a convenient manner certain uses of the words, and certain analogous connections which are formed among them in the composition of sentences, but that our present inquiries relate to a period of language much earlier than such contrivances; and, where the meaning can be shewn to be the same, diversities arising from these causes do not fall under our consideration.

It might, however, be objected to the whole reasoning here employed, that, if all sentences appear to be imperatives, there is no meaning in supposing those words which are usually called imperatives of verbs to be the earliest parts of speech, and in deriving from that consideration the brevity of their form. These particularities should at least imply that they differ from other imperatives. The nature and consequences of this difference require therefore to be pointed out. When we use the imperative of a verb of action, the name of the act expresses our ultimate wish, viz. the wish that the person addressed should perform it. Its name is originally contrived for this particular purpose. When we use it for other purposes, these require to be stated; and even the mere absence of the imperative use is denoted by the additional signs which we have already mentioned as distinguishing the infinitive of the verb. When we direct a person to think of objects of other kinds, each object may admit of being expressed by a very brief sign. But, for the most part, various circumstances require to be specified. Our intentions respecting any object admit of considerable latitude, and are to be particularized on each occasion by the indication of a connection betwixt that object and some others, or betwixt it and some voluntary effort which we dictate to the individual addressed. These relations, being various, require signs to distinguish them; and these signs, being generally in the form of terminations, give rise to the greater length of the words. But even in those instances in which the word used for an imperative suffers no change in its form when converted into a noun or any different part of speech, it cannot like an imperative, stand alone to form a sentence. Though not lengthened by the addition of a syllable, it requires to be accompanied by some other word.

We have maintained that every noun implies an imperative act of demonstration, or a call for attention; but it may be objected, that, as this is necessary to all language, and does not serve to distinguish one word from another, it cannot be said to be contained in the word, though implied in the act of speaking. Speech may have an imperative character, and yet it may not follow that its materials consist of imperatives alone. The names of surrounding objects may not be necessarily considered as expressive of different imperative acts, like the imperatives of different verbs. When we resolved the copula "is" into an imperative, this, perhaps, appeared an excessive refinement, and a strained attempt to give exclusive support to a particular system. It may appear sufficient for the maintenance of our fundamental theory, to keep in mind that a note of attention is implied in the act of speaking. If these views seem to our scientific readers more just than those which have been here suggested, we shall not, on so abstruse and so nice a point, urge any farther argument, but leave the preceding observations to their deliberate reflections. We have endeavoured to make as near an approach as possible to the formation of a general theory on the nature of sentences. But the views which we have given are not all essential to those that are to follow. The latter will, we hope, exhibit evidences of their own, independently of the consent of our readers to give to those contained in the present Chapter, a strict application in every particular to the parts of speech.

Language must be regarded by all as an instrument by which we direct the thoughts of one another. It has thus an undoubted imperative character, and this character receives subordinate variations, depending on the mutual relations of the speaker and the person addressed, with reference to the subject upon which it is employed. It includes four forms of influence, which have been already alluded to, and shall now be enumerated. 1st, We influence one another to exert the powers of voluntary motion. This gives rise to *Imperatives* in their acknowledged form. 2d, We direct the attention of one another to all the varieties of objects already mutually known. This gives occasion to the contrivance of *Names* to represent them. 3d, We influence one another's opinions and state of knowledge. This gives rise to the words which are particularly subservient to *Assertion*. 4th, We influence one another to communicate specific information. This gives rise to *Interrogatives*.

Though we have already given some account of the differences of words as subservient to these different uses, there are many varieties, as well as many analogies of form and use among them, which have not come under our consideration. The analysis of these will throw light on the general faculty of speech, and will furnish some rules for preserving us from mistakes in language, and from mistakes of greater importance regarding the diversified subjects to which language is applied. The remaining Chapters of this article will be occupied in investigating the differences which are commonly considered as constituting the different parts of speech.

## CHAP. III.

### *Of the Parts of Speech.*

These have been variously enumerated. Grammarians have not only differed in their arrangements, but in the number of parts of speech which they have allowed. The character of a particular language may, in some instances, determine the propriety of an arrangement in so far as concerns itself alone. The Latin language has no word exactly corresponding to the article ὁ, ἡ, το, in the Greek, and *the* in English. Those therefore who consider these words as the only definite articles in these two languages will consider the Latin language as possessing no such word; the circumstance denoted by it in other languages being left to be inferred from the connection.

But, independently of any difference originating in causes of this kind, some have called in question the propriety of certain distinctions maintained by others, whether as existing in the same language, or as common to all. Some parts of speech, reckoned by the generality to be distinct, have been ranked together by a few individuals under a more comprehensive head.

This generalization has been carried the greatest length in Tooke's *Diversions of Purley*. This author reckons the *Noun* and the *Verb* the only essential parts of speech. He does not, however, acquiesce in the views of Mr Harris, who sets out with a binary division of the subject which has the appearance of being similar. Mr Harris considers the adverb, the preposition, and the conjunction, as merely subsidiary and inferior materials, which connect the other parts of speech, and give ornament and fulness of expression to the whole; while Mr Tooke considers them, in every instance in which they are used, as equally essential with nouns and verbs, and refuses them a separate rank only because they are possessed of the same character with one or other of these parts of speech. He considers their only peculiarity as consisting in an abbreviated form, which has originated in the efforts of mankind to express their thoughts with celerity.

We have already observed that Mr Tooke founds his doctrine of the distinction of all words into nouns and verbs on this principle, that language implies "the signs of ideas," and also a "separate instrument for the purpose of communication." This separate instrument he calls the verb. He considers every verb as implying a noun, and also as implying something more, though he leaves the problem unsolved, what is that definite circumstance which, when added to the noun, makes it a verb?

We coincide with this author in so far as he maintains that language consists of the signs of ideas, together with certain contrivances for connecting these so as to answer the purposes of language. We adopt from him the valuable suggestion, that the verb contains the name of an idea, and, in this respect, comprehends the character of a noun, together with some additional circumstance; but we are obliged to give this suggestion a much wider extension, and to consider all the parts of speech, the noun itself included, as consisting of two parts, one of which is the sign of an idea, and the other a sign of a definite place which that idea is to occupy in the order of discourse Instead of saying with this author that the verb is *quod loquimur*, and the noun *de quo*, we would say that both the one and the other contain the name of an idea, and also a mark of some specific application, arising from the present occasions of the speaker. Both express certain objects *de quibus loquimur*, while the *quod loquimur* is the result of the collocation of the words thus mutually adapted

Such differences of mutual adaptation furnish the only good foundation for a distribution of the parts of speech. Great nicety in our subdivision is not essential to the explanation of their nature. We may, independently of this, point out the circumstances in which any part of speech to which we happen to give a separate name approaches to various others, or differs from them in its character. We shall therefore, without condemning the plans of others, adopt the division and arrangement which appear to us, in the mean time, most convenient. Even where a dispute may arise about the propriety of a particular distinction, in consequence of a slight difference in the obvious form of some words, which may have led to an erroneous conception of their nature, this is worthy of being noticed, for the purpose of assigning to it its due share of importance. Useful information may be derived from the detection of deceitful resemblances and deceitful differences, as well as from processes of analytical science apparently more profound. To content ourselves with showing that other persons were misled by them, and reprobating the errors which they embraced, is a plan of conduct neither fitted to promote scientific inquiry nor liberality of feeling.

## CHAP. IV.

### *Of Nouns.*

#### Sect. I. *The Nature of the Noun.*

The word *Noun* in our language, as well as the corresponding words used by grammarians in other languages, signifies "a name." Nouns are, for the most part, defined to be "words which denote *objects* or *substances*." Some consider them as including substantives and adjectives; substantives denoting substances, and adjectives denoting qualities. Others regard these two sorts of words as deserving a separate rank in language, and therefore restrict the meaning of the term "noun" to substantives. The words to which these different appellations are assigned agree in some respects, and differ in others; and the propriety of ranking them together or separately will depend on the definition given to the noun. Mr Tooke considers both substantives and adjectives as nouns, and as in fact the same sort of words, only that the adjective contains, besides the name of the object, a sign that it is to be coupled in language with some other. We shall, on the present occasion, restrict the term noun to the substantive, and shall use these terms indiscriminately, sometimes preferring the latter as better fitted to prevent any ambiguity on the part of the reader, created by the general usages of grammarians.

We may trace in the prevalent method of describing the nature of the noun, as distinguished from other parts of speech, some of the hurtful effects of the opinion entertained by grammarians, that the history of language implies a history of human knowledge and thought. Condillac maintains that languages are analytic methods, and are necessary both for giving an account of our thoughts to our own minds, and conducting us to ideas which otherwise we could not have possessed. He thinks that the investigation of them furnishes us with convenient means for the analysis of thought, and he conceives it a radical mistake to regard them merely as the instruments of communication. Conformably with this notion, that author, like many others, considers the different parts of speech as expressions for different kinds of thoughts. We hope gradually to exhibit, in the sequel of this article, an ample collection of facts in refutation of these opinions. We shall, in the mean time, illustrate their fallacy, by pointing out the fallacious character of the metaphysical speculations with which, as applied to the noun, they have been associated.

Substantive nouns have been considered as the names of substances. The word "substance," is derived from *sub* and *stare*, because they are considered as beings existing under the qualities perceived by the senses, and giving these qualities support. It is granted by every person who endeavours to go a step farther back in this speculation, that the nature of a substance, as separate from its qualities, and which metaphysicians, for the sake of distinction, denominate a *substratum*, is unknown. Notwithstanding this, such words as "stone," "earth," "wood," and "iron," are regarded not as the names of particular instances and forms of hardness, weight, visibility, colour, and other qualities which are perceived, but of substrata which possess these qualitities.

Some grammarians, following a similar theory, have represented the distinction betwixt substantives and adjectives as having for its foundation a difference existing in nature betwixt *things* and their *manner of existence.* Things are said to be substances which exist by themselves, but the manner of existence of things is said to form accidents which only exist in consequence of the existence of substances. This is the opinion advanced by the authors of the *Grammaire Generale et Raisonnée.* Words which signify the objects of thought are, in that work, distinguished into those which signify substances, and which are substantives, and those which signify accidents, and contain at the same time a notification that there is some substance to which these accidents belong. These last words are adjective nouns, or, to express each by a single word, the former are called nouns and the latter adjectives.

It is, however, an obvious fact with regard to nouns, that many of them are the names of qualities. Such are the nouns, "hardness," "blackness," and "whiteness," which have as much the character of substantives in their use in language as the words, "iron," wood," and "stone."

In order to surmount this difficulty, these have been regarded as a secondary or improper kind of substantives, and the ideas expressed by them as not originally entitled to be expressed in that form. They have been considered as originating in a figure of speech, by which qualities are treated as if they were substances. The authors of the last mentioned Grammar ingeniously attempt to solve the difficulty, by describing the qualities thus designated as *subsisting by themselves in language*, being so used as to have no need of another noun, although they are, in their own nature, mere accidents. A very little more inquiry would have led these writers to the true doctrine on the subject, that the mode of treating the sign of an idea, and the idea itself by means of it, in language, is the sole foundation of the peculiarities of the substantive noun.

The difference betwixt a substance and its qualities, and the whole doctrine of a substratum, seem to be mere assumptions of an excessively inquisitive species of philosophy. The only real objects of our knowledge are qualities. It is vain to tell us that the qualities are merely the media by which we obtain a knowledge of the substance. Our ideas of the qualities themselves are clear and precise; but we never find that our knowledge of them conducts us one step towards the knowledge of the substratum. The doctrine of the existence of the latter ought therefore to be rejected as an unfounded assumption, and the objects which we call substances ought to be considered as consisting entirely of definite assemblages of sensible qualities. We cannot, indeed, disprove the existence of a substratum, nor can we prove that this substratum is not the cause of the qualities, and the bond of their union. Nature contains riches to which the human understanding has no access. But we must have some intelligible description before we can entertain any idea of it, and we must have some proof of its existence before we can reasonably believe in it. If any person should assert that every particle of earth contains a miniature of the planetary system, we should understand his meaning, and it would not be in our power to disprove his assertion. But we should undoubtedly reject it as unsupported by evidence, and ascribe the belief of it on his part to extreme credulity, a passion for singularity, or some other of the sources of self-deception by which men are so often misled. But the doctrine of a material substratum is not merely destitute of proof; it is unintelligible. The word is pronounced without any appropriate meaning. It is not probable that a notion of this sort obtains among mankind at large. It is probable that the vulgar never think of any substratum containing the sensible qualities which they perceive, and that their ideas of matter are restricted to qualities which are the solid and real objects of their knowledge. The doctrine of a substratum has been invented by men in quest of subtleties; and it seems to have been supported by the other error already mentioned, that the structure of language exhibits an analytical view of our thoughts, and that different kinds of thoughts must be expressed where different kinds of words are used. Man is liable, in such inquiries, to give way to a precipitate curiosity, which leads him to frame hypotheses on subjects beyond his reach. He does not repose in his actual discoveries, but labours to account for what he knows; and, rather than leave this unattempted, he explains what he really knows by something which he does not know, and thus infallibly renders it more obscure. He imagines that he obtains solutions of his difficulties, while he only indulges a confused and mystic feeling associated with the use of particular words.

When several qualities are observed to be constantly united in nature, a strong association is formed among our ideas of such qualities; but if we make a careful analysis of mental phenomena, we shall find that, in pronouncing the name of any material being, certain sensible qualities, more or less vaguely conceived, are the only objects of our thoughts.

This dissertation on our ideas of substances may appear a deviation from the subject of Universal Grammar. But, since grammarians have supposed these ideas to be closely connected with the theory of nouns, it seemed necessary, in order to do justice to our subject, that we should shew the fallacy of the common doctrines from the nature of our thoughts, as well as from the structure of language. The views which we have stated lead us to no vague or perplexing conclusions. The fact of the uniformity of the definite combinations of certain material qualities, is in no degree deprived of its solidity or interest, though we decline to admit the hypothesis of a substratum. The rejection of this hypothesis will assist our physical, as well as our grammatical studies. It will relieve us from the embarrassment of the understanding, which sometimes takes place when particular qualities are found in a detached state. Those who are unpractised in the accurate exercise of thought, and have been led astray by words, have, in the outset of their physical inquiries, found it difficult to conceive that a body which is felt yet not seen, as the air, has an existence equally substantial with other matter. They have also considered light, which implies an object of sight unaccompanied by any object of touch, as on this account more difficult to be understood than earth, stones, and other substances, which are both tangible and visible. The most rational proceeding is, to satisfy ourselves with such qualities of tangibility and visibility as we can ascertain in any of their peculiarities and relations, whether they are observed in a state of conjunction or of separation.

Thus, when we attempt to trace the supposed differences betwixt substances and qualities, we find no foundation for a distinction into two kinds of objects, and much less for a distinction in the kind of terms by which such objects should be expressed. This is the same conclusion to which we are led in tracing the history of nouns. We find that the same kinds of ideas are designated by them as by adjectives.

If the distinction betwixt nouns and other parts of speech cannot be founded on the place which the objects expressed by them occupy in nature, it must rest entirely on the manner in which they are introduced with relation to the other words with which they are conjoined. It depends on the rank which the word occupies in a sentence, and which the thought excited by it is intended to occupy in that mental series which we wish to produce.

How, then, are we to define the noun, so as to distinguish it from the other parts of speech? Shall we, with Mr Tooke, consider it as the "mere name of an idea?" Shall we consider the verb as a part of speech more complicated in its nature, by containing "some circumstance in addition to the name of an idea?" And shall we be induced to extend a similar character of complication, in a smaller degree, to the adjective? This mode of proceeding might at first appear plausible. But, on closer reflection, we shall find that no word, not even a substantive noun, exists as the mere name of an idea; that there is always a demonstration of some further definite use to which it is to be applied. This we know to be the purpose of the variations called cases. Even the nominative case has a peculiarity which does not consist in the want of any such demonstration. The syllable *us* in *dominus*, denoting the nominative case, informs us that the noun is to be connected with a verb of assertion. The genitive case, and all the others, in like manner point out some definite use of the noun. If we separate these terminations, and consider them as distinct signs, and regard the radical syllables as containing the essence of the noun, (as in this example the syllables *domin*,) we shall still retain the name of the idea, but we shall have nothing to distinguish the noun from the other parts of speech. If a verb is deprived of all the parts which are intended to connect the idea which it represents with the other ideas expressed in a sentence, we shall, in like manner, retain the mere name of an object. In *domin* we have the radical syllables of the verb *dominor*, as well as of the noun *dominus*.

Taking the noun with all the terminations incident to it, we might still be supposed desirous of giving it a definition. In its different forms we have a variety of uses to which it is applied. With these in our view, we may now ask, what circumstance is common to them all, which does not belong to the same etymon in the form of a verb. It will not be easy to give a formal definition of this. It appears to us to consist in the degree of conspicuousness which the word has in a sentence, and the ascendant interest which the idea expressed by it is intended to have in the mind of the person addressed. The noun is a name for the central object of interest. When we come to consider the different cases, it will be made to appear that they refer us to degrees of importance different from one another; but they all agree in expressing ideas nearer to the central object than those expressed by the other parts of speech; or, at least, this will be shewn to be their original destination. This may seem a very imperfect definition of a particular part of speech: it expresses, however, nothing but what is true; and the same truth will be more fully developed in other instances, as we proceed with the discussion of the various kinds of words. Although no formal definition has now been given of the noun, the purpose of a definition is ultimately answered, when it is described by means of a comparison with other words, the only objects from which it requires to be distinguished.

When no termination is affixed to the radical sign, the distinction betwixt its application as a noun and as a verb is designated by its mode of connection with other words in the sentence. When the general idea expressed by the word "love" is exhibited as the chief object of interest, "love" is a noun, and the purposes of speech require it in that use to be connected with some sort of verb, as "love is a pleasing emotion." It is thus fully distinguished from the *verb* "love," which is known to be a verb from having a noun connected with it as introductory. In such sentences as, "I love," "you love," "they love," the subject of discourse is always denoted by a substantive noun. Other substantive nouns may indeed be introduced as subordinate to that which signifies the subject chiefly spoken of. The differences of these relations will be afterwards attended to. In the mean time we shall regard this general purpose as giving origin to that part of speech. In the noun the name of the idea has also greater latitude in the uses to which it is applied. It is a sign by means of which the same idea may, in the progress of discourse, be represented repeatedly, and in a great variety of aspects.

### Sect. II. *Concrete and Abstract Nouns.*

Nouns are either concrete or abstract. A concrete noun signifies a congeries of qualities habitually presented together in nature. An abstract noun signifies a quality separately conceived.

The words "man," "woman," "wood," "stone," "house," "city," are examples of *concrete nouns*. They are the same that have been considered by grammarians and metaphysicians as the names of substances, that is, of subtrata possessing definite qualities. The qualities and the substances have been supposed to be firmly conjoined; hence the name concrete, by which their nature is expressed, is derived from the Latin words *con* and *cretus*, signifying "grown together." Though the hypothesis of a substratum is rejected, the term *concrete* is perfectly well adapted to represent a congeries of qualities which have become associated in the mind, in consequence of certain specimens of them in nature being habitually found in conjunction. The name of a person well known to us suggests some or all of the qualities by which he is distinguished, such as his appearance, the sound of his voice, and the particulars of his personal character. The name of any well-known river, hamlet, field, or other inanimate object, suggests, in like manner, the distinguishing characters of each. The same thing is even done, though in a different way, by concrete terms of more general application, such as the words "river," "mountain," and "city." Sometimes one quality of the object, and sometimes several, occur to the mind as associated with the word; sometimes merely a vague impression of a scene, in which we expect to find certain qualities which are the objects of our remembrance. The limits within which the expectations connected with words of this sort are confined constitute their precise meaning, or mental definition.

The scene by which we are continually surrounded consists of groups of sensible qualities, which are various in extent, and variously combined. This diversity gives origin to a diversity of terms. Terms are rendered necessary on account of the subserviency of many surrounding objects to our first wants, and their importance as instruments of mutual assistance among men. When they are present, we may, by merely looking or pointing at them, direct to them the attention of one another, and, when they are absent, we may think of them independently of any names. But, when one man wishes to execute any purpose regarding them in their absence by exciting the ideas of them in the mind of another, he requires signs to represent them; and from the familiarity of the mind with these objects, the contrivance of names becomes a very early operation of the social individual.

*Abstract nouns* are those which signify qualities separately conceived, such as "whiteness," "roundness," "softness," "form," "magnitude," "beauty." The nature of these nouns, and of the objects which they designate, has given rise to controversy. Some have denied that they express definite or separate ideas, because qualities never exist by themselves, but are always attached to some substance; and because it is impossible even to think of the qualities without thinking of the substance. It has, for example, been declared impossible to think of whiteness, blackness, redness, straightness, or hardness, without thinking of a *thing* or substance which is white, black, red, straight or hard. In so far as this doctrine implies the impossibility of thinking of qualities without the substrata, it has been already discussed, and must be laid aside by every person who recollects that the substratum is regarded, even by those who believe most firmly in its existence, as the most difficult to be apprehended of all material objects. Those who imagine that they think about substances to which such qualities as have now been mentioned belong, merely think more or less obscurely of other qualities with which they have a strong inclination to connect those which happen to be named. Each quality is an independent object of knowledge: but the ideas of different qualities are strongly associated in the mind, and the activity and versatility of its operations produce a proneness to conjoin each one that comes into view with others conceived to be collateral. During the first evolution of our senses, our knowledge is acquired by attending to single qualities. Persons who are born blind or deaf, and consequently have none of the ideas imparted by that sense which is deficient to mingle with their other ideas, retain through life a separate conception of certain material qualities which, by the greater part of mankind, are constantly associated with others. When a person, under these circumstances, happens to recover the deficient faculty, the ideas which it conveys are at first separate, and it is only by experience that the habit of associating them with others is gradually produced. This process has been illustrated in the history of persons born blind from an opacity in the crystalline lens of the eye, and cured by a surgical operation, at a period of life when their mental faculties were so far unfolded as to enable them to describe their sensations. In mankind at large, the combinations of sensible ideas are formed long before language is attended to; and on this account the structure of language affords no analytical view of the process. If it did, the names of single qualities would be the simplest words, and the names of the assemblages which we denominate matter or substance would be comparatively compound. The reverse of this is the case. The names of habitual assemblages of objects are less compound, because the utility of assigning names to them is of prior suggestion. Single qualities are later in becoming leading subjects of discourse, and hence their names are later in assuming the form of substantive nouns. "Whiteness," "blackness," "redness," "hardness," "straightness," "roundness," are not so short as many names of objects, which comprehend one of these qualities in combination with several others. "Egg" is a shorter word than "whiteness," "soot" than "blackness." Even the names of single qualities comprehend, in their original formation, a general mark of reference to some congeries of which they are supposed to form a part, and the name is subordinate in discourse to the name of some such congeries. "White" is the name of a quality, and contains a reference to some congeries to which it is described as belonging. The separate consideration of the quality is a subsequent object of interest; therefore the term for it is of subsequent creation, and an additional sign to denote this separate consideration is attached to it. This sign is the termination "ness." From "white," we have "whiteness;" from "red," "redness;" from "round," "roundness;" from "great," "greatness." Different languages have different terminations adapted to the same purpose. From the Latin *magnus*, we have *magnitudo* in Latin, and "magnitude" in English.

Some have denied that we can have any ideas of separate qualities. It must be granted, as has been already observed, that the human mind has a strong propensity to conjoin different qualities mutually as objects of thought, and thus form conceptions of compound individuals. We mentioned, however, that it ought to be recollected, that a person whose sensibilities are only as yet beginning to be unfolded has separate perceptions of the different qualities. It is now further to be observed that any person, even one whose habits of association are most inveterate, may direct his *chief* attention to one particular quality. Others may indeed involuntarily intrude in combination with it, or he may have occasion to think of the relations in which it stands to others; but this one in particular is distinguished as the chief object of his attention, and is also thought of with constancy, while the others with which it is accidently associated are both less attended to and in themselves varying. We therefore see no impropriety in saying that this is a separate object of thought. We are certainly entitled to regard it as a separate subject of discourse. It is this alone that gives origin to such terms, and confers on them all their meaning and utility. If the present were a proper occasion for entering on such disquisitions, we might shew that even the names of concrete objects do not always excite in the mind the same constant and definite ideas, which are, on mature consideration, attached to them. When a concrete noun implies many ideas, we do not think of the whole of them. When it implies very few, we think of something else with which we suppose them to be in contact. It is seldom that the mind is occupied with the full meaning of any word, to the total exclusion of other ideas. Very little difference, therefore, exists betwixt our mode of conceiving the objects signified by concrete and those signified by abstract nouns. The comparatively complicated form of the latter arises from the comparative recency of the period at which a distinction becomes requisite, for denoting single qualities as the principal subjects of discourse.

### Sect. III. *Particular and General Nouns.*

Nouns are either particular or general. Particular nouns, or proper names, are those which are applicable only to individauls. General nouns (commonly called general terms) are those which are applied to a plurality of objects possessing a mutual resemblance.

When human knowledge becomes somewhat extended, it is impossible to conduct language by means of proper names alone. Individual objects are too numerous to receive distinct names; and, if these were imposed, it would be impossible for the most tenacious memory to retain the nouns of any language. A sense of this inconvenience has been supposed by some grammarians to have given origin to the expedient of arranging objects in genera, each genus including all the individuals which resemble one another in certain particulars, and which on that account receive one common name. Such are the words "tree," "field," "house," "bird," "horse," "elephant," "man," "woman." This history of general terms, however, is not agreeable to fact. Mankind have a *native bias* to give the same name to objects which are nearly alike. They delight to show, in this manner, that they recognise in a new object a character similar to that of something previously known. They prefer the use of words habitually significant to the coining of terms entirely new. This tendency is observed very early in children. They apply the same words, even in cases in which the resemblances of objects are not sufficiently strong to render the general application of a term satisfactory. A child introduced for the first time to the sight of an uncommon animal, such as a camel, gives it an appellation borrowed from some familiar object. First, observing its majestic size, he calls it a horse; next, the form of its head, he calls it a sheep; and, by passing from one designation to another, he shows a powerful inclination to apply to it some general term. The application of common names is always most constant where the mutual resemblances of individuals are greatest. When they are perfectly alike, it is as natural to give the same name constantly to them all as to give the same name at all times to an individual.

It has been said that all terms are at first proper names. But the name which we first apply to an object is proper only when we are acquainted with no other object resembling it, or when an individual so frequently claims our separate interest, that a name to distinguish it from all others is absolutely necessary. This last circumstance is the foundation of the application of proper names from the very beginning to all our familiar friends, notwithstanding the obvious mutual resemblances of human beings. Under other circumstances, we no sooner perceive resemblances than we form general terms, or, which is the same thing, give a general application to such terms as we possess. With regard to the greater part of nouns, it is probably nearer the truth to say that general terms are first in order, and that men, finding it convenient to designate individuals by single terms, consequently create proper names, than to maintain that a sense of the inconvenience arising from the mere multiplicity of proper names gives rise to the abridged method of forming general terms. By a tenacious disputant, it might be contended that we become acquainted with objects one by one, and that therefore, if a name is given to the first object of our knowledge as soon as known, it must be a proper name; but this speculation supposes man to form words much sooner than it is possible for him to do, that is, before he possesses any variety of knowledge; a state of things which precludes all occasion for language as well as the possibility of articulation.

Here it will be requisite to describe the nature of general ideas, a subject which has given rise to much controversy. Some have maintained that no such ideas exist; others, that they owe their existence to the previous formation of general terms. The chief argument against the existence of general ideas is deduced from the fact, that when we endeavour to think separately of the circumstance which is common to all the individuals of a genus, we can obtain no distinct image. To think of "a man in general" is said to be impossible. The man of whom we think must be tall or short, naked or clothed, fair or dark, lively or dull. In like manner, if we endeavour to form a general idea of "a tree" by contemplating nothing but what is common to all trees, the image no longer resembles any tree.

The denial of the existence of general ideas has sometimes been accompanied with a misconception, arising from the confounding of two things which are in themselves distinct; the existence of ideas in the mind, and the existence of external objects. It seems to have been tacitly taken for granted, that the same laws which regulate external objects should apply to the ideas which the mind entertains concerning them. All external objects are individuals, and therefore it has been supposed that all our ideas of them ought to be particular. External objects retain during the lapse of time their individual identity. The names assigned to them have therefore been supposed to retain one constant meaning in our minds, and this constancy has been regarded as the foundation of our ideas of particularity. Hence proper names have been supposed to be peculiarly exact in their meaning. But the fact is, that, even when we think of the same individuals in nature, our ideas at one time are different from what they are at another. They depend on the state of the mind and on the point of view which we take of the object, independently of any change to which its real qualities are liable. If particularity implies invariableness, our ideas, as existing at a specified instant of time, are the only ones that can be regarded as particular. Ideas of the same external object existing at different times, though resembling each other, may also in some respects differ; and, however nearly they may coincide, they are always distinct facts in the mind. When two ideas of the same external object entertained at different times are placed together and called one idea, this idea is general in its nature. Thus proper names have not such a steadiness in the ideas which they excite as has been ascribed to them. We shall further find that the ideas attached at any particular moment to a general term, are not so vague as has been supposed. They have a distinct character; they form a definite affection or state of mind, and that state of mind is a particular or individual fact. Individuality, however, as relating to the idea in the mind, does not form the foundation of any sort of words, because words are understood from time to time, and are considered as retaining the same meaning independently of the fluctuations of human thought. The foundation of this supposed constancy is, that the ideas attached to them have always a mutual similarity. They differ from one another, but this difference has its bounds both in proper names and general terms. The ideas attached at different times to proper names differ according to the situations and aspects in which objects are viewed, and according as the mind takes in the whole, or only a part of any object represented. It is evident that the ideas attached to general terms are subjected to the very same variations. They are also liable to variations peculiar to themselves, arising from the dissimilarities subsisting among individuals of the same genus. This cause of diversity seems to have been exclusively attended to in the inquiries instituted into the subject of general terms. Yet it is not always greater than the other. In some instances it has no effect. This takes place wherever these diversities are so slight or so void of interest as to escape observation. Such are the differences betwixt one *fly*, one *swallow*, or one *mouse*, and another. The general terms applied to these objects excite no greater variety of ideas than is liable to be excited by the proper names of individuals belonging to the respective species. It is of importance now to remark, that even general words, significant of classes of beings among which prominent distinctions exist, along with the similarities which form the foundation of the general application of the words, are to be considered as retaining from time to time the same meaning, because the ideas which they excite are variable only within certain bounds. Some definite idea is therefore strictly attached to each term. This may be considered as a detached thought, in so far as it may be made the only, or at least the leading object of attention. We may think of the objects signified by any term as one genus, and investigate their common properties. The versatile nature of the human mind makes it prone to mingle its ideas of these properties with various others, and these others are for the most part such as are combined with the character of the genus to form particular individuals. But the general property may be principally thought of, as well as solely designated.

With regard to the opinion of those who allow the existence of general ideas, yet maintain that they owe their existence to the formation of general terms, it seems to us completely incongruous. A term is invented for the purpose of expressing an idea. The recognizance of a resemblance among a plurality of individuals is the foundation of a general idea, and this always exists before any general term is invented, and before any term which was formerly a proper name receives a generic application.

The resemblances among objects have various degrees of extent. Some genera are much more comprehensive than others. Some include subordinate divisions into more limited genera. The word *genus*, as technically used in the arrangements of natural history, represents one stage of subdivision: those immediately subordinate to it are called *species*. If it is found convenient to subdivide these, the subdivisions are called *sub-species* or *varieties*. Those which are more comprehensive than genera are called *orders*. Others still more comprehensive are called *classes*. The most general division of all is into *kingdoms*, called the animal, the vegetable, and the mineral kingdom.

In the greater part of objects, however, the resemblances pass gradually into one another. One object resembles many others, each in different respects and in different degrees. Every point of resemblance and of difference has a generic name, because many exemplifications of all of them occur. In consequence of the endless variety of existing combinations, we may designate a particular object, by enumerating the general properties which meet in it to form its character. It is thus that we describe either a limited species or a single individual. This may be done without giving it an appropriate name. We never pursue a system of classification to its utmost extent, so as to give characters to all the subdivisions that might be formed. However near we have brought any two objects together by the limitations of our specific characters, it is still possible to find out some circumstance in which they differ, either in their intrinsic nature or their external relations; and, if upon this, in union with their other characters, we were to establish a term in our subdivisions, the gradations would be so much extended as to become equally numerous with individuals. Thus classification would produce no compendiousness of plan. It would give rise to as many names as there are individuals, besides encumbering us with the names of all the subdivisions. But we have no motives for proceeding in this manner. In most instances, the peculiarities of individuals, or of very limited species, do not sufficiently interest us. When they excite occasional interest, they are designated as possessing certain specific assemblages of qualities expressed by general terms, and our descriptions are aided by the employment of clear references. To designate the properties of interesting genera, species, and individuals, is a great part of the object of written language. It often happens that not only sentences but books are made subservient to the description of one object. Many others are indeed introduced for illustrating the relations sustained by the leading one; relations which undoubtedly constitute part of the character of these others, and more or less promote the elucidation of all.

The terms which designate single qualities are always general. The cause of this feature in language is worthy of investigation. The fact itself has given rise to an idea, that single qualities are not individuals; that they are mere modes applicable to different individual substances; or that, if each quality is an universal individual, it is moveable in its relations with other qualities. But single qualities, wherever they come under our knowledge, are in reality different individuals. The whiteness of snow, and the whiteness of bleached linen, are different objects. The whiteness of one piece of linen is a separate object from the whiteness of another. It is the similarity, more or less perfect, of the objects, in all instances of whiteness, that gives rise to the general name of the colour; and it is for no other reason that one common name is given to concrete assemblages of objects possessing a mutual resemblance, whether in arrangement or in kind. It is for the same reason that a plurality of objects receives the name of "stone," "mountain," or "field." Yet, however exactly coincident the colour of one object may be with that of another, and however hopeless a task it may be to attempt to distinguish them, except by the differences of their association with other qualities, the colour is in each case a separate individual. It has no proper name; because, while our attention is attracted by it, we are at the same time presented with other qualities (that is, other objects) closely conjoined with it, and it is the combined scene that fixes our attention. It is to the combined scene that we apply a name, in consequence of the joint interest which we and others take in it. The only interest that we have in marking a separate quality of this scene is, to point it out as a circumstance in which it resembles others. Hence it is only when we perceive similar objects, that we give this single quality a name. Thus the word in its very creation is general. The exactness of the resemblance which different exemplifications of single qualities have to each other is another reason why generic terms alone are applied to them. Although different objects, they are not intrinsically distinguishable, and the idea which we apply to a plurality of instances of them resembles, in its constancy, the idea attached to the same individual.

Even when any congeries of objects has a quality (or, in other words, comprehends an object) altogether peculiar, we give it no distinct name. If it is known to other persons, we refer to it by means of the concrete name by which the group of which it forms a part is known. If it is a peculiar sensation, as some of those which arise from disease, the only description that we give of it to one who has not experienced it, consists in a statement of its total dissimilarity to every other. Even when a kind of qualities belongs to a limited range of assemblages, (or, in other words, a limited species of substances,) we borrow the name of the quality from the name of the concrete assemblage of which it forms a part. The taste peculiar to an apple, an orange, a pear, or a cucumber, although forming each a peculiar class of tastes, has for its only designation a reference to the species of fruit with which it is connected.

### Sect. IV. *Etymological History of Nouns.*

The transmissions of words from one language to another are so much varied that it is not easy to trace the derivation of all. The simple sounds of which they are composed are but few; for, though the modifications of pronunciation may be infinitely multiplied, these variations do not exhibit distinctions of origin and of meaning. On the contrary, we find sounds which are very dissimilar mutually exchanged in the transmission of a word from one dialect to another. The sounds, therefore, that are inconvertible into others, or the collections of sounds which, though mutually convertible, are never exchanged for any that are different from them, are reduced within a small compass. In reviewing the history of languages, we might at times suppose that almost all sounds are mutually convertible, and, in despair of finding satisfaction from etymological researches, acquiesce in this account of them, *Les voyelles sont pour rien, et les consonnes pour peu de chose.* Such researches are most secure from fallacy, when we trace the mutual concordance of languages which are historically known to be akin. When we grasp at the resemblances among the languages of nations, which can scarcely be supposed to have ever been connected by mutual intercourse, we are in danger of mistaking for actual derivations instances in which a coincidence has accidentally taken place, amidst the sparing number of short combinations which can be produced among a few elementary sounds.

We must therefore in many cases abandon the investigation of the origin of oral signs, as concealed by the total want of documents, or other means of tracing them. In some cases, however, the natural relations of objects to certain sounds discover the origin of words; in others, an evident leading analogy enables us to trace the same radical signs through different languages. In both of these fields of research, we have an opportunity of discerning some important mental operations concerned in the formation and application of languages. We shall therefore take notice of a few general varieties in the derivation of nouns.

Some nouns shew an evident adaptation of sounds naturally connected with the objects which they denote. Whether these sounds have been received into one language from another, or owe their origin to the immediate suggestion of nature, is a matter of little moment. The principle which produces an adherence to the use of them is in both cases the same. Among these we may reckon the nouns *cuculus* in Latin, and *cuckoo* in English, evidently intended to imitate the note of the bird which they signify. The Latin *perdrix* for a partridge is a near imitation of the sound made by that bird when disturbed in the field. Of the same kind are some nouns descriptive of particular sounds. We may take for examples, the words *corn-craik* for the land rail, *pees-weep* for the lap-wing; *hubble-bubble* for a noisy smoking instrument; also such words as *hiss*, *splash*, and *splutter.* Though some of them are provincial, and others are reckoned extremely vulgar, they exhibit one feature of the tendencies of mankind in the creation of signs.

Many nouns are derived from verbs of motion. This is the case not merely with such as signify certain motions in the abstract. Many concrete nouns are also formed from such verbs, in consequence of the selection of qualities or objects to be concreted being originally suggested by some relation to the voluntary motions of mankind. Of these we have an ample list in Tooke's *Diversions of Purley.* That author seems to consider the circumstance of so many names of objects being derived from verbs as leading to important general conclusions, although these are not specified. This feature of etymology evidently arises from the interesting nature of the voluntary motions of our species. From this cause, as we have already remarked, the earliest and simplest form of words of motion is that of the imperative; a wish to receive assistance from the activity of others being the earliest motive for speech. The interesting character of these motions also appears in the prevalent etymology of names for external objects. Though the objects themselves are previously known, our first motives for contriving signs to represent them arise from their known subserviency to the directions which we mean to give to the actions of others. Their connection with these actions affords a principle by which the surrounding scene of things is divided into groups. "Fruit" is derived from the Latin word *fruor*, to enjoy, the participle of which is *fruitus* or *fructus.* It signifies "aliquid *fruit*-um," or something enjoyed.

| | |
|---|---|
| A "debt" is | aliquid *debit*-um. |
| "Rent" | aliquid *rendit*-um. |
| "Tribute" | aliquid *tribut*-um. |
| An "act" | aliquid *act*-um. |
| "Expence" | aliquid *expens*-um. |
| "Merit" | aliquid *merit*-um. |
| "Accent" | aliquid *accent*-um. |
| "Fate" | aliquid *fat*-um. |

"Alley" is formed from the French verb *aller*, to go, meaning a sort of passage. "View" is from *vû*, the past participle of the verb *voir*, to see, and signifies something seen. "Destiny," *une chose destinée.* The derivation of all these words is sufficiently obvious.

Mr Tooke has with great ability traced to a similar origin many English nouns in which it was not formerly suspected. "Spot" he derives from the verb *spit*, of which he considers it as the past participle The noun "gate," from the verb *go*, or *gae*; "road," from the verb *ride*, signifying a place that has been *rode* upon. "Head," according to him, is from *heav-ed*, and means a part elevated. "Heaven" is from the same verb, and similar in its original meaning, though different in its application. A "flood" is something which has *flowed.* "Bread" is grain, which, in one step of its preparation for food, has been *brayed.* "Weft" is the past participle of the verb *weave.* The "haft" of a tool is the part *hav'd.* A "hift" is a part *held.* "Brood, breed, and brat," are from the Saxon verb *bredan*, to cherish. "Hand" from *hentan*, to lay hold of. "Fang" and "finger," from *fingan*, to take. "Truth" comes from the verb to *true*, and signifies that which a man *tru-eth*, or believeth. "Birth" is that which *bear-eth*: "Growth" that which *grow-eth*: "Wealth" that which *weal-eth*: "Earth" that which a man *car-eth* or plougheth.

Some of Mr Tooke's etymologies, tending to the illustration of the same general remark, have been disputed; but the etymologies substituted on these occasions generally turn out to be of a similar nature, deriving the names of substances from verbs of motion.

When a concrete noun is intended to convey the impression of a connection betwixt an object and any voluntary human act, the etymology is for the most part intentionally obvious. Thus from the verb command we have the noun "commandment," for a sentence employed in commanding. From accompany we have "accompaniment;" from judge "judgment," or opinion; from invest "investment." A great number of nouns of this description, derived from Latin verbs, terminate in *tion*; as "fraction, sanction, conflagration, collision." Some terminate in *ance* or *ence*; as "resistance, inheritance, science, prudence." We have others from the same language with different terminations; as "lecture," from *legere* to read. From the English verb know, we have the noun "knowledge." Sometimes nouns are formed, by adding to a verb the termination *ing*, as "landing" from land, and "fighting" from fight. Sometimes the use of the word as a noun is not indicated by any particular sign, but merely by the scope of the sentence. The words "love," "fight," "stand," "fold," "tie," "fly," "escape," are used both as nouns and as verbs.

Nouns of a similar structure, and sometimes the very same nouns, are used to express the abstract ideas comprehended in verbs. "Government" expresses either the abstract idea of the act of governing, or the concrete ideas of a particular instance in which this act is exercised, as "the British, the American, and the Turkish governments." Even the more general expression, "a government," is concrete, while "government" is abstract. A similar two-fold application may be made of the nouns "reflection," "understanding," "judgment," "pleasure," "love," "decision," "repetition." We may speak of "love" in general as an affection of the mind; or, a swain, in speaking of his mistress, may call her "his love." We may speak of "judgment" and "reflection" as faculties of mind, or we may call the sentiments resulting from their employment, "judgments" and "reflections." It was, at one time, common in our language to employ different forms of the word on these two occasions. We had, for example, "excellence" and "dependence" in the abstract; and "excellency" and "dependency" in the concrete.

Many nouns, both concrete and abstract, are derived from adjectives. Instances of concrete nouns of this origin we have in the word "white," for the white of an egg, and in the appellation "black, or negro," for a man of a black complexion. On the same principle, articles of merchandize are called "goods." Regiments are distinguished by the designations of "the blues," "the buffs," or "the greys;" and showy persons are denominated "beaux and belles." These words denote collections of ideas, or qualities, each under a designation borrowed from one of the most conspicuous. Hence they are described by Mr Tooke as specimens of subaudition, one quality being mentioned, and the rest which form the individual understood.

Many of them approach in their nature and etymology to nouns which are derived from verbs by passing through the medium of the participle, a part of speech resembling in some respects the adjective, and often considered by grammarians as in no respect different from it.

Abstract nouns also, or the names of single qualities, are derived from adjectives. This is done in our language by the addition of the termination *ness*, as in "goodness," "whiteness," "brightness," "redness." Whether or not this termination is originally the same with the French word *nez*, signifying nose, and with the termination "ness," as applied to projecting points of land in such proper names as "Inverness" and "Sheerness," we shall not stop to inquire. Whatever is its derivation, it has the same meaning with the word "quality." Whether it was, at any former period, a separate word under a different extent of application, is a question of inferior importance. A termination regularly used as a sign has all the distinctness of a separate word, though written more close to another connected sign, and sometimes involving a greater rapidity of pronunciation.

Abstract nouns derived from adjectives belonging to other languages are various; some terminating in *tude*, as "gratitude," "magnitude;" others in *ty*, as "purity," propriety;" or in *ence*, as "prudence," "science," and "patience."

Some abstract nouns are derived from compound adjectives owing their origin to previously existing nouns. "Loveliness" is derived from the adjective "lovely," which comes from the noun "love." We have, in like manner, "faith, faithful, faithfulness;" "boy, boyish, boyishness," and many other exemplifications.

Sometimes an abstract is derived from a concrete noun, by means of a termination, as "boyhood" from "boy," and "neighbourhood" from "neighbour."

Nouns originally abstract are often applied as concretes. A female possessed of the qualification of beauty, is called "a beauty;" a person of a strange character, "an oddity;" and a curious object, "a curiosity."

Mr Tooke endeavoured to prove by the etymology of nouns that abstraction was not an act of the mind, but only an operation in language, and that the whole operation consisted in subaudition. We have found his account of the subject applicable to nouns derived from words signifying single qualities and used as designations of compound objects, while the other qualities are understood. But all these nouns are concrete. Mr Tooke does not acknowledge any difference betwixt these and the nouns which grammarians distinguish by the appellation *abstract*, such as "beauty," "elegance," and "prudence." Without even remarking that they had ever been considered as of a different nature, he includes them in the list of those which imply the operation of subaudition. He considers *providentia*, "providence," as the neuter plural of the participle *providens*, and meaning "provident things," *i. e.* expressing one quality with the subaudition of others. This subaudition is indeed more general than it would have been in the word *providens*, if such a word had been used for "a provident person." He probably considered it as a mode of contriving a word capable of being adapted to every example in which the property denoted is found. But the opinion of this author is not stated with the explicitness due to its singularity and its importance. We must confess that it seems to us totally unfounded.

We have already observed that it is in our power to make single qualities the principal objects of thought, and that no greater difficulty exists in thinking of them exclusively than in making the idea represented by a proper name, at any time, the full and only object of thought. The etymology here advanced by Mr Tooke appears in itself fanciful. Nouns in *antia* and *entia* are the only ones which give it any shadow of countenance. The genius of the Latin language does not incline to the use of other neuter plurals as names for separate qualities. In English, indeed, we say, "the agreeable," "the picturesque," "the sublime," "the beautiful," instead of "agreeableness," "picturesqueness," "sublimity," and "beauty." We also adopt the Latin expression from Horace, "the *utile*" and "the *dulce*." But whatever the etymology of the nouns called abstract may be, the manner of their signification is that which we have already stated.

### Sect. V. *The choice of Designations and the nature of the Pronoun.*

When a compound object is designated by a noun which expresses one of its qualities with a subaudition of the rest, there is evidently no reason why the same quality should always be selected for a designation. Every such object resembles in some one quality a number of others, and admits of being placed in the same class with them. In a different quality it resembles a different set of objects. Hence it may receive various general designations. The choice which we at any time make of a designation for it depends on the design which we have in view in distinguishing it from others. The same human being may be called "a man," "an African," "a slave," "a negro," or "a fool;" or he may be designated by some occasional temporary circumstance; he may be called "a debtor," "a creditor," "a patient," "a culprit," or "a witness." In using any one of these terms, we wish to call into view the very same individual, with all the parts and qualities essential to him, but designated by one of these as the most appropriate to the point of view in which the tenor of our discourse leads us to represent him. Those who regard his proper name as his chief designation will consider the others as occasional substitutes for it. But even that name may be common to him with some other men. If he has two names, (which is the case with Europeans,) a personal and a family name, he will have one of these in common with several other persons, and the other in common with a different number; and it is by the combination of the two that he is distinguished. But this very combination may happen, in some instances, to be applicable to another person equally well known to us. We must then add a third mark of distinction, such as one depending on differences of age, country, or profession. Any designation becomes completely distinctive or not according to the occasion on which it is employed. It is probably most accurate not to consider one as substituted for another, but to consider each as rendered proper on particular occasions, when a complete and interesting distinction is thus formed.

These considerations will lead us, by a direct road, to a proper estimate of the *personal pronoun*, which many grammarians have reckoned a separate part of speech, and have defined to be "a word that is used instead of a noun." Its whole office is to point out an individual by an occasional mark which distinguishes him completely from all others. It is often shorter than the name of the individual, and this seems to have led some to conceive that it is contrived for the purpose of abbreviating discourse. But it does more than this; it points out the person referred to in the most interesting temporary relation.

The *first* personal pronoun *I*, denotes "the immediate speaker" as distinguished from others by this circumstance in preference to any other character that he may bear. The *second* denotes "the party addressed" as characterised by the present circumstance of his being addressed. This character is preferred to any other that he may bear, as distinguishing him from other persons. The *third* personal pronoun has been erroneously defined to be a mere negation of the other two. This is not implied in it. When Cæsar, describing his own actions in his Commentaries, uses the third person, sometimes employing his own name, at other times *ille*, he shews that these designations are applicable to the person who speaks or writes, as well as to others, although it is most natural for all men to use peculiar words for themselves as speakers. Among some nations it is considered as treating the person addressed more delicately, and tending less to look him out of countenance, to call him *he* than *thou*. The Italians say, *Come sta*, literally, "How does he do," instead of, *Come state*, "How do you do;" and the French, in like manner, say, *Monsieur comment se porte-t-il*. A rustic girl in this country meeting a familiar friend, says, with a kind of mirthful respect, "Where is she going?" for "Where are you going?" It is also to be remarked, that a mere negation of the circumstance of being either the speaker or the person addressed would never afford a sufficiently distinctive character, and therefore could be of no use as a designation. The real office of the third personal pronoun is to designate an individual by the circumstance of "having been lately mentioned," or "much nearer to the thoughts both of the speaker and the hearer than any other who could, on that occasion, be referred to by a similar circumstance." It is thus sufficiently distinctive at the moment to prevent ambiguity.

To have a closer illustration of the nature of the pronoun, we may observe that some designations are much more durable than others. The designations "man," "king," "Dane," "Indian," "sailor," "soldier," are of a permanent nature. Some are founded on more limited external relations, and are seldom used with propriety except in particular connections, as "father," "brother," "friend," "enemy." These generally require mention to be made of the object to which the individual bears this particular relation. Others are merely temporary and occasional, as "plaintiff," "defendant," "speaker," "hearer," "buyer," "seller," "assistant," "opponent." All these words are used on particular occasions with as great propriety as the names, or any other designations of the persons spoken of. Of this last occasional kind are the words called personal pronouns. They distinguish individuals by the temporary characteristics now enumerated.

What then has led grammarians to assign to these words a separate place in language under the name of pronouns, and to describe them as possessing the peculiar character of being the substitutes of nouns?—The only circumstances in which they differ from other appellations are, that they are shorter and more familiar. Their shortness has probably made them appear unique, and their familiar recurrence has made them appear of peculiar importance. The frequency of their use, though worthy of attention, is a quality attached to words in various gradations. In this instance we have perhaps the acmé of frequency, because the pronouns are founded on the very circumstance of the use of language. Language always implies a speaker, who to himself appears important, and a person addressed, who, in order to be operated on with advantage, has a prominent interest assigned to him in our discourse.

It is probable that pronouns are of very early origin. Attempts have been made to trace the etymology of the first and second in some languages to a word signifying the hand, or some other object near and inseparable. It is sufficiently natural to suppose that persons who have words to represent such objects, and no personal pronouns, might resort to such expedients. But it is equally supposable that certain sounds might, in the very first instance, be applied to this use, on the same arbitrary principles which must have regulated the pristine application of the greater part of articulate sounds.

If no pronouns were in use, a speaker would probably point to his own body in speaking of himself, and to that of the person addressed in speaking of him. On this account some philosophers have considered it as the peculiar nature of the pronouns to be "substitutes for that pantomimical act." But the act of pointing is also used in designating other objects that are presented, especially if the speaker and hearer have no language in common.

The personal pronouns combine a great degree of generality in their use with a well-marked particularity in the instances of their application. The word *I* may be applied to any person, but only by one speaker, viz. that person himself. The quarter from which the sound proceeds determines its exact application. In the same manner *you* may be applied to any one individual, but only when the words are particularly addressed to him, and this circumstance gives us on every occasion an unerring indication of its use. *He* may be applied to any *man*, *she* to any *woman*, *it* to any *thing*, and by any individual. But they imply no reference to the present use of language. They imply some previous mention of the object referred to, and this must be well understood in order that their particular application may become intelligible. They have exactly the same meaning with the word "foresaid." Some assistance is given towards the ready understanding of their application by distinctions founded on personality and sex. The pronoun *it* is distinguished from *he* and *she* by the absence of personality; *he* from *she* by the circumstance of sex.

The term pronoun, as used by grammarians, is on the whole productive of confusion and ambiguity. It is extended to some adjectives, which are called pronominal adjectives, or adjective pronouns. Such are *ille*, *hic*, *alius*, in Latin, and *this*, *other*, in English. The word "other" has evidently the same meaning with "different," although neither the English word "different" nor the Latin word *diversus* is ever included in the list of pronouns.

### Sect. VI. *Genders.*

In the following Sections of this Chapter we shall consider some prevailing marks which accompany the application of the noun, and which adapt it to particular purposes.

As our own species comprehends the most interesting subjects of discourse, any common distinctions found among them appear worthy of being pointed out. The situation of the two sexes in society, and their general habit and appearance, afford the most remarkable distinction, and the implication of this naturally accompanies the mention of of individuals. Even when it would not be sufficiently interesting to be mentioned, provided a separate word were required for the purpose, it is sufficiently important to determine some part of the names by which persons are designated. The Greeks and Romans effected this by differences of termination. The English language has current proper names exclusively applicable to a particular sex. Similar differences are implied in the names given to domestic animals, and sometimes to animals of other kinds.

But language has not always stopped at this reasonable point. The active imaginations of those by whom it has been modified have, from vague analogies, ascribed sex to objects destitute of it. In Greek, Latin, and French, this is done in very numerous instances. In French, the genders of nouns are not easily distinguished by their terminations, yet a particular gender is uniformly attached to each, and regulates the termination given to every adjective agreeing with the noun. The details of the genders must therefore be studied by every person who wishes to speak the language with sufficient accuracy to preserve him from ridicule. These circumstances render that language of difficult acquisition.

In the Hebrew, Italian, Spanish, and French languages, there is no neuter form, so that every object must, in the syntax of words, be either masculine or feminine.

Attempts have been made to account for this prevalent arrangement, which appears in itself so absurd. But no explanation has been given that is sufficiently steady in its application to afford material assistance in facilitating the acquisition of any language. Names of objects which are masculine in one language are feminine in a second, and neuter in a third. Names of objects of the same kind, and even nouns that are synonymous, differ in their gender in the same language. Those who take pleasure in tracing these whimsical proceedings in the formation of language, will find some ingenious remarks on the subject in Harris's *Hermès*, and Tooke's *Diversions of Purley*.

The English, the Persian, and the Bengalese languages are free from the embarrassments of arbitrary genders. In English, indeed, a few objects destitute of sex have a phraseology applied to them, borrowed from sexual distinctions. But this is on rare occasions; and, as no marks of gender are attached to our adjectives, the inconvenience now stated does not occur. The whole difference in the adaptation of other words consists in the use of the personal pronouns *he* and *she*. This application of words denoting sex only partakes of the nature of poetical personification. It does not consist in such an adherence to gender as affords a basis for grammatical rules. The sun is called *he*, on the same principle on which we might compare that luminary to a king, for the splendour which surrounds him; to the cherishing father of a family; or to a presiding mind, by which extensive systems are regulated. The moon is called *she*, on the same principle on which it might be compared to an eminent female, who does not overawe by an oppressive effulgence, but diffuses a mild radiance, productive of a gentle pleasure.

### Sect. VII. *Number.*

That accident of nouns which we call *number* is a sign for representing the exemplification of a general idea in more than one individual. It does not apply to proper names. A proper name is in its nature descriptive of only one object, and therefore essentially singular. As soon as it becomes susceptible of plurality, as when we speak of the twelve Cæsars, or the seven Jameses, it ceases to be a proper name. Spain is the proper name of a country, and Spaniard has by some grammarians been called the proper name of a people; but the latter is a generic word, characterizing any one of a great number of persons by their connection with Spain. When a name is applicable to two individuals, these are to be considered as constituting a limited genus. This circumstance may not depend on any inherent character, but may be an accident occurring in the transference of proper names. The name is originally intended, in both instances of its application, to be completely adequate to distinguish an individual from all those with whom he might have been confounded. But, when the two individuals chance to meet in the same place, or to be mentioned near to one another in discourse, they must be distinguished. If the name of both is Scipio, they are to be considered as a genus coinciding in this trivial circumstance of their history, that they have received the same name.

Some nouns which are general in their acceptation do not admit of a plural, because the objects which they signify are not permanently portioned into individuals. This is the case with nouns which express such plastic materials as are capable of being easily arranged in pieces of any form or size. We have examples of it in the names of the different metals, as "gold," "silver," "iron," and "brass," words which are never used in the plural. The plural word "irons" is not applied to pieces of the metal, but to instruments formed of it. The noun "stone" is also the name of a material, of which variously shaped objects may be formed; yet it has a plural in frequent use, because nature divides it into masses which are not easily reunited so as to become homogeneous. These objects have therefore more of the character of permanent individuals. Such words as "gold," "silver," "clay," "dough," may be said to have neither singular nor plural, and to be entirely independent of number. We cannot prefix to them the word *a*, which is the sign of the singular, with any greater propriety than we can invest them with the plural form.

In most languages, nouns receive alterations in their spelling for the expression of plurality. These sometimes consist in the addition of a letter or a syllable, sometimes in the substitution of one for another. Such alterations, however, are not absolutely necessary. Number might be pointed out by separate words, or might be inferred from the connection. Many English words have no distinction betwixt their use in the singular and in the plural, such as "sheep," "grouse," and "deer." Some Latin words are the same in singular as in the plural in one or more of their cases. *Fructus* signifies "fruit" or "fruits." *Res*, "thing" or "things."

It is not easy to discover by what circumstances a community, during the formation of its language, has been influenced in choosing its mode of expressing plurality.

Some grammarians have thought that much satisfaction would be obtained, if we could always trace the plural termination to some separate word signifying a *collection*. The addition of a term of this sort is the mode of expressing plurality in the Bengalese language. *Projaa* signifies a peasant, *lok* people : and *projaa-lok* signifies peasants. The authors of Rees's *Cyclopædia* derive the plural sign in Greek, Latin, and the modern languages of Europe, from a word in the Hebrew language המון, which signifies multitude. They suppose that this word was at first subjoined to the singular word, and that afterwards, for the sake of brevity, the Hebrews designated plurality by retaining only one of the letters, *m* ; the Chaldeans, Syrians, and others, by retaining the *n*. Thus the plural was in Hebrew *-im*, in Chaldean *-in*, in Arabic *-oon*, and in Persian *-aan*. This theory further supposes the letters *n* and *s* to have had the same origin. The Chaldean *-in*, therefore, is supposed to have become *-es* in the formation of many Greek and Latin plurals. From the same source they even wish to derive the *s* which forms the plural terminations in English and French ; while the Italian language is considered as following in all nouns the analogy of the second declension of the Latin, by adopting the terminating vowel *i*. The same authors might have added, that this *i* of the Latin and Italian is the vowel letter of the Hebrew plural *im*, (ים). This vowel does not, indeed, happen to belong to the independent word המון, which they consider as giving origin to the plural sign ; but we find it used in Hebrew, not only along with the letter *m* for a familiar sign of plurality, but also by itself (י.) And it was sufficiently natural that a language derived from the Hebrew should adopt this plural sign.

This whole style of etymology, however, is questionable. It has indeed the authority of Horne Tooke's approbation. One great principle of that author was, that terminations were originally separate words ; and another principle was, that the alterations which take place in the progress of language have an abbreviating tendency. But terminations ought to be considered as equally independent signs in this form as if they were separate words ; and when any idea is of perpetual occurrence in language, as that of plurality is, it is natural to expect that the sign used for expressing it should be originally brief. Signs, however, are often changed. With some people, the mere circumstance of being long familiar renders both words and terminations of words apparently stale, and they apply themselves to the contrivance of others in their stead. These others are generally derived from sounds previously used for ideas somewhat akin.

The English plural termination may, we think, be traced with greater probability, as well as greater beauty, to a later origin than that now mentioned. Our terminating *s* seems to have arisen from a syllable which was once applied to signify a more extensive modification of the uses of the noun, and was gradually varied, in the improvement of our language, for the purposes of more precise distinction. It was anciently the syllable *is*. "Towns," the plural of town, was *toun-is*. The same syllable was also used for what we call a genitive. "Father's" was *father-is* or *fader-is*. It is only among those who are inordinately attached to the present habitudes of our language, that the termination *is*, in these two applications, will be considered as necessarily of different origin. The sign for the genitive and that for the plural are only different exemplifications of one sign, which in its meaning includes both. It was simply a term of relation synonymous with the English preposition "of," i. e. "with respect to." "Bees," for example, signifies relating to the bee ; "bees wax," wax connected with the bee ; "two bees," a repetition or doubling with respect to the bee. "Scot," is a designation for a native of a particular country. "Scotis," or "Scots," means relating to such a native. Two individuals are "two Scots ;" a "Scotswoman," a woman relating to Scot ; and, in the same manner, the word might be used in such phrases as, "the Scots court," "Scots customs," "a Scots dress." The meaning of the letter *s* in these different instances is not different : it is only general ; and, therefore, susceptible of different specific applications. Any particularity in the application intended was, in the first instance, left to be inferred from the connection ; and, afterwards, some slight differences in its orthography, pronunciation, or both, were adopted, and appropriated to the different applications. We have "Scot's" for the genitive ; "Scottish," or "Scotch," for the descriptive adjective ; while "Scots," if used at all, is restricted to the plural.

This derivation of the English plural from a more general modification of the noun will acquire confirmation, when we reflect that, in spite of the strictness of formal grammatical rules respecting the plural number, we often use the same form of the noun which denotes plurality, on different other occasions. We speak, for example, of introducing a knife "lengthways," though the way is only one. "Edgeways" is used in the same manner. The word "otherways," now changed to "otherwise," is a similar example. "Sides foremost" is a common provincial phrase in some parts of England. We speak of going "up stairs" or "down stairs," where there is only one stair, meaning up or down with respect to stair. Some of the English even speak of going "up streets" and "down streets." A boy in tossing a halfpenny calls "heads or tails," though it has only one head and one tail. If to the question, "have you any pens?" a person should reply, "yes, I have one ;" the answer would be condemned by some as ungrammatical, because one pen is not plural, and a person who has only one cannot be said to have "pens." Yet we have a constant tendency to this mode of speaking. Common sense, adhering to the powerful analogies of language, bears down the authority of formalizing systems, even in cases in which she does not possess sufficient dialectic knowledge to vindicate her proceedings. The word "pens" in this instance is merely general. It is independent of all ideas of number. It is no more restricted to plurality, so as to exclude the singular, than it is restricted to two, four, or any particular number. Had the word "pen" been used in the question now alluded to, it would have been considered as exclusively singular. But it was necessary to use one of these forms of the noun, in order to represent the genus independently of number. To prohibit the employment of any form of the noun in a manner thus general, would imply an extreme obstinacy of artificial regulation, in no degree conducive to accuracy. The want of a *separate* form for this general application of the noun, independently of number, sometimes gives rise to the following awkward circumlocutions in proclamations and legal writings : "If any *person or persons* shall transgress in the manner underwritten, *he or they* shall be subjected to the following punishments."

Another English plural is formed by means of the termination *en* as in oxen. Such plurals were much more common at a remote period of the English language. *Housen*, for example, was used for "houses." They abound in the modern German, which owes them to the same source. This syllable, like the one already mentioned, was originally of a more general application, signifying "of or relating to." The application of it which is most abundantly retained in English is for the descriptive adjective, as "wood*en*, earth*en*, gold*en*," words the same in meaning with the phrases "*of* wood, *of* earth, *of* gold." The old English language was little varied in its modifications. The syllables *is* and *en* both expressed the general circumstance of relation betwixt the idea expressed by any noun to which they were attached and some other. They were applied indiscriminately to relations of every kind, and the occasions of discourse were trusted to for the suggestion of particular ideas. A desire of improving the language, amidst the multiplicity of relative ideas which arose from intellectual improvement, led our ancestors to appropriate one termination to one subdivison of that general meaning, as well as to produce a still greater particularity, by varying the modes of writing the termination. The English thus made a nearer approach to the copious and refined languages of classical antiquity. The final *s* and the termination *en* came to signify important distinctions, *en* being used to form the descriptive adjective, and *s* for expressing various relations, including that of plurality. Wood*en* is the adjective: wood*s* is the plural. The word ox is an instance in which the *en* is retained as the plural sign, and the *is* (in ox*is* written ox's) is the genitive. We say a "drove of ox*en*" for the plural: "an ox's gall" for the genitive. Here we have a specimen of the simple but effectual expedients, to which mankind so readily recur in order to express the varieties of their thoughts.

### Sect. VIII. *Cases.*

Cases are changes of form to which nouns are subjected for the purpose of denoting annexation. Some of them are more general than others. The marks of annexation are external to the name of the object, and might therefore be expressed by separate words. But they are often attached to the name in the form of terminations. This circumstance, though not affecting their meaning, occasions a particularity of aspect in certain languages in a written state, by abridging the number of words, and also a particularity of sound when a language is spoken, because a termination is placed after the name of the object, but a preposition before it. The cases often express circumstances so general and so evanescent, that no separate word to represent them has ever been used. On this account, it is convenient, even in a philosophical treatise, to consider them in conjunction with the noun.

The *Nominative* has been represented by some as implying nothing more than the name of the idea expressed by any noun, and therefore the least complex of the cases. But it always has a reference to a verb, and this verb for the most part follows it in the same sentence. It often happens that, compared to the other cases, it is short, and that the others are distinguished by the addition of one or more syllables. Of this we have instances in the Latin nouns *vir* and *sermo*. But it more frequently happens that the nominative has a peculiar termination, and that in the formation of the other cases this is left out, and its place supplied by different terminations affixed to the radical letters. The radical letters of *dominus* are *domin-*, and the *-us* is as much a separate sign as the *i*, *-o*, *-um*, *-e*, *-orum*, *-os*, and *-is*, which form the other cases. *Dominus* is therefore something more than the name of an object. It would be contrary to the analogy of language, and of all the operations of the human mind, even the least correct, to suppose that the syllable *-us* has no original meaning. We may pronounce it a superfluity, if the definite application of the noun which it expresses can be understood without it. Yet we have no right, on this account, to pronounce it destitute of meaning. It is in fact a sign of connection with another word of definite character and use, the verb.

We have farther to observe, that the nominative gives the noun a higher rank in a sentence than the other cases. It differs from them in a manner nearly resembling that in which the noun differs from the other parts of speech. It expresses the central or focal idea, to the description of which the other words in a sentence, including the other parts of speech and nouns in the other cases, are subordinate.

The sentences which may appear exceptions to this doctrine are very numerous. This is occasioned by the general pursuit of that variety which gives elegance to language, and by the presence of other circumstances which preserve the importance due to the leading subject of discourse. By some writers the hero of a biographical narrative is mentioned in the nominative case more uniformly than by others; but by none is such a rule invariably followed. Suetonius probably follows it as often as any writer, and thus gives his biographical delineations a more concentrated force. Yet this author, in relating the death of Julius Cæsar, introduces the persons by whom he was killed in the nominative case, in preference to Cæsar himself, thus making them apparently the most important subjects for a time. Assidentem conspirati *specie officii circumsteterunt: illicoque* Cimber Tullius, *qui primas partes susceperat, quasi aliquid rogaturus, propius accessit: renuentique et gestu in aliud tempus differenti, ab utroque humero togam apprehendit, deinde clamantem, "Ista quidem vis est."* Alter Cassius *adversum vulnerat paulum infra jugulum.* 'The conspirators, under pretence of shewing 'Cæsar respect, stood up around him as he sat. Then 'Cimber Tullius, who had undertaken to commence the 'deed, approached nearer to him, with the apparent de- 'sign of making some request. As soon as he observed 'that Cæsar, by a wave of his hand, declined conversation, 'and put him off till a future time, he laid hold of him by 'the toga on both shoulders, an act which made Cæsar ex- 'claim, "This is downright force." At that instant one 'of the Cassii wounds Cæsar in the neck.' In the relation of these circumstances Cæsar might have been mentioned in the nominative case, thus: 'Cæsar was surrounded by 'the conspirators, affecting to pay him respect, was ap- 'proached by their chief Cimber Tullius, who pretended 'to make some request, and, on waving his advances, was 'seized by the toga on both shoulders; but as he exclaim- 'ed, "This is downright force," he received a direct thrust 'of a mortal weapon from the hand of one of the Cassii.' This mode of writing would keep the mind of the reader more constantly fixed on the person who is the chief subject of the narrative as a whole; but it would often render language insupportably monotonous. The author, therefore, relieves the attention of his readers, by assigning in some of his details a subordinate place to the principal personage. His importance is always maintained by the ultimate tendency of the narrative, as well as by the advantage of being more frequently than any other subject mentioned in the nominative. After the historian has, in the manner now described, varied the current of his language, he is enabled, with gracefulness as well as force, to introduce the chief subject in that mode of diction in which he will hold, by means of the nominative case, the most dignified rank in the sentence. After these details of the conduct of the conspirators, Suetonius thus proceeds: Cæsar *Cassii brachium arreptum graphio trajecit: conatusque prosilire alio vulnere tardatus est. Utque animadvertit undique se strictis pugionibus peti, toga caput obvolvit; simul sinistra manu sinum ad una cruræ deduxit, quo honestius caderet. Atque ita tribus et viginti plagis confossus est: uno modo ad primum ictum gemuit, sine voce edito.* 'Cæsar seized the arm of Cassius, pierced it with 'his writing style, then endeavoured to rush forward, but 'was prevented by another wound. Finding himself 'assailed in every direction with drawn swords, he co- 'vered his head with his toga, and, in order that he 'might fall with the greater decency, drew the lap of it 'with his left hand over his limbs. Thus he fell, stabbed 'with twenty-three wounds. He emitted a single groan 'when he received the first; but met his fate without utter- 'ing a word.' The peculiar propriety and force of these latter sentences, and a slight character of inversion, of which we are sensible in reading those which precede them, are proofs of the superior rank of the nominative case.

The *Vocative* case, or that which is used in naming the person addressed, comes next in order, not merely from its frequent coincidence in form with the nominative, but from its being probably of earlier origin in the proper names of persons than any other form of the noun. It is peculiar to nouns which designate persons, because it applies only to beings capable of hearing what is said. In these, however, it seems to be prior in the order of nature to the nominative. The Latin vocative, wherever it differs from the nominative, inclines to greater brevity. *Virgilius* was addressed *Virgili*, *Minutius*, *Minuti*, *Dominus*, *Domine*, and *Filius*, *Fili*. In this characteristic the vocative case of the noun resembles the imperative of the verb. Being the earliest use of the word, it is its shortest form.

When we enter on the consideration of the *Genitive*, *Accusative*, and *Dative* cases, especially the two last, it is found difficult to assign to each an invariable meaning, however general. In particular phrases their uses are steady; but no principle strictly universal seems to regulate their application. The most comprehensive that we can adopt is found liable to exceptions. The most likely way to discover their original meaning is, to observe the prevailing application of each, and also to enquire if there is any circumstance of application, however limited, which is peculiar to one. It is thus also that we shall be most likely to trace the species of idiom which has given origin to such exceptions as occur. Some have proceeded in a contrary direction. They have first attached to the particular case a plausible general meaning, and then exerted their ingenuity, to show that this meaning would be found applicable to instances which at first appeared most distant from it. But these modes of explanation might easily be applied to account for any possible substitution of one case for another, and therefore are erroneously considered as illustrations of a principle, while they are exceptions to a rule.

It has been common to consider the different cases as intended to express different sorts of ideas, or different relations existing betwixt the objects named. On mature reflection, we find it more conformable to the general aspect of the facts, to consider them as referring rather to the different parts of speech with which the noun is connected, and the different degrees of importance which are assigned to the idea in the present use of language. These circumstances may sometimes arise out of permanent relations; but this does not uniformly take place, and therefore the cases do not depend on them. This opinion derives presumptive evidence from the illustrations already given of the nominative and the vocative.

Our attention will be chiefly directed to cases as exemplified in the Latin and English languages. The Greek cases follow different rules, a comparison of which with those of the Latin language might suggest some interesting conjectures respecting their original uses; but they would lead us into details too extensive for the limits of this article. The Latin language, when it borrowed its cases from the Greek, deviated from the parent language in the extent which it assigned to each. A different conception seems to have been attached to the use of them. This appears in a particular manner from the addition which they have given of an ablative case, which does not depend on a subdivision of one of the others, but is in some of its uses substituted for the genitive, in others for the dative of the Greeks.

The variations and exceptions to general rules which are so often practised in the use of the cases diminish their importance in the doctrines of universal grammar. Such distinctions as they imply might have been in most instances dispensed with. The discussion of them partakes more of the character of an inquiry into the conjectural history of particular dialects, than of an investigation of the radical principles of language; and the length to which that discussion sometimes extends is due rather to the difficulty than to the importance of the subject.

The *Genitive* case, though sometimes governed by a verb, as by the verbs *potiri*, *fungi*, *meminisse*, and *angi*, sometimes by an adjective, such as *similis*, appears to have been originally applied in the Latin language to signify a relation betwixt the idea expressed by a noun and that contained in *some other noun* in the same sentence. The English preposition *of* corresponds so exactly to it, that any observations made on the one are equally applicable to the other. Attempts have been made, both by means of etymological derivations and explanations of existing phrases, to represent the word *of* as signifying some specific relation, as, for example, possession or origin. These attempts, however, have failed. We find it expressing every sort of relation that can exist betwixt the ideas contained in two nouns. This circumstance implies no ambiguity. It arises from the mere generality of the sign. When it is too general for expressing our meaning, we add some more specific ideas. In the article GRAMMAR of the *Encyclopædia Britannica*, it is justly observed that *injuria regis* may mean either "an injury inflicted by the king," or "an injury received by the king." The specific idea intended to be conveyed, must either be inferred from the connection, or pointed out by some additional sign.

The genitive case, though thus general, and supposed by some to have in the Greek language derived from this circumstance its technical name πτωσις γενικη, ought not perhaps to be considered as more general than the others. It is distinguished from them by the circumstance of being employed to show that the word put in this case is subordinate to a noun. Nothing more than a general relation betwixt the two ideas is expressed; but the connection thus established has something particular in its adaptation to the purposes of discourse. The ideas thus connected could not exchange places, nor are they of equal importance in the sentence, as they would be if conjoined by means of the word "and." "The man of virtue" and "the virtue of the man" do not mean the same thing. The ideas expressed by the words man and virtue are indeed *connected* in *both* of these phrases; but when we say "a man of virtue," it is intimated that something further is said of "the man" When we say "the virtue of the man," it is intimated that the subject on which we enlarge is "the virtue." Both of these are different from a connection formed betwixt two nouns by the word "and;" which intimates that they are on equal terms in the assertions which are made.

Such instances as we mentioned of the genitive being put after verbs and adjectives are so rare, that they may be considered as exceptions in which a stretch is made to give these governing words the power of nouns in the use of language. Every word resembles a noun in containing the name of an object or idea. It is only in relative importance in the syntax of sentences that nouns differ from other parts of speech.

Exceptions of a different kind are also found. Nouns are in some instances annexed to other nouns by marks different from those which form the genitive; e. g. *homo a secretis*, a Latin phrase for a "secretary;" and in English we have the phrases "father-IN-law," "cousin BY the mother's side." This last phrase is seldom employed without the use of the verb IS preceding it, which gives a different turn to the whole phraseology, and has the power of introducing a greater variety of words than can be annexed solely to the noun. Such exceptions as we have now mentioned are equally rare with the former; a circumstance which shews the nature of the genitive case to be almost peculiar.

In the Hebrew language, the placing of one noun after another is often the only sign of the genitive. *Jein* signifies wine, *Helbon* is the proper name of a mountain, and *Jein Helbon* is the expression for "wine of Helbon." Sometimes it is expressed in a manner which must appear remarkable to those who are not acquainted with any analogous language. The change indicating this mode of annexation is made on the governing noun, which is then technically said to be in its *constructed state*, while the noun in the genitive case undergoes no change. *Dábar* signifies word, and *Elohim* God; but there is no separate word for *of*, nor is any change made on *Elohim*, to make it equivalent to "*of* God." *Dábar* is put in its constructed state by being changed into *debár*, which signifies *word of*. *Debár Elohim* is "word of God." In like manner, *gedolim* signifies "great men," *haghir* "the city." Great men of the city is not *gedólim haghir*, but *gedolei haghir*.

In English, as has been already observed, the genitive case is sometimes expressed by the termination *s* with an apostrophe, as in the first line of Paradise Lost, "Of *man's* first disobedience, and the fruit." It is thought by some grammarians an improvement in nomenclature, to call this form of the noun an adjective of possession derived from the noun. This distinction makes no difference of doctrine. That mode of describing it seems to have been inconsciously suggested by the circumstance of its being, like the adjective in English, placed before the noun to which it is subordinate. But nothing more than the meaning of any genitive is signified by the adjective noun itself, as will appear when we come to treat of it. The English *s* has, with regard to its etymology, been considered by some as an abbreviation for *his*. But this (or the equivalent syllable *is*) is evidently an original sign in our language, at least independent of such words as *his*; and the latter is evidently derived from the pronoun *he* by having this sign attached to it.

The genitive case is sometimes expressed in English, as it is in Hebrew, by the mere juxtaposition of the nouns, with this difference, that the governed is placed before the governing noun; as in "cart wheel," "corn field," "garden wall." Some of these phrases are of more frequent recurrence than others. Sometimes the two words thus conjoined have, both in spelling and pronunciation, been run together into one, as in "timepiece," "statesman," "footman." Others of them are frequently connected in writing by a hyphen, to denote that they are scarcely to be considered as one word, yet not so much separated as two words generally are. In other instances, they are kept as distinct in a sentence as any other words. The meaning is not affected by this variety, and is so clearly expressed by simple juxtaposition in this order as never to admit of ambiguity. Here we have one fact, by the consideration of which any inordinate predilection for the individuality of words may be reduced within just bounds.

The chief ultimate purpose for which the genitive case is employed is, to add a particular circumstance for completing the description of an individual, or of a species of objects, already characterised by a term which is in itself too general for the purpose. "Man" is a general word. "A man of genius," "a country man," are instances in which the genitive is used to point out a relationship for designating a limited species contained in the genus "Man." This may be done when an individual, or a species, is introduced as the subject of discourse; as, for example, "A man of genius differs from other persons in his feelings and habits;" or it may be introduced into the predicate of a sentence, and form a part of some new assertion, as, "Bacon was a man of genius."

The other cases are distinguished from the genitive, by denoting an annexation to some part of speech different from the noun.

The *Accusative* and *Dative* have by some been considered as very nearly alike. By others some differences have been stated betwixt them, depending on differences in the objects, motions, or relations, represented by the governing word. Attempts of this last sort have proceeded on principles which served to explain a limited set of phrases, while they were totally inadequate to explain others.

The most obvious circumstance which distinguishes the *Accusative* case in Latin from the genitive is, that it is governed not by nouns, but by active verbs and certain prepositions. It is by attending to the different occasions on which it is employed, and tracing the properties which uniformly adhere to it, that we shall make the most convenient approaches to an explanation of its use.

Sometimes it represents an object to which some action or motion passes, or in which it terminates, as *Hæc studia adolescentiam alunt, senectutem oblectant*. This character, however, has been ascribed to the accusative in phrases in which it will not apply. When the verb "to love" governs the noun signifying the object of that affection in the accusative, it expresses no transition of an act. The person who is loved may be ignorant of this passion, and totally unaffected by it. When we speak of "loving all mankind," we do not speak of any action which terminates in that extensive range of objects. This remark applies to all transitive verbs, expressing emotions of mind that have a reference to external objects, as "to hate," to dread," "to respect," "to esteem." These affections may be productive of acts by which the objects of them are affected; but such acts are not implied in the affections themselves. They are excited by the objects named in the accusative, but they terminate in the individual mentioned in the nominative. To represent them as terminating in the beings called their objects, is a mere fiction: it applies only to the range of ideas of the individual mentioned, not to the actual relative energies of the different objects. Some other verbs governing the accusative are expressive of quiescent qualities, which do not affect any object different from that to which they belong. Yet these qualities imply a reference to other objects, and the mention of this reference is absolutely necessary. These other objects are put in the accusative case. Such are the verbs "resemble" in English, and *similare* or *simulare*, and *referre*, when used in that sense in Latin. Here, as no transition of any act or motion from one object to another takes place, the accusative cannot be considered in any respect as expressing such a transition. It will give but little satisfaction to say in reply, that, though nothing of this kind exists, yet it is figured in the speaker's mind, and that even in such a proposition as this, "a benevolent man loves the whole human race," we imagine a benignant emanation proceeding from the benevolent man to influence the whole species. This is an evasion of the argument. It is in like manner an evasion, rather than an explanation, to say that a person who asserts that one man "resembles" another, seems to consider such a man as influencing the state and relations of the other. This is an unconscious acknowledgment that the conceptions of the speaker, or the transitions of his thoughts, and the transitions which he studies to produce in those of the hearer, are the foundation of the use of the accusative case. This is the view which we consider as on all occasions the true one. Such mental transitions have a certain degree of rapidity, which corresponds more closely with the idea of an action terminating in an object named, than with the greater part of our associated ideas. On this account the regimen of the accusative case is more frequently applied to signify these than any other trains of thought.

When the accusative is governed by prepositions, these prepositions prepare us for a transition equally rapid with that of the active transitive verb. In order to shew that this regimen does not depend on the *idea expressed* by the governing word, we shall take this opportunity of stating a circumstance, which might otherwise appear an anticipation of our observations on the verb: to wit, that some verbs, which are completely synonymous in the ideas which they express, are totally different in the transitions of ideas which they are intended to create in the mind of the hearer. The Verbs "to speak," and "to say," signify precisely the same act. Their difference consists in this, that the verb "to speak" does not intimate an intention to state what was spoken, but the verb "say" always does. When we say "Cicero spoke," we may probably rest satisfied with mentioning the act in connection with the agent. Our hearer may, if prompted by curiosity, ask what Cicero said when he spoke? But, if we use the phrase "Cicero said," we pledge ourselves to give some account of what he said, or to subjoin the accusative of some noun, such as the word "nothing." If we do not proceed further than the words "Cicero said," the person who hears us asks the question now mentioned in a different tone: he reminds us that we have stopped short in our discourse, and have not fulfilled the promise implied in the use of the verb "to say."

The *Dative* case might easily receive a plausible explanation in a large proportion of the phrases in which it is employed. But a difficulty has arisen, in consequence of the approximation which some of its uses seem to make to that of the accusative. Some verbs which govern the accusative are synonymous with others which govern the dative. An example of this exists in the verbs *lædere* and *nocere*. *Antonius nocuit Ciceroni* is equivalent to *Antonius læsit Ciceronem.*. But though these phrases are synonymous, it is possible that the words of which they respectively consist are not equivalent. It is possible that in one of the phrases a greater share of the meaning may be contained in the verb, and less of it in the governed noun. This is rendered probable from one circumstance, that there are no verbs which admit of either case indiscriminately, so as to form with them two synonymous phrases.

We ought first to attend to those phrases in which a verb governs one noun in the accusative, and another in the dative. This may be a verb of *giving*, as in *Dedit mihi dextram*, or a verb of *declaring*, as in *Narras fabulam surdo*. One difference seems here to take place, that there is a more ready and rapid transition to the idea expressed in the accusative, than to that expressed in the dative; and the idea which is expressed in the accusative is more necessary to the completion of a significant phrase than the other. *Dedit dextram*, and *narras fabulam*, though both evidently incomplete sentences, are not quite so deficient as *dedit mihi*, or *narras surdo*. The verb is so contrived in the arbitrary application of words, as to lead the hearer to expect with greater rapidity and impatience the idea which is subjoined in the accusative, than that which is in the dative. When the dative is placed first in order, as in the phrase *dedit mihi dextram*, we are sensible of a degree of inversion, or a short suspension of the governed word most nearly connected with the verb. This mode of speech is contrived for the sake of variety and elegance, or for the convenience of dwelling on the idea expressed in the accusative, by attaching to the noun some additional parts of speech; as, *Narras mihi fabulas gigantum incredibiles*.

In the use of verbs of giving and declaring, a difference in the *actual relations* of the *object* mentioned in the accusative and that in the dative case is evident; but in verbs of *comparing* no difference of this sort is necessarily implied. The sentences, *Comparo Virgilium Homero*, and *Comparo Homerum Virgilio*, may be used for conveying the same meaning in exactly the same manner as to thought. The interest taken in one of the objects compared may not be greater than that taken in the other, and the transition made to the two may be equal in its degree of rapidity and deliberateness. At the same time, if there is any such difference of interest, it seems natural to put that object to the description of which the comparison is principally subordinate in the accusative, and the other in the dative.

These facts may furnish some illustration of those phrases in which a verb governs the dative case alone; for example, the verbs *nocere*, *favere*, *placere*, and *resistere*. The English verbs into which these are translated are equally transitive, and govern the same form of the noun, with those which correspond to Latin verbs governing the accusative. But in the Latin language it is probable that they are not so completely transitive, and resemble in their genus those English verbs to which nouns are subjoined through the medium of the preposition *to*, as the verbs "yield," and "submit." Thus the translation of *obedire* by the verb "submit" would be more accurate than by "obey," in so far as regimen is concerned, although the former of these English verbs, as applied to the expression of ideas, may be less nearly co-extensive with the Latin word. It is conceivable that a verb, which is originally not used transitively, may be more easily made to govern the dative than the accusative, whether it is employed in its simple state, or in composition. The verb *resistere*, for example, is derived from *sistere*, which signifies to stop or remain fixed, and does not prepare the hearer to expect the mention of any other object affected. This state, however, admits of being also mentioned as an impediment to the progress of another. The name of this other may be subjoined with a slight degree of ceremony; and a semi-transitive verb may be formed signifying that fixed state, together with an intention of mentioning the object impeded. The machinery of prepositions or other intervening words, for the introduction of the latter object, is dispensed with; yet the verb is made to govern a case which implies some slight degree of ceremony in the mental transition intended.

We have heard it suggested that a verb which governs a single noun in the dative implies in itself the force of a noun governed in the accusative; that *resistere*, for example, has the force of the phrase *obstaculum opponere*. Whether this suggestion has any truth in an etymological point of view, or is in any degree to be considered as a probable account of the sentiments originally attached to such verbs, we shall not stop to inquire. But a translation of some phrases, on this principle, into the English language, will afford us a clear analysis of these two cases, as well as of the verbs which respectively govern them, and yet are otherwise synonymous. The English language expresses the dative by means of the preposition *to* prefixed to the same form of the word which constitutes the accusative; just as if, in Latin, the dative case were wanting, and the meaning of it always expressed by the preposition *ad* with the accusative. This would certainly shew a more leisurely and ceremonious transition than the accusative without a preposition. Both these sentences, *Nocuit Ciceroni*, and *Læsit Ciceronem*, may be translated, "He did harm to Cicero;" but, in the first, the force of the preposition "to" is contained in the dative *Ciceroni*, and, in the last, it is contained in the verb *læsit*.

| | | |
|---|---|---|
| *Antonius* | *nocuit* | *Ciceroni.* |
| "Antony | did harm | to Cicero." |
| *Antonius* | *læsit* | *Ciceronem.* |
| "Antony | did harm to | Cicero." |

Thus the verb which governs the accusative is more completely prepared for the intended transition than that which governs the dative. This view of the cases is not, we confess, in the present instance, supported by the comparative brevity of the Latin dative and accusative, which is in favour of the dative. It depends for its proof on the use of them in language. Their comparative brevity, however, in the English language, contributes to the illustration of our views, especially as it consists in a difference of the entire word *to*, and therefore is less liable to be ascribed to accident.

The Latin dative appears, on the whole, to be appropriately employed where the verb has a degree of transitiveness intermediate betwixt those which govern the accusative and those which do not govern any case. The latter may express actions in themselves transitive, though they have not been formed for the purpose of transition, but merely for attaching the accident implied in the verb to the subject mentioned in the nominative. After such verbs the object affected may be introduced, but it requires, even in the Latin language, an intervening preposition; we say, *Lutetiam* VERSUS *contendit*, and, AD *prælium progressus est*.

The intermediate character of the dative case betwixt the accusative and the use of a governing preposition is confirmed by this circumstance, (especially as it is apparently accidental,) that, in the English language, which has no termination or peculiar form of the noun for expressing the dative case, it is sometimes expressed by the preposition *to*, and at other times by the noun in the same form which constitutes the accusative. We say "I sent a letter *to him*," or, "I sent *him* a letter." "Give *him* the money," or, "Give the money *to him*."

The *Ablative* case of the Latin language has been often considered as possessing a variety of powers. Sometimes one of these, sometimes another, has been selected as its original characteristic. Those who first assigned this case its present name have considered its original, or at least its most conspicuous application, as equivalent to the English preposition *from*, representing the object expressed by the noun as the point of commencement of motion. The author of Grammar, in Rees's *Cyclopædia*, describes it as denoting the instrument or medium by which an action is effected, and, of course, considers its meaning as most clearly expressed in such sentences as *scribo calamo*, "I write with a pen." This account of that case, however, will not apply to every sentence in which it occurs. We suspect that any detailed attempt to make instrumentality the universal characteristic of the ablative would involve the subject in inextricable confusion. The writer in the *Encyclopædia Britannica*, impressed with the hopelessness of all attempts to reduce the meaning of the ablative to any one species of relation, describes it as implying nothing more than the simple mention of concomitance. The noun which is put in the ablative may either represent a cause, an instrument, some circumstance of manner, a portion of time, or some other relation; but any one of these is inferred from the nouns employed, and from the evident mutual relations of the words composing the sentence, and not simply from the ablative case. These aids to the meaning are also rather to be regarded as limiting the generality of the case than as correcting any ambiguity. The objection to which this theory is open is, that it is too general to indicate a distinction betwixt this and the other cases of the noun. All the circumstances brought together by words in a sentence may be represented as concomitant. Something further seems necessary for the purposes of precision. The peculiarity of the ablative seems to be, that it is the only case which expresses a concomitant circumstance *by a noun alone*. It is an abbreviating contrivance for dispensing with the introduction of another verb. *Scribo calamo* is used instead of *scribo et habeo calamum*, *calamus est mihi*, or *moveo calamum*. The pen is merely mentioned in the ablative to supply the place of these circumlocutions.

In an example quoted by the last mentioned author, *templum clamore petebant*, clamour is represented only as concomitant with the action of going to the temple. These mere concomitances are called by grammarians the manner.

When we say *palleo metu*, fear is merely mentioned as a concomitant circumstance with the paleness. Yet it is intended to signify, from the natural connection betwixt paleness and fear, that the latter is the cause, and the inference is instantly made. It is because such inferences are drawn with the utmost readiness, and without any sensible interval of time, that grammarians have been deceived into the belief that the meaning inferred is fully expressed by the ablative case.

The expression of this variety of concomitant circumstances by the ablative without the intervention of an intermediate word, for the sake of connecting the noun with the preceding words, has obtained for some of its uses the designation of *the ablative absolute;* as in the phrases *Illo mortuo; Caio et Cassio consulibus*. It might be considered as absolute in its other uses, as in the annexation of cause, manner, instrument, or time. When an historian says *hoc anno floruit*, it is from the word *annus*, and not simply from the ablative case, that the idea of time is inferred by the hearer.

Attempts are sometimes made in the English language to follow the Latin idiom of using nouns in a form thus absolute; and the nominative or simple form of the noun, is employed instead of the ablative; but when we express the cause, the manner, or the instrument, we always introduce definite prepositions; hence it is translated in our language sometimes *in*, sometimes *by*, *with*, or *from*, and its meaning is rendered more special than in the original Latin. It is scarcely necessary to mention, however, that even in Latin it may also be preceded by prepositions, though it does not necessarily require them. We may say either *se gessit summa cum prudentia*, or *summâ prudentiâ*.

Some verbs govern the ablative as a single case, that is, with the apparent meaning of the accusative. These are chiefly neuter or deponent verbs. They seem to have originally been of the intransitive kind, and afterwards made to govern a noun in this slightly connected and least dependent of the cases. As *gaudere* "to rejoice," *gaudere felicitate alicujus* "to rejoice, the happiness of another being a concomitant event," which evidently would not be mentioned in this connection except as the cause of the joy. The verb *fruor*, in all probability, was originally passive in meaning as well as in form, and is capable of being translated "I am privileged," or "I am rendered happy;" *fruor vita*, "I am rendered happy in life," or "I enjoy life." *Potiri viribus*, "to be made rich by, or to possess, power."

The ablative is sometimes subordinate to an adjective, as *inops ratione*, "needy with respect to reason," translated "void of reason."

It is also governed by certain prepositions. Among these there are some that are also used in such a manner as to terminate the meaning without being followed by any noun; for example, *clam* "privately," and *palam* "openly." *Clam Cæsare* is "privately as to Cæsar," afterwards translated "without the knowledge of Cæsar." It is indeed true that even such prepositions as govern the accusative are sometimes used in the same manner as adverbs, that is, without any subjoined noun. This is the case with *juxta* and *contra*. But some difference may here be perceived; *juxta* and *contra* always refer to some specific object previously mentioned; *clam* and *palam* may be wholly general.

Some illustration of the ablative as compared with the accusative case may be derived from this consideration, that all the prepositions which denote that an action or motion terminates in the object signified by the governed noun, govern the accusative, as *ad* "to," *contra* "against," *in* "into;" they have thus a general analogy to active transitive verbs; while all those which denote that the object signified by the governed noun is the point at which motion commences, govern the ablative, as *a* and *ab* "from," *e* and *ex* "out of;" and, finally, those which denote fixed posture or condition are in their regimen distributed betwixt these two cases. *Ante* "before," *apud* "at," *secus* "along," *citra* "on this side of," and some others, govern the accusative; while *cum* "with," *pro* "for," *præ* "before," govern the ablative. But, though no uniform circumstance of syntax marks these last mentioned prepositions, some motive must have directed the persons by whom the language was modified to prefer in each instance one of the cases to the other. If we should suppose that they were derived from pre-existing verbs, the regimen would depend on the genus of each original verb. Prepositions governing the accusative are those which are most completely prepared for a transition of thought to the noun, and thus possess the most complete active energy. *Juxta*, for example, may be held equivalent in force to *jungentia* "joining," *apud* to the word "accompanying," *contra* to the word "opposing." Those which govern the ablative must have been considered as more passive, leading by a more leisurely transition to the subsequent noun. *Cum* might be considered as equivalent to "accompanied." The meanings of these prepositions may be expressed either in an active or a passive form. *Circum* may be analysed into "surrounding," and thus it governs the accusative. If it had originated from some such passive participle as "penetrated," it would have governed the ablative. This variety of syntax might sometimes be founded in etymology, and sometimes the result of arbitrary fancy.

The Greek language has no case corresponding to the ablative. The use of the genitive is in that language extended in such a manner as to include it. The Greek genitive seems to have a greater similarity to the Latin ablative than to the Latin genitive, as the ablative is the least dependent of the two, and possesses the most general application. In Latin it is in some instances governed by a noun; a circumstance which we have not before mentioned, as it takes place only in particular phrases, as *vir egregiâ sapientiâ*, or *vir egregiæ sapientiæ*. The Greek genitive is governed by prepositions like the Latin ablative; and the noun in the absolute state, which in Latin is put in the ablative, is in Greek in the genitive. In this latter language therefore we are left to infer from the connection, whether the meaning of the genitive case or one of those applications which in Latin are assigned to the ablative is attached to it in each particular instance. The only meaning proper to it is the general one of concomitance; and it may be either a concomitance with an object expressed by a noun, or, like the ablative, it may be concomitance with an idea expressed by an adjective, a preposition, or a verb.

In the French and English languages, the noun is subjected to very few variations corresponding to cases. We have the genitive in *s* with an apostrophe, which is sometimes called the possessive case. In the pronouns "I," "thou," "he," and their plurals, we have one variation, consisting in a case equivalent to the Latin accusative, and technically called the objective case; as "me," "thee," and "him." It is by means of this form, preceded by the prepositions "of" and "to," that the genitive and dative in Latin are translated; and by different other prepositions suited to each occasion, we express a variety of relations which in Latin are indiscriminately, and with less particular meaning, expressed by the ablative. In the French language, the nouns *je* and *tu* have in like manner *moi* and *toi* for their objective cases. *Moi* in that language is even used where the nominative would be used in English, as *c'est moi*, for "it is I." Hence some have described *moi* as a complete noun, being a nominative as well as an objective form. In the use of the English language, persons who have not been taught to adhere rigorously to grammatical rules, sometimes say "it is me," instead of "it is I." It is probable that this was orignally a legitimate use of the word, and that the establishment of a contrary rule has proceeded from a forced application of a Latin idiom. Even *moi* in French is not used as a nominative to a verb. The French do not say *moi parle*, or *moi fais*. It is only that sort of nominative which follows the substantive verb. (We do not here speak of that subsequence in mere arrangement which indicates interrogation, and depends on inversion, in which the nominative always follows the verb, as in *suis je;* and we do not think that any attentive reader would have taken such an exception against our views, though we had not stated this circumstance. Those who would have been so disposed may object to several others which the limits of this article do not allow us to defend against every slight exception. We here speak of that form of the noun which follows a substantive verb, after that verb has been introduced by its proper nominative.)

This application of the noun after the substantive verb is peculiar, and might with as great propriety have a peculiar form assigned to it as those which are expressed by cases. It has not an appropriate form, because it is of less frequent recurrence. In Latin, it is put in the nominative. In French it is put in the objective case, being treated as a state of the noun introduced (or governed) by the substantive verb. In English we now adopt the Latin idiom. But, while our language was unfixed, it certainly would have been equally natural to have followed a similar usage to that of the French.

## CHAP. V.

### *Of Adjectives.*

#### Sect. I. *The Nature of the Adjective.*

The impropriety of considering adjectives as intended to express our ideas of qualities, in contradistinction to our ideas of substances, has been already pointed out. The only objects known to us are qualities, and therefore this distinction has no foundation in nature. Qualities habitually conjoined, and forming definite assemblages, comprehend the whole of our concrete ideas, called ideas of substances. We have words to represent these assemblages, and words to represent single qualities. But this does not constitute the distinction betwixt substantives and adjectives. Both kinds of ideas are indiscriminately expressed by these two parts of speech. The adjective, like the substantive or noun, is the name of an object. The circumstance which constitutes its peculiarity is, that it also contains an intimation of the subordination of the idea expressed by it to the idea expressed by a noun in the same sentence. It has in fact the same application with the genitive case of the noun. Sometimes these two parts of speech may be shown to be synonymous. The words "Peter's," "Solomon's," "Cicero's," are by some called genitive cases, by others adjectives of possession. The words "Aristotelian" and "Ciceronian" are reckoned adjectives by all, and also such words as "Roman" and "Grecian." All of these equally contain the name of a person or country, with an intimation that it is to be connected with some other idea expressed by a noun in the sentence. We shall soon see the similarity of use betwixt these adjectives and such as discover less composition in their structure. We shall also see the cause of their apparent difference.

Some have asserted that the adjective by itself expresses no idea. This opinion has arisen from the circumstance, that it supposes some other idea expressed by a different word. But this is in reality an addition to its meaning. Every idea expressed by a substantive may also be expressed by an adjective, and *vice versa*. The idea expressed by "man" is also expressed by "manly;" and the idea expressed by the adjective "good" is also expressed by the substantive "goodness."

Perhaps it will be alleged that, when we use the adjective, we do not give a full representation of an object, but merely refer to it by mentioning a quality founded on some connection with it; that the words "Roman," "English," "Ciceronian," do not imply the full meaning of "Rome," "England," and "Cicero." In answer to this we must observe, that the greater part of words in a sentence are merely introduced for reference. Sometimes, where many words are used, and many objects of thought mentioned, those which are mentioned on their own account are comparatively few, the greater part of the words, including the nouns employed, being merely introduced for the sake of reference. "A Roman senator," and "a senator of Rome," mean exactly the same thing; therefore the ideas contained in the word "Rome" are also contained in the word "Roman."

Those whose reflections are in the habit of suggesting more subtile arguments may object, that the word "Rome" is a proper name, while "Roman" expresses a general quality. This, however, is the same objection in a different form. A part of the word "Roman" is a proper name. The generality of such adjectives arises from the variety of occasions on which proper names may be used. Their application in connection with other words thus becomes general, and the same thing may be said of any form of a noun that implies definite connection with other words. The adjectives "Roman," "Grecian," "French," "English," "Alexandrian," "Ciceronian," "Foxite," "Pittite," contain the names of individuals, but they become general from being applicable to many objects. A relationship to an individual becomes a generic quality.

There are, however, adjectives which express the possession of general qualities founded on no reference to a particular individual. These adjectives have less appearance of composition than those now mentioned, and are always shorter than the substantive nouns used to represent the qualities as separate objects. "Good," "bad," "hard," "soft," "light," "heavy," are shorter words than "goodness," "badness," "hardness," "softness," lightness," and "heaviness." It is from the aspect of words of this sort that grammarians have concluded that the adjective does not express a complete idea. They are never derived from the general name of the quality. It has been imagined that the ideas which such adjectives express are *essentially* general, that they have no corresponding objects possessed of an individual existence, and that, when substantive nouns, such as "goodness" and "badness," are derived from them, a forced effort is made to treat qualities in language as if they were substances. The just conclusion was not drawn, that substantives and adjectives, as mutually distinguished, are forms fitted for certain purposes in language, and not signs founded in any differences in the nature of the external objects signified.

The reason of the comparative brevity of words signifying general qualities, when in the form of adjectives, has been already hinted at. Individual instances of these qualities have no separate interest attached to them, and therefore the words expressing them contain an intimation of their annexation to some group. The names of groups, even though generic, are in the first instance so contrived as to be fitted to become the names of leading subjects of discourse; and ever after merely require a proper introduction to render them distinctive signs for individuals. It is at a more advanced period of human thought that single qualities become separate objects of attention, and then it is natural to create names for them by the composition of words previously in use.

The adjective, like the genitive case of the noun, is a word subordinate to a noun by which it is introduced. Sometimes it is employed to remind us of one of the ideas contained in the noun, as when a poet speaks of "fleecy clouds," "the azure sky," "and verdant foliage;" or when a historian, under impressions of indignation at any series of outrageous conduct, uses such expressions as "the infamous Robespierre."

The most usual effect of adjectives is, to reduce within a more limited range the application of a general term, by the addition of a circumstance which belongs only to a limited part of the genus which that term expresses. "A man" means one individual belonging to a certain class of beings. The words, "a good man," represent one belonging to a limited part of that class. An additional circumstance, attached by means of another adjective, would limit the meaning still more: and an accumulation of adjectives of this sort is capable of affording a combination of sufficiently limited occurrence for any purpose of distinctive description.

The subordination of the idea contained in the adjective to the noun with which it is coupled is in some instances less strict than in others. On some occasions, the ideas expressed by these two parts of speech might exchange places, without any material alteration in the meaning of the compound designation thus formed. "A written libel" is equivalent to "a libellous writing;" "a false assertion," to "an asserted falsehood." Although the purposes of connection in discourse require one of the ideas thus nearly equal in importance to be expressed by a substantive noun, the choice is left to the option of taste and convenience. In other instances in which they may be made to shift places, when the ideas which they express are the subject of a sentence, a corresponding change is required in the predicate, in order that the identity of the meaning may be preserved. The sentence, "a good man is a happy man," may be converted into "human goodness is conducive to human happiness."

It sometimes happens that the adjective expresses the idea which is intended to be the principal, and to which that expressed by the substantive noun is subordinate; as in the Latin phrase *ab urbe condita ad* (*urbem*) *liberatam*. In the translation of such phrases, the idea that is primary is expressed by a substantive noun, and the subordinate one by an adjective. The primary ideas introduced in this phrase, by the prepositions *ab* and *ad*, are the "building" and the "deliverance;" hence it is translated, "from the building to the deliverance of the city." Such idioms are to be considered as arbitrary inversions of the parts of speech, and do not invalidate the original subserviency of the adjective to the substantive noun, as well as of the genitive case to the noun by which it is introduced.

The adjective is very often employed as the predicate of a sentence. It then conveys, by the help of the substantive verb or copula, information of a connection betwixt the idea conveyed by it and the leading subject expressed by the nominative prefixed to this verb. As in the sentences, "Cicero was eloquent," and "Solon was wise."

### Sect. II. *The Etymology of Adjectives.*

Amidst the obscurity in which etymology is involved, it would be difficult to trace all adjectives to other parts of speech, and thus prove that none of them are original. But many of them which might be supposed from their appearance to be simple have been shown to be derived from verbs, and these verbs are expressive of motion.

Sometimes the adjectives thus derived signify qualities *produced* by particular motions. The adjective "left," in contradistinction to right, is from the verb *to leave*. The left hand is that which we leave or decline to use. "Tight" is *tied;* "full" is *filled;* "loud" is from *low'd*.

Sometimes the adjectives thus formed merely contain an *allusion* to the motions from which they are derived, as "odd" from *ow'd;* "straight" and "strict" from *stringere* to pull; "blind" from the old verb to "*blin*," or stop; "bold" from the verb to *build* or establish. "Brown" is from the verb to *bren* or *burn*. "Lewd" is the participle of the verb to *lew* or allure. "Profligate," an adjective used to depict a character destitute of all rectitude of principle, is derived from *profligare* to defeat.

Adjectives expressive of single qualities are sometimes derived from the names of habitual assemblages in which such qualities are conspicuous. The colour "yellow" is in Latin *flammeus* or *luteus*, because it is the colour of flame or of clay. The English word "yellow" is derived from the Saxon verb *geælgen* to burn or flame. *Viridis* in Latin, is from *virere*, to vegetate; and "*green*" in English from *grenian*, to grow.

From the analogies in etymology disclosed by the researches of Mr Tooke, it would appear that verbs expressive of human motion have been the roots from which almost all adjectives, as well as substantives, have been derived. This fact tends to illustrate the views given at the beginning of this article, on the principles which regulate the progress of the human mind in the formation of language.

Some adjectives contain an intentional allusion to the nouns and verbs from which they are derived, and something more is recognized in them than the current signs for annexed qualities. Such are the adjectives "*man*ly, *gentleman*like, *prince*ly, *nation*al, *provinc*ial, *world*ly, *earth*ly;" also "*earthy*, *hilly*, *stony*." The substantives are here fully expressed, and the terminating syllable denoting annexation is capable of being separated. Sometimes this last is merely a general sign of connection; at other times it signifies something more specific, and then the adjective is to be considered as formed by the combination of another adjective with a noun. Thus, "faithful" does not mean simply "connected with faith," but "full of faith," and, if analyzed into the genitive case, it would not be represented by the phrase "of faith," but "of fulness of faith." A "gentleman-like youth" is not "a youth of, or connected with, gentleman," but "of the resemblance, or likeness, of a gentleman." Where several synonymous adjective terminations exist, though all general in original meaning, different specific applications may be afterwards appropriated to them. Thus "earth-*en*" means made of earth, "earth-*y*," abounding with earth, "earth-*ly*" connected with the earth. In some examples we find both parts of the compound word restricted in their meaning. If *ly* means "like," the etymological meaning of the word "earthly" must be "similar to earth;" yet the word is employed solely to signify "connected with the system of of our earth," in contradistinction to the invisible world.

There seems to be a constant tendency amidst the fluctuations of language to coin new adjectives, by derivation from substantive nouns, for the sake of producing greater liveliness of expression. When such a word as "manly" is first used for describing an individual, the hearer more readily imagines to himself a "man," with all his suitable qualifications for the illustration of the quality named, than when such epithets as "bold" or "firm" are employed.

Some adjectives derived from *verbs* contain an equally palpable allusion to the parent words as those do which are derived from nouns, and thus bring more fully into view the motions or actions which they denote. The most remarkable adjectives of this sort are also called participles. They resemble other adjectives in every feature which has yet been mentioned; but many of them imply an additional characteristic, which will come into view when we treat of the verb. The participle expresses the meaning of the verb, together with its subordination to the idea expressed by a substantive noun. The words, "pining," "thriving," "dazzling," are as completely adjectives in meaning and use, as "weak," "strong," and "bright." Sometimes it contains the addition of a particular modification of connection. There is generally a difference betwixt the participle in *ans* or *ens* and that in *us* in Latin, and betwixt the participle in *ing* and that in *ed* in English.

The adjectives of some languages are subjected to variations corresponding with the cases, numbers, and genders of the substantive nouns to which they are attached. These are terminations. They are extraneous with regard to the meaning of the adjective, and are merely convenient marks for designating, in complicated sentences, the noun with which each adjective corresponds. They served, in the Greek and Latin languages, to obviate that ambiguity which must have been the consequence of the inversions of the order of words which the writers of these languages, especially the poets, perpetually practised. This circumstance, though merely accidental, has probably formed the ground on which grammarians have proceeded in calling the adjective a sort of noun. The declensions have given it a similarity of aspect to the substantive noun. The metaphysical reason for adhering to this nomenclature assigned by Mr Tooke, that both equally contain the name of an object, seems not to have occurred, and labours under the disadvantage of applying also to other parts of speech.

### Sect. III. *Degrees of Comparison.*

Many adjectives are subjected to variations, which indicate a comparison of the degree in which a quality is to be attached to different objects. There are adjectives which do not admit of this variation, because there are qualities which do not admit of degrees. Such are some of those which denote figure; as, "circular," "quadrangular," and "triangular." Adjectives subjected to degrees of comparison are those which express qualities which admit of being more or less intense. No language is without separate words to signify comparison. But an expression of that act is so frequently required, that it has been found convenient to combine the sign of it with the adjective, in the form of a termination.

Three degrees have been enumerated; the positive, the comparative, and the superlative. But the positive form is the simple state of the adjective, and should not be called a degree of comparison.

The comparative degree is formed, in Latin, by adding the syllables *ior* to the radical letters of the simple adjective; the superlative by adding the syllables *issimus;* as *mitis*, *mitior*, *mitissimus;* in English, by adding the syllables "er" and "est," as, "meek, meeker, meekest." When the euphony of our language does not admit of this mode of formation, the same thing is expressed by prefixing to the simple adjective the adverbs "more" and "most." Several grammarians have described the meaning of these degrees of comparison as consisting in this, that the comparative expresses a comparison betwixt two objects, i. e. a comparison of one with another one; while the superlative expresses a comparison with many, i. e. with the whole of a class. But we find that the comparative degree may be employed for comparing an object with many others as well as with one; as when we say, "He was *wiser* than all his teachers;" "Charity is *better* than a thousand sacrifices." The superlative degree, in its turn, may be used when only two objects are compared, as, "James is the *wisest* of the two." The difference betwixt these two sorts of expression, which should rather be called *forms* than *degrees* of comparison, is, that the comparative considers the subjects compared as belonging to different classes, while the superlative compares them as included in one. When we compare two men, if we oppose the one to the other, we use the comparative, and say "that he is *taller* than that other;" but when we place the two together to form a group, and point out the superior rank which one of them holds in this group, we say, "He is the *tallest* of the two."

In like manner a comparison in which more than two are concerned may be expressed either by the comparative or the superlative. The comparative is thus used when we say, "Greece was more polished than any other nation of antiquity." Here Greece is considered as not belonging to the class mentioned after the words "more polished." For this purpose these nations are designated by the term *other*. "Greece was none of those *other nations;* it was more polished than they." The same idea is expressed by the superlative when the word *other* is left out; "Greece was the most polished nation of antiquity." We here assign it the highest place in the class of objects among which we number it,—the nations of antiquity. A similar option is left in conveying such sentiments as the following: "Mr Fox spoke more forcibly than any other member of the House;" which may also be thus expressed, "Mr Fox spoke the most forcibly of all the members of the House."

The comparative is indeed sometimes used instead of the superlative where there are only two in a group; as when we say in Latin, *senior fratrum*, and in English, "the elder of the brothers;" "the wiser or the taller of the two." The frequency with which the comparative form of the adjective is employed in comparing only two, has misled some technical grammarians to state it as a principle, that this is the only proper form where no more than two objects are concerned, even although they should be represented as belonging to the same collection or class. But, though habit has admitted some instances of this phraseology, it is an error to form such a rule, and it is injudicious to check any tendency to use the superlative in its original application.

### Sect. IV. *Numerals.*

Numerals have the same relation to the substantive noun as adjectives, and therefore belong to this class of words. They express a modification or limitation of the idea conveyed by some substantive. Their peculiar object is, to denote the degree of frequency with which any sort of thought contained in a noun is repeated; that is, the frequency of the exemplification of a general idea.

In English, the singular number is sometimes merely distinguished from the plural by the want of the terminating *s*, as "the house" for the singular, and "the houses" for the plural. At other times the word "one," or the word "an," or "a," is prefixed. "An" and "a" have been called by grammarians indefinite articles, but in this there is no propriety. They merely signify unity, and this is expressed by them in the most definite manner. In the French language, they are always translated by *un*. They ought, therefore, to be called numeral adjectives. They cannot be prefixed to plural nouns, being peculiar to the singular, or the exhibition of an idea without repetition.

The words "some" and "several" are used as general plural adjectives. There are others implying the result of a general comparison with respect to number; as, "few" and "many." But these words do not describe the frequency of the repetition with precision, and for this purpose language is furnished with corresponding numeral adjectives. One added to one, forms a number which has the separate name "two:" one and one and one, or two and one, have the name "three:" one repeated once more, or a repetition of two, forms the number called "four." Our idea of number, as a separate subject of thought and of language, has no existence previous to our experience in numbering individuals. This gives rise to the observation of a general feature in the acts of the mind, called numbering; and hence the generalization of numbers. Words signifying a particular degree of repetition become applicable to all acts of the mind in which an idea is repeated with the same frequency.

The general words expressive of numbers are derived from the names of particular objects; though, perhaps, we can seldom succeed in tracing them. As the two sides of the body exhibit pairs of organs, two eyes, for example, and two hands, the word for "two" might arise from the most interesting of these pairs. Perhaps the numeral *tres*, "three," has been borrowed from the idea of vibration, and owes its etymology to the verb *tremo*, or some older verb of the same meaning. The two words are at least evidently akin. The words first used to express the succeeding numbers might be suggested by the first two or three, with the help of a sign intimating *reduplication*, as in "two," "four," and "eight," or *addition*, as in "five," "six," "seven," and "nine."

Numeration by *tens* has, with very few exceptions, taken place in every part of the world. This has been suggested by the numbering of the fingers, which form an assemblage familiar to us from our childhood. The word for "ten" would therefore be borrowed from the word signifying "hand," or "fingers." *Δεκα* in Greek, and *decem* in Latin, evidently spring from the same root with *δακτυλος* and *digitus*, a finger. The combinations of tens with one another, and the addition of the words for the different units, are prominent processes in the words employed among the ancients as well as the moderns for the higher numbers, and in the marks invented to express them compendiously in writing.

### Sect. V. *The Article.*

There is one adjective which, from some peculiarity, has been generally reckoned a separate part of speech, under the title of "the definite article." The English words *an* and *a* have been called indefinite articles, but their nature has been shown to be that of numeral adjectives. The words *ὁ*, *ἡ*, *το*, in Greek, *the* in English, *le* and *la* in French, and the corresponding words in other languages, have been called the definite articles; but they have every characteristic of the adjective. They have even corresponding inflexions in those languages in which adjectives are inflected. Their general meaning, and the purpose of the speaker in using them, are the same with those of the adjective. They represent an idea or quality subordinate to an object expressed by a substantive noun. This quality consists in a reference to some previous mention, or to some knowledge previously possessed of an object. A historian, after having named and described a variety of objects, speaks familiarly of them, by using their general names preceded by the adjective *the*, as, "the army," "the town," "the battle," "the siege," and "the truce."

Another use of it is, for attaching a speciality by means of a genitive case, or another adjective, or some of those phrases which we shall afterwards show to be equivalent; as, "*the* King of Prussia," "*the* governor of Malta," and also, "*the* French nation," "*the* Italian territory," "*the* Christian religion." Where no speciality is attached, it means, "known by former mention," or, "mutually understood betwixt the speaker and the hearer." Where it is followed by the genitive or another adjective, it means, "to be known or distinguished by this mark."

Some classes of objects are never mentioned without the use of this adjective, as, "*the* French," "*the* English." This phraseology has arisen from the habit of prefixing the words French and English to more general nouns, as, "the French or English people." We say, "the French are gay;" "the English love the pleasures of the table." We have, indeed, equivalent expressions without the article in the words, "Frenchmen," and "Englishmen."

The only circumstances which have led to the idea that the article was a distinct part of speech, seem to be the same which we have mentioned of the pronoun, viz. its brevity, and its frequency. It is a mistaken notion to consider it as possessing the power of distinguishing the application of a generic name to an individual, from the use of that name in a less definite acceptation. It has not this power in a greater degree than other adjectives. If we speak of "the man," we no more distinguish any individual, than when we say "a man," and not so much as when we say, "a wise man." It is only after an individual has already been distinguished that the adjective "the" characterises him, by referring to that description. It is of very general and familiar application; because any object may be mentioned as already known, or may be introduced with a view of being characterised by some special mark. Like every other adjective, it becomes fitted to particularise the intended object in proportion as it is used with skill and propriety.

Mr Tooke (vol. ii. p. 60.) derives "the" from the Saxon verb *the-an*, "to take," of which he supposes it to be the imperative. "The man," accordingly, means "take man;" and implies a direction to the hearer to select an individual from the rest of the class. This is its meaning, when the object is first introduced for the purpose of being described. When afterwards used for reference, it must mean "taken" or "selected."

Very nearly allied to the adjective "the" are the words "this" and "that," which have been denominated by grammarians adjective pronouns. "That" is considered by Mr Tooke as also derived from *the-an*, "to take;" and as, in fact, its past participle. In actual application "this" means "near," and "that" "at a distance." Another adjective, "yonder," signifies, "at a considerable distance," or on the other side of something referred to. "This" and "that" are either prefixed to nouns, as "this man," "that thing," or are used by themselves, as "this is good," "that is indifferent." In the last form of speech there is a subaudition of the noun; or the adjective may be considered as converted into a substantive noun, in the same manner as we have shown that many substantives are created. Like them, it expresses one quality, with a subaudition of the rest. An adjective used with the subaudition of a substantive, is very nearly akin to a substantive formed from an adjective by subaudition.

## CHAP. VI.

### *Of Verbs.*

### Sect. I. *The Nature of the Verb.*

The verb, as exhibited in elementary grammars, especially those of the Greek and Latin, is much more varied than any of the other parts of speech. Some ingenious attempts have been made to trace its complications, and to analyse its different forms. We find the offices performed by words called verbs to be various, and it would be satisfactory to discover the cause of the application of one common term to words so diversified.

The following are the queries which this subject suggests. Does the verb perform any office which is peculiar to itself, and is this common to every word which, in the present practice of grammarians, receives the appellation of a verb? Are there more points of coincidence than one in the application of the various forms of the verb? Is this coincidence in office strictly universal? Or are these different offices sometimes united in one verbal sign, while only one of them is performed by others? Are the offices performed by the respective words called verbs thus different among themselves? Are there any functions common to the verb with some other parts of speech, though more advantageously and more frequently performed by verbs than by these others? Does this circumstance render it advisable in any instance to retain the name of verb, even while the office performed by it is not peculiar? Or ought scientific accuracy to concur with convenience in leading us to alter in this instance the nomenclature of the parts of speech? These questions can only be answered by investigating the nature and use of every sort of word which, in the habitual language of grammarians, is denominated a verb, and making a comprehensive survey of their applications, in order to assign to all of them respectively their just rank in universal grammar. We must therefore suspend the discussion of the leading problem implied in the title of the present Section, and leave the reply to be gradually unfolded in the sequel of this Chapter.

One important form of the verb, the imperative, created by the earliest occasions for the invention of language, has already come under our notice. We have found imperatives to be the shortest of all words, and to consist of the roots from which the greater part of other words derive their origin. But, since we have considered all language as imperative, that subject does not form an appropriate commencement to our inquiries into the peculiar nature of the verb; and, in fact, it scarcely requires any additional observations to those already made on it. Many verbs from their meaning do not admit of direct imperatives, (to wit, those which do not signify the voluntary acts of mankind,) yet possess many forms in common with active verbs.

We shall first consider those forms of the verb which are subservient to affirmation, or, as it has been sometimes termed, *predication*, for the sake of including negations.

Sect. II. *Verbs as subservient to Assertion.*

Assertion or affirmation is the act peculiar to the verb, being never performed by any word which grammarians have referred to a different part of speech. That part of the verb by which it is most evidently and most frequently performed is called the *Indicative*. By means of it we convey information. This, though not the original object of language, is by far the most frequent application of it, especially in an improved state of society. It proceeds from that great characteristic of our species, the love of knowledge, implying an inclination to convey it to each other. It is by means of affirmation that language becomes the instrument of the most important improvements in human thought and in the character of society. An inquiry into its nature must therefore throw considerable light both on thought and on language.

In affirming, we connect different ideas together, and thus dictate an arrangement which we wish such ideas to assume in the mind of the person addressed. To this object a particular part of speech is devoted; but that part of speech often consists of a word which contains a sign of various other ideas. When we say "the man walks," the word "walks" contains the name of a particular motion, at the same time that it expresses a connection betwixt that motion and the object denoted by "the man." Mr Tooke considers the verb as containing a noun and something more; and he proposes it as a question worthy of the attention of philosophers, what is that circumstance which, when added to a noun or the name of an idea, makes it a verb? The answer to this, in so far as the indicative is concerned, is, that it contains a sign of asserted connection betwixt the object expressed by that noun or name, and some other object which is also mentioned in the sentence. But we have other signs of connection which are never considered as giving a word the nature of a verb. The genitive case implies a sign of connection betwixt the object expressed in that case and some other; the adjective performs a similar office; but there is a difference betwixt these signs of connection and that implied in the indicative of the verb.

The nature of these two sorts of signs, and the difference betwixt them, will be most clearly perceived by attending to the structure of those languages which enable us to resolve the indicative of every verb into its constituent parts, by affording distinct signs for each. In English "the man walks" may be resolved into this sentence, "the man is walking." The termination *ing* implies a connection similar to that expressed by the genitive case or by the adjective, while the word *is* gives the sentence the character of assertion, and fits it for conveying new information.

For the sake of possessing appropriate terms on this part of the subject, it will be convenient to borrow the technical language of logicians, who call a sentence a *proposition*, consisting of three parts, a *subject*, a *predicate*, and a *copula*. In such a sentence as we have now mentioned, each of these parts is expressed by a separate sign. "The man" is the subject, "walking" the predicate, and "is" the copula. The author of Grammar in Dr Rees's *Cyclopædia* maintains, that "is" does not express assertion, but connection. Connection, however, is often expressed by words of very different import: therefore that term is less appropriate to the copula than assertion.

Sect. III. *The Substantive Verb.*

The copula has been denominated the *Substantive Verb*, and it undergoes a variety of changes, called inflections, corresponding to the changes incident to other verbs.

The radical nature and common use of this verb is not, as Mr Harris supposes, to express existence, but to assert a connection betwixt one object and another. The author now mentioned has been unfortunate in his mode of describing the use of this verb. He pronounces it an undoubted axiom, that "an object must first be, before it can be any thing else;" an opinion in all points of view untenable. In the first place, it is not necessary that the subject spoken of should have an actual existence. We can speak of supposed as well as of existing objects. In the next place, an assertion that any object which has existence is something else, implies an absurdity.—What then is an assertion? Do we by means of it assert an object to be the same that is implied in the term used for an introductory designation? This is not the case; it would form an unmeaning truism; and the predicate is generally a different word from the subject. In this act we neither assert the subject to be the same, nor to be something else. The office of assertion consists in pointing out a relation betwixt the subject and some other idea. The word "gold" has one meaning, and the word "metal" has a different one. When we say "gold is a metal," we do not intend to say that the words "gold" and "metal" have the same meaning, but that the qualities expressed by the word "metal" are connected with the object called "gold." When we say "sugar is sweet," "wormwood is bitter," our intention is to produce in the mind of the person addressed a connection betwixt the ideas which have been previously attached to the word "sugar," and the further idea of "sweetness," and betwixt the ideas attached to "wormwood," and the idea of "bitterness." Sometimes nothing may be previously known concerning the subject of the proposition. We may speak of sugar and of wormwood to a person who has never heard of either. In that case the terms are only introduced as signs requiring the person addressed to attach to the one of them the idea of sweetness, and to the other that of bitterness, as contributing to those compound ideas of which he may afterwards consider the words as significant. The idea expressed in the subject must always be different from that expressed in the predicate. This is the case even though the expressions used would on a different occasion be synonymous. When the sentence "London is the capital of Britain," is uttered, if the hearer had any ideas about London, he is desired to connect with these the further circumstance of its being the capital of Britain: if he had no idea on the subject, except that London was a name written or pronounced in a certain manner, he is desired to connect this word as a name with those which form the predicate of the sentence. Sometimes, by a figure of speech, the same word is used for the subject and the predicate: for example, "Home is home." In the employment of this figure, however, it will be found that such a word as "home" in these two situations has a different set of ideas attached to it. The meaning of this sentence is, "Home, though often thought and spoken of with indifference, is, when made the subject of reflection, connected with feelings which interest and attach us."

The substantive verb differs from verbs of motion in being radically indicative in its character. Assertion is the cause of the contrivance of it. It does not originate in the imperative mode, any further than an imperative effort to command attention is implied in all language. The use of the substantive verb is, to direct the thought of a person to the connection of one idea, or one assemblage of ideas, with another, and thus to indicate congruities, incongruities, and relations of all kinds. The substantive verb is employed in the imperative, conformably with the usages of other verbs. We say, "be wise;" "be ready to do your duty;" but this imperative has always an awkwardness and a want of emphasis, compared to that of the active verb. An active imperative may be considered in such phrases as understood. It seems an absurdity to desire any person or thing *to be*, or even simply to be connected with another object, or to be endowed with a particular character. The imperative radically implied in such sentences is a command or solicitation to use such *exertions* as tend to the production of a certain state. *Sis probus* means *fac ut sis probus*, cause yourself to be good; act in such a manner as to support a worthy character.

All the other forms of this verb coincide in meaning and emphasis with the corresponding parts of other verbs.

The peculiar character of the indicative of the substantive verb is, to express in a separate word that general act of the mind which is common to all verbs in the indicative mood.

The *predicate* of a proposition may either be an adjective noun, as "Cicero was *eloquent*;" "Solomon was *wise*;" or a participle, as "the man is *walking*;" "the boy is *riding*." A substantive is applied with equal frequency to the same use, as "Isaac is *a philosopher*;" "George is *a king*;" "Alexander is *an emperor*." A connection betwixt the ideas expressed by these substantive nouns and those attached to the *subjects* of the propositions, is then asserted by means of this simple verb. The verb still merely serves the purpose of a copula. The noun becomes an adjective by its situation.

Dr Smith infers from the generality of the character of this verb that it must have been the result of much thought, and could have been formed only after refinement in metaphysical science had made considerable advancement. For this inference, however, there is not sufficient foundation. The acts exerted in all assertions have a character mutually similar, and are therefore called the same act; and nothing is more natural than to express the same act or similar acts by the same sign.

The early attempts of a child to speak are often made without the use of the substantive verb. He says, "That bread good," instead of "that bread *is* good." He possesses the ideas of bread and of goodness, and, by pronouncing the one in immediate succession to the other, he attempts to convey the impression which he has received of their mutual connection. The same mode of speaking may be supposed to take place among a people, whose mutual communications are few and crudely executed. But, as the juxta-position of nouns may also be applied to other uses, a separate sign is afterwards introduced for indicating assertion; and no depth of metaphysical knowledge is required to induce men to use the same sign on every similar occasion. Although some risk of error attends the intellectual exercise of retracing and analysing the progress of our mental operations, and hence metaphysical mistakes and difficulties have been handed down from age to age, no hesitation or impediment occurs in the employment of the faculties for the common purposes of speech. The human mind has always proceeded without embarrassment in contriving signs for its communications. The formation of a general word is equally easy with that of a significant general termination for shewing that words are applied to similar uses. A termination expresses some point of mutual resemblance in the application of words. The same thing is done by a separate word, and a separate word may be uttered with equal facility. The forms, in fact, which are common to all other verbs are exactly synonymous with the pure substantive verb. All other verbs consist of the signs of ideas, coupled, as we have observed, with the sign of adjection, and the sign of assertion; that is, the meaning of the participle with that of the copula.

### SECT. IV. *The Neuter Verb.*

SOME languages have verbs which contain the meaning of an adjective and the copula condensed in one word, and which have no further characteristic in the construction of sentences than these parts of speech when separately expressed. Perhaps this is not the case with every language, and there are probably none in which such verbs abound. In the Latin language, *rubere*, *virere*, *calere*, *frigere*, are instances. In English we have the verbs "to glow," "to blush;" but we for the most part express such ideas by using adjectives with the substantive verb in a separate state. The verbs now mentioned are called *neuter* verbs, in consequence of the absence of certain qualities which we shall find other verbs to possess.

### SECT. V. *Assertions made by Verbs of Motion or of Action.*

IT has been already observed that the first object which a man has in view, in using speech, is to excite to action. Were mankind destitute of vocal language, they would imitate the particular actions which they intend the person to whom they speak to perform. This is always done by persons who wish to converse while they are not acquainted with any common language. The case is necessarily the same with dumb persons. In tracing the origin of the words by which particular actions are represented, and the establishment of them as conventional signs, we find no general principle to guide us. The motive for using a particular sound is of so casual a nature, that its history is lost before it receives an established application. The want of written documents, and the total inattention to retrospective analysis, which exist in a state of society so rude, involve the origins of words in obscurity. Etymology can only trace a word from one application to another, and follow its variations through the different languages into which it has been adopted. Even this exercise is liable to deceptions which it is difficult to avoid. Yet it must be allowed that, when conducted with caution, it may prove extremely useful, by discovering analogical principles of transition, which elucidate this department of human art.

After men have learned to employ words for exciting one another to those actions by which reciprocal services are performed, the extent of the uses to which language may be applied must be soon more fully perceived. Men contrive to describe to each other various surrounding phenomena. Some of the most interesting of these consist of the actions of their fellow creatures.

The same sign by which we desire a person to perform a particular action, is naturally retained as a symbol of that action in describing any series of events of which it forms a part. After we have used the words "come," "go," "stand," "sit," "run," as imperatives, we spontaneously apply the same words, either in the same form, or with some slight addition or alteration, in affirmative sentences, such as "John stands," "John sits," or "John runs."

It has been already remarked that these indicative forms may be resolved into the copula with a participle, and are equivalent to "John is standing," "John is sitting," and "John is running." The connexions expressed by the participle are observed in the operations of the solitary mind before we are capable of using language, and form an extensive series of relations among the objects of our knowledge. But the earliest use that arises for connecting the significant words is the conveyance of information. On this account the copula and the participial sign are not originally separate, but condensed into one word with the name of the action specified. This early date of the condensed phrase is the cause of a comparative simplicity in the indicative form. It is prior in formation to the participle. We have occasion to say that a man "walks," sooner than we have occasion to use the compound designation "the man walking," as the subject of a different proposition. It follows *a fortiori* that the simple indicative is prior to that indicative which is formed by the participle and the copula. The division of it into these two parts might make the indicative appear more complicated in metaphysical analysis, and some might be disposed, on this view of the subject, to consider the usual indicative as a species of contraction. But this is not its character. The act which consists in the union of the meaning of these two signs is spontaneous, and of an early origin. On this account the indicative has even less complexity of form than the participle.

## Sect. VI. *The Active, Passive, and Middle Voices.*

It most frequently happens that, in describing an event, whether consisting of a voluntary human action or not, we have occasion to bring into view, by means of a noun, some object which has a conspicuous concern in it. The occasions on which no inclination to do this exists are but few, and the events which are described in a manner so simple are not of the most interesting kind. They occur in Latin in the use of such verbs as *ningit* and *pluit*, "it snows," "it rains." Each of these verbs, without any nominative, contains a full account of an event.

When we describe an action which has an intimate connection with some other objects, we generally have occasion to extend our description by the mention of the object or objects so situated. We may either mention one or more of the agents who perform the action, or an object affected by it. If the noun expressing this object is put in the nominative case, it becomes the leading subject of the sentence.

When the nominative is the name of an agent, the verb is said to be *active*. When it is the name of an object affected, it is said to be *passive*. (This mode of expression is somewhat illogical. It is the noun that becomes active in the one instance, and passive in the other. The difference of these two uses of the verb is, that they give these differences of character to the noun. We shall, however, adhere to the established nomenclature, as established by common usage, and possessing the advantage of a convenient briefness.) There are not in every language two separate forms of the verb for these two applications of it. In modern English, some verbs are used in the same form in an active and in a passive application. We can use the verb "cut" in any one of the three following ways: "They *cut* the tree;" "These tools *cut* smoothly;" "Fir *cuts* more easily than oak." We say, "Look at that person's face;" also "He *looks* well;" "Drink some wine;" and "This wine *drinks* pleasantly."

Some grammarians, impressed with the prominent distinction existing in the Latin language betwixt the verb in the active and the passive voice, would insist that "to drink" and "to cut" are essentially active, and therefore that the phrases "fir cuts easily" and "this wine drinks pleasantly" are ungrammatical. But we shall probably entertain a more enlarged as well as a more correct idea of the verb, by conceiving that those which we call active verbs are in their earliest application of no particular voice, though, from the agent generally appearing in the mind of the speaker more important than any object acted on, the active application of them is the most frequent. The original indicative of the verb thus points out a connection betwixt an object and an event, without specifying the nature of this connection. The circumstance of agency or any other may be safely left to the inferences formed by the understanding of the hearer.

In other instances, it is found convenient to contrive a mode of expressing by some slight alteration in the form of the verb the circumstance of being the object acted on. An expression of this sort, if found to harmonize with the genius of a language, may be afterwards universally adopted; and the original form of the verb will then be limited to the active application. In such languages, the distinction betwixt the active and passive voices will be most constant. This happens in the Latin language, and in the active and passive voices of the Greek. But, where the contrivances adopted for this purpose are in point of convenience less fortunate, they will be more varied and less strictly adhered to. Much will be left to urgent occasion or individual taste. Of this we have instances in the middle voice of the Greek verb, and in several phrases in the modern languages of Europe.

The French apply the verb in a passive acceptation, by introducing the same object as the nominative and the accusative to it, as *Le vin de Bourgoigne* SE BOIT *partout*, literally "the wine of Burgundy *drinks itself* every where." A verb thus used has been called a reciprocal verb, and it appears particularly appropriate when the same object is the agent and the object affected, as in the phrase "he prepares himself." Yet it is not necessarily limited to such occasions. *Le vin boit* does not mean "the wine performs the act of drinking," but "the wine has some connection with the act of drinking." The nature of that connection is here indicated by the accusative *se*. The phrase *le vin se boit* may be thus analysed, "The wine is concerned in drinking, by being the liquor which some one drinks." But we find that in English, when we say "the wine drinks pleasantly," the kind of connection betwixt the wine and the act of drinking is left to be inferred from the nature of the subject. This is of itself sufficiently prominent to prevent ambiguity, notwithstanding the incomparably greater frequency of the active application of that verb.

In other instances, a slight addition or a mere alteration is used for denoting the passive. In the Icelandic language, *æg elska* signifies "I love," *æg elskast* "I am loved." In Latin, we have *amo* for "I love," and *amor* for "I am loved." The expedients adopted in different languages will depend on the previous state of each. When a language already possesses a word expressive of suffering or being acted on, it will be natural to employ this, or some part of it, in union with the verb to denote the passive. It is not improbable that the letter *r*, which distinguishes the passive voice in Latin, is derived from *res* "a thing," or some previously existing word of similar import. The radical letters *am* signify "love;" *am-o* "I love," i. e. "I have some general connection with loving." *Am-o-r* "I am connected with loving as the *thing* or object loved." The letter *r* runs through all those forms of the passive voice which are produced by inflexion, with the exception of the second person plural.

The preterite tense of the passive verb in Latin is made up of a compound phrase, consisting of the participle with the substantive verb. The participle employed is derived from the past tense. *Amatus* is most probably a contraction for *amavit us*, and derived from *amavit*. The past tense is thus converted into a part of speech resembling the adjective; and the effect of the past is exhibited as a quality which is to be connected or adjectived to some other idea expressed in the form of a substantive noun. The introduction of the copula forms an indicative or asserting sentence. This shows that assertion was not early appropriated to that particular sort of connection betwixt actions and other objects.

The best passive form of the verb which the English language possesses is in the preterite tense, and yet it is of an equally compound nature with this part of the Latin passive. We adopt the sign of past action in the form of an adjectived quality, and complete our assertion by inserting the copula. "Destroyed" is the past tense of the verb "destroy." "The enemy's troops *destroyed* the city" expresses the active voice. "The city is *destroyed*" expresses the passive.

We have no good contrivance for a passive voice in the present indicative. *Domus ædificatur* cannot be literally translated into our language. When we say "The house is built," we assert the completion of an action. The nearest approach which we make to it in respect to tense is by the phrase "the house is building;" but here we confound the voices, at least we employ a word which in respect of voice is general, as the participle in *ing* is most commonly used in the active voice. Some of our southern neighbours choose to express their meaning by the phrase "the house is being built," which is no farther appropriate to the present tense than as the same combination never happens to be used for the past. It labours under the disadvantage of an awkward verbosity, which prevents it from being generally adopted, or sanctioned by the authority of persons of taste. Another effort has sometimes been made to supply this want by prefixing the letter *a* to the present participle, and thus converting it into a passive present, as "the house is *a*-building," but this has not succeeded in meeting with a permanent adoption. A strictly appropriate phrase has not been found absolutely necessary, because a slight alteration in the form of our sentence enables us to dispense entirely with the passive form of the verb. We can say "the building of the house goes forward," or "the work people are engaged in the building of the house." No inconvenience is experienced in expressing our meaning; it is confined to our attempts to translate Latin sentences literally into English.

In the French language the passive voice is much less frequently used than in English. That language has a resource which few others possess, for introducing the object acted on after the active verb without the mention of any particular agent, as it has a nominative of a very general application, *on* or *l'on*, signifying merely "some being or beings real or imaginable." This is prefixed to the active form of the verb, and the object acted on is conveniently made to follow in the accusative (or objective) case. *On le dit*, "some being or beings say so," is translated, with propriety "it is said."

Our language is equally defective in a passive voice for the future as for the present. If the sentence *domus ædificabitur* is translated by the phrases "the house will be built," or "the house will be building," or "a-building," or "will be being built," we shall find these forms to labour under the same disadvantages with the attempts already mentioned to give a translation of the words "*domus ædificatur.*" Yet we experience equally little inconvenience in this as in the former instance, because a moderate skill in varying the turn of our sentence enables us to convey our meaning clearly without the use of a passive voice.

A neuter voice might be formed, consisting of a separate word to signify that an action takes place, in a manner similar to the words *ningit* and *pluit*. We might have a single word for "there is," or "there was a walking;" in French, *l'on se promene*. In Latin, the passive voice is sometimes used in this neutral or impersonal manner. *Ambulatur* is not passive in any thing else than in form. It means "the act of walking goes on;" *ambulatur ab illo*, "the act of walking is performed by him," for "he walks."

### Sect. VII. *Regimen of the Active Verb.*

Some actions are of such a nature that the object affected by them is always interesting, and, in the earliest use of language, such actions are never related without immediate mention of an object thus affected. It also happens on such ocasions, that the manner in which the object is affected is evident from the nature of the action. Of this nature are the actions expressed by the verbs "to make," "to build," "to cut," "to strike," "to kill." Such verbs in the Latin language generally govern the accusative case, intimating the most rapid transition from the idea conveyed in the governing verb to that conveyed in the noun. The noun governed may, in consequence of its own regimen, be rendered introductory to further additions both to the form and meaning of a sentence. The verb thus becomes a hinge on which the greater part of the meaning of a sentence turns. The large proportion of verbs which govern nouns in this manner has conferred a conspicuous rank on this part of speech. It is in this respect more powerful than the adjective. Even when adjectives are used as predicates in affirmation, the meaning which they introduce generally terminates in themselves, or leads to subordinate ideas only through the medium of prepositions. We say "this man is good," "that man is just;" also, "this man is good at heart," "that man is just in all his conduct." It is seldom that adjectives in Latin can be admitted to govern the accusative; and even the phrases in which this might appear to take place, such as *Os humerosque similis*, are commonly explained by the subaudition of the preposition *quoad*. These differences betwixt the active verb and the other parts of speech have had a secret influence in leading grammarians to attach great importance to the verb. Its full power seems to reside in this form of it. Verbs of other kinds have appeared to be exceptions, or words to which convenience has assigned a verbal form, though they are not originally entitled to it.

The governing powers of the active verb are retained by the active participle and the infinitive mood. This act seems to have led grammarians to consider these forms of words as parts of the verb properly so called. The participle is distinguished from the adjective by regimen alone. Hence those grammarians who call participles real adjectives have always been most fully satisfied with the appellation when applied to the participles of verbs destitute of regimen, such as "thriving," "charming," "surprising," words which are in all respects used as adjectives, though participles in etymology and in form.

The infinitive mood has the same similarity to the substantive noun as the participle has to the adjective. It may become a nominative to a verb, as "*to enjoy* is to obey;" or an accusative, as "men generally wish to *live* long;" but, when introductory to other words, it has a more powerful and ready regimen than the noun. In Latin, it like the verb governs the accusative, and not exclusively the genitive, like the noun. We shall afterwards consider more particularly the participle and the infinitive mood. At present we have merely accounted for the fact, that grammarians have reckoned them real parts of the verb.

It must always have been obvious that this office of the active verb is not common to all verbs, and therefore is not characteristic of this part of speech; and, if the participle and the infinitive mood are to be reckoned parts of the verb, the problem still remains unsolved, what is the true characteristic of the verb? Mr Tooke intimated that he was prepared with some doctrine which appeared to himself satisfactory as a description of the verb, including its infinitive mood. Every philologist must regret that this acute writer did not communicate his views more fully to the world. On this part of the subject, it is possible that they may have been both well founded and original. We are certain that they would have been at least worthy of attention. They appear to have been valuable in his own eyes; they would have been exhibited in a forcible manner if he had chosen to publish them, and might have led the way to a more satisfactory account of the subject. But, as no explanation of this sort occurs on our own most matured reflections, we naturally suspect (however presumptuous the declaration may appear,) that his theory would have either turned out eventually inconsistent with some of the opinions which he has published, or would have been in itself unsatisfactory.

A precise answer to the question in the form now proposed is not of great importance. We have pointed out assertion as one office which is performed by verbs alone. We have pointed out the quality of an active regimen, as belonging to an extensive department of verbs, and have shown that this quality is possessed by parts of speech closely allied to the verb in etymology, and generally numbered among its parts, though not possessing an asserting power. We have shown in what words assertion and a transitive regimen are separate, and in what they are combined. Assertion is separate in the indicative mood of substantive and neuter verbs; the transitive regimen, in the infinitive mood and active participle of active verbs. We have endeavoured to investigate the connection betwixt these parts of speech and the indicative of the verb. In so far as their character is inconstant or complicated, we have stated the causes of these characteristics, and the shades of variation by which they are distinguished. We have shown in what respects the intermediate kinds of words partake of the nature of one part of speech, and in what respects they partake of the nature of another. If the particulars on these subjects are impressed on our minds, our theories will be exempt from ambiguity or confusion.

### Sect. VIII. *Intransitive Active Verbs.*

Neuter verbs have no such regimen as has been now described. Hence some have assumed this as a mark of distinction betwixt them and active verbs. It did not however escape observation, that some verbs which do not govern any noun signify action, and that therefore the term *neuter*, as implying the absence of active power, did not apply to them. For this reason these have been retained in the list of active verbs, but distinguished from verbs of regimen by the additional epithet *intransitive*. Their peculiar character has been generally represented as arising from this peculiarity in the nature of the actions signified, that they do not affect any ulterior object. But this is not true in point of fact. The transitive or intransitive nature of verbs of action depends solely on the occasions of mankind in making use of language. Transitive verbs are those which express actions when we have occasion instantly to mention an object acted on. Intransitive verbs describe actions when we are satisfied with stating the connection betwixt the action and the agent. Verbs which admit of no direct regimen, and therefore are termed intransitive, may introduce other ideas, expressed by nouns, through the medium of prepositions. The verb "to strike" is *transitive*, while the verb "to walk" is called *intransitive*; and yet it is evident that in the act of walking one or more objects are acted on as much as in the act of striking. Only it happens that when we speak of striking, it is generally of importance to point out the object that is struck; but, when we speak of walking, our attention is chiefly directed to the act as connected with the agent. In walking, however, a man walks *upon* some object which supports him; he walks *from* some place, and *to* some other. Each of the phrases "I strike my horse," and "I walk upon the ground," expresses, in a manner equally explicit, a particular act, together with an object affected. The intervention of a preposition in the one case, and the absence of one in the other, imply no difference in the energy of the act related, but only the different degrees of interest excited in the connection of it with the object affected. It might naturally be expected, from the numerous and varied occasions which we have for the relation of events, that, even in describing the same sort of action, we should sometimes have a motive for mentioning an object affected, and sometimes not. For this reason some verbs differ from each other only in their transitive or intransitive application, of which we have already given an instance in the difference betwixt the verbs "to speak" and "to say." In other instances the same verb is used either transitively or intransitively. We may say at one time, "a miller grinds corn;" in this sentence, corn is the object affected by the act; at another time we may speak of the same act as characteristic of the situation and employment of an individual; as in the sentence, "two women were grinding at the mill, the one was taken and the other left." Here no occasion arises for mentioning any object on which the act of grinding is exerted. These however are not two different meanings given to the verb. In both cases it is used in its full meaning, that of describing a species of action. Whether we choose to introduce or omit the name of the thing acted on, depends on the design which we have in forming our discourse. It may or may not be of use to add this circumstance to the description. It makes no more difference in the original meaning of the word, than the introduction of a second sentence in elucidation of the subject would affect the meaning of the words in the sentence first employed.

Sometimes verbs which are originally intransitive, and evidently not intended to have nouns subjoined to them, except through the medium of prepositions, are afterwards applied as active verbs governing the accusative, in consequence of the familiarity which the expression of particular kinds of connection acquires from habit. The verb "escape" originally required the preposition "from" to express a certain sort of connection betwixt the act and other objects. Yet we not only say "a prisoner escaped from prison," but, speaking of our own memory, we may say that "names and dates escape us." *Fugere*, in Latin, is a verb of the same kind, and the corresponding phrase *me fugit* is used in that language. *Me latet* is of a similar nature. *Ardere* is transitive, or perhaps ought rather to be called neuter, yet it is made to govern the accusative: *Formosum pastor Corydon* ARDEBAT *Alexin*.

In some instances an active verb, which we are in the habit of connecting with nouns by means of prepositions, is used to form a transitive verb, by being compounded with a preposition governing the accusative, and evidently derives its transitive power from the preposition. Such a verb, like others which govern the same case, may be used in the passive voice. In Latin we have such words as *initur*, "it is entered on." In English the same thing takes place, though the two words continue separate. The phrase thus formed is treated like a compound word, and made to pass through variations similar to those to which entire words are subjected. Such are the phrases "to laugh at," and "to trifle with:" the preposition and the verb coalesce to form a sort of compound verb, which is used passively in the phrases "to be laughed at," and "to be trifled with." This species of coalescence of words into phrases, subjected to a peculiar inflection, even takes place in instances in which an active verb governs a noun in the accusative, and then leads to another by means of a preposition: as in the phrase "to make a fool of;" for we do not say in the passive "a fool was made of him," but "he was made a fool of." We have many analogous examples; as, "to be made game of," "to be evil spoken of," "to be taken notice of," "to be taken care of." Some even say, "to be paid attention to." This last expression is inelegant, because it shews an unsuccessful grasping at a variety of accommodation.

On the *diversity* of regimen of verbs, see our account of the cases of the noun. The subjects are inseparably connected, and under that head such observations as appeared necessary have been delivered.

### SECT. IX. *Persons and Numbers.*

VERY little remark is required on the meaning attached to the *Persons* and *Numbers* of the verb. But the nature of their connection with this part of speech may be illustrated by their etymology.

In those languages in which verbs receive separate terminations for distinguishing the first, second, and the third persons, such terminations are pronouns, and are equally complete as if they were separate words. The terminations *o* in *amo* was probably derived from *ego*, the *s* in *amas* from συ, the *t* in *amat* from αυτος, the *amus* in *amamus* from ημεις. These terminations shew traces of being the same pronouns slightly modified. Some philologists who find themselves at one time dazzled by Mr Tooke's plausible etymologies, are at another startled on finding instances to which his principles cannot be applied, and on this ground rashly become disposed to condemn the whole as fanciful. A person under these impressions might perhaps stop us short in the inflections of *amo*, with asking the etymology of the terminations *-atis* and *-ant* in the second and third person plural. *Atis* affords no vestige of the Greek ὑμεις, nor *-ant* of αυτοι. It would be too bold to maintain that they are derived from words so dissimilar to themselves, unless we were able historically to point out the intermediate steps of their transmutation. But difficulties of etymology do not in the least invalidate the general position, that such terminations are real pronouns. *Atis* and *ant* have exactly the same meaning with ὑμεις and αυτοι. Whether they were derived from words subsequently forgotten, or were applied in the first instance as terminations, they are to be considered as complete signs, equally significant with separate words, and differing from the latter only in being placed not before but after the radical letters of the particular verb, and written in closer connection with them. The resemblance of some of the terminations to the separate pronouns is in fact happily adapted to corroborate the identity of their signification; but though no such resemblance existed, just reflection would lead to the same conclusion.

In speaking of the personal pronouns, we observed that they have all the characters of nouns, and that their whole peculiarity consists in their frequent use, which has occasioned a convenient brevity in their form. It is to the same cause that they owe the further distinction of being attached to many important words in the shape of terminations. In Greek and Latin we find them attached to the verb. In the Hebrew and Arabic they are attached in the same manner to nouns. *Ism*, the Arabic word for "a name," receives the terminations *-i*, *-ek*, and *-ou* for signifying "my name," "thy name," and "his name."

The inflections of the English verb possess a character somewhat different from those used in the Latin language. They do not supply the place of nominatives, but are used along with them. We say "I love," "thou lovest," "he loveth" or "loves." We never say "love" for "I love," "lovest" for "thou lovest," nor "loveth" and "loves" for "he loveth" and "he loves." The terminations in English therefore are not complete pronouns, as in Latin; they are only accompanying signs, denoting that a particular sort of word is the nominative to the verb. They might be represented as redundancies, but they are not destitute of meaning and utility. Though not absolutely necessary to guard us against mistake, they contribute to precision. They enable us to expatiate on a variety of circumstances in connection with the object exhibited in the nominative case, before we introduce the verb; and then the form of the verb shows its connection with the person mentioned in the nominative. But as the terminations in English are not so essential as in Latin, they are fewer and less varied. The first person singular, and all the three persons plural, consist of the simple verb with the pronoun prefixed. "I love, we love, ye love, they love." For this, among other reasons, our language admits of less inversion in the order of the words.

The same observations apply to the *Numbers* as to the persons of the verb. The use of them in the imperative mood is conducted in the same manner as in the indicative. In the passive voice they follow similar analogies as in the active.

### SECT. X. *Tenses.*

A REFERENCE to time is inseparably connected with the narration of events, and therefore many parts of the verb are so contrived as to indicate in their structure a connection with some portion of time, in contradistinction to another. The point of reference naturally first assumed is the instant in which the sentence itself is uttered. Hence the first general division of tenses is into present, past, and future. Points of reference may also be selected from the past and the future, and expeditious methods, suited to our various occasions, adopted for expressing relative precedence or subsequence.

References to the division of time into definite portions, as hours, days, weeks, months, and years, are always made by means of nouns contrived for the purpose.

1. *Tense of the Imperative.*

Before proceeding to the tenses of the indicative, which are the most important and precise, that of the imperative claims some attention. The form most frequently used in Latin and in English has been called the present imperative; but a little attention will shew that imperatives are essentially future. The act to be performed must be subsequent in time to the command. In many instances they may be separated by a considerable interval, without any alteration in the form of the verb employed; as when we say, "come to this place to morrow." Though sensible of this circumstance, grammarians seem not to have been aware of its importance in demonstrating the tense proper to this form of the verb. Perhaps a vague idea existed that the time of the *giving of the command* ought to fix its tense, but this is obviated by the slightest reflection on the subject, as the act performed by the speaker in every sort of sentence is present. Perhaps the *immediate* nature of the *influence* intended to be produced by the imperative on the mind of the person addressed has, though future, been considered as sufficient to entitle it to the appellation of present. But this influence is in no respect a proper foundation for a distinction of tense. All language is intended to produce an immediate effect on the mind. It is therefore solely with the time of the action or event specified in the verb that philosophical grammar is concerned in tracing the different tenses. The future in English is sometimes used instead of the imperative, as "thou shalt not kill;" "thou shalt not steal." Perhaps grammarians who delight in distinctions would perceive in this phraseology, as compared to the common English imperative, some analogy to the varieties of imperatives in the Greek language, and would denominate the sentences last mentioned future imperatives, in contradistinction to the common form called the present. But in the meaning of the sentences the tense is equally future in both.

The Greek language has various imperatives, which grammarians arrange along with the different tenses, and distinguish by the names of the present, the aorist, and even the preterite imperatives. But this diversity of form can produce no corresponding diversity of tense, unless this should consist in discriminations in the portions of future time to which the commands refer. We may order a person to begin an action at a particular time; or we may order him to be engaged in some occupation which is supposed to be previously begun; or we may order him to have an action completed. But, with reference to the primary division of tenses into past, present, and future, the imperative must be regarded as essentially future.

2. *The Aorist and Present Indicative.*

Mr Tooke has remarked that the part of the verb called the present indicative is a simple or general indicative, and that no tense is implied in it. When we say "the sun rises in summer much earlier than in winter," we assert a fact applicable to past, present, and future. Of the same nature are mathematical theorems and all general propositions. This form of the verb might therefore with respect to tense receive the appellation of a universal aorist. This indeed is the form of the verb used for describing present transactions. The idea of present time is on such occasions attached to the sentence, in consequence of an inference drawn from the nature of the subject.

In some languages it is elegantly used to describe a long portion of past time extending to the present: as in French *Je suis ici trois ans*, and in Latin *Tres annos hic adsum*. But it is also used in describing events which have been completed at a time past, as, "Yesterday, when walking along, whom *do* I meet but my old kinsman:" "I am glad, *says* he, to find you looking so well." Grammarians, never doubting that such indications are essentially of the present tense, have supposed that in such sentences the past is, for the sake of vivid representation, described by a figure of speech as present. The facts now stated shew that such explanations are unnecessary; and if they are in any degree just, or adapted to the conceptions which we attach to this form of the verb, the consideration that this indicative is not restricted to any tense will account for the facility with which we reconcile our minds to a figure of speech, which would otherwise appear a distortion.

We sometimes also use this general indicative in describing future events, and their futurity is pointed out by some other word in the sentence, or by the evident import of the whole. "Next Tuesday *is* the first of April," is a sentence equally proper with "next Tuesday will be the first of April." And we say, without any dread of being accused of vicious diction, "To-morrow he *begins* his journey."

It would be possible for men to convey their meaning on all occasions by indicatives, without any distinction of tenses. The mention of other circumstances might serve to prevent the hearer from confounding the past, the present, and the future. But a sign of general application, consisting either of a separate word, a termination, or a systematic variation of the verb, is an important convenience.

We are not altogether destitute of resources for marking with precision the present tense. Every language possesses separate words for the purpose, such as *now* in English, and the corresponding words in other languages. It happens that, in our language, without the use of such additions, we indicate present time, by employing the substantive verb with the participle instead of the usual indicative. "He writes" is the indicative without tense. "He is writing" is the present indicative. When we say "He writes a good hand," or "He writes to his relations every month," we restrict our meaning to no particular time. But, when we say "he is writing," we describe a present transaction. This distinction is entirely conventional. The original meaning of this combination of words implies nothing to distinguish it from the simple indicative, as the verb "is," and the termination "ing," are, with respect to tense, equally general.

3. *The Preterite Imperfect and Perfect.*

The preterite tenses are of great importance in language; and all tenses by which knowledge is communicated imply a reference to past time. To the past we owe our information. Our efficient communications of knowledge consist in references to the past. Though the present exhibits nature as immediately perceived by the senses, which are the inlets of knowledge, it is by means of the past that we are enabled to form a judgment concerning the objects perceived. On our past experience depend all our judgments and expectations regarding the future. If language consisted essentially in assertion, the past tense would be the original form of the verb. Grammarians state this to be the fact in the ancient Hebrew. In that language the preterite is in all verbs simple and uniform, consisting of two syllables, which are formed of three consonants, with two interposed vowel sounds. The differences of the consonants distinguish the verbs from one another, while the vowel sounds are the same in all. Such are the verbs בקר (*pakad*) *visitavit* כתן (*nathan*) *dedit*. The verb in this form is considered as furnishing roots from which all other words are derived. But those who have concluded, from the concurrence of all the facts in other languages, that the imperative is the original form of the verb, will find no necessity for adopting a different opinion of the formation of that ancient language. The imperative is in it equally simple with the preterite, generally consisting of the same consonants, varied most probably by a variation of the vowels. It has, therefore, on this principle, an equal claim to be considered as the root. In some instances it is shorter: in the verb כתן (*nathan*) it is תן (*then*.) Verbs thus formed are on that account denominated irregular. But the fact, in such instances of the greater brevity of the imperative, shews that the Hebrew in this respect does not differ from other languages. The simplicity and regularity of the preterite, however, in Hebrew, may be considered as a consequence of the important rank which that tense holds in the most prevalent application of language.

In English, the past tense is formed by a variation on the root of the verb as used for the imperative. This most commonly consists of the addition of the termination "ed." Others are formed by variations of the vowels; as "struck" for the preterite of "strike," "wore" of "wear," "bore" of "bear", "drove" of "drive." "I walk," and "I drive," are assertions in the aoristic or present indicative; "I walked," and "I drove," are in the past. This tense implies that an action was begun, and was continued at some past period. It is called the *imperfect*, because no definite relation to the present state of the event is implied in it, and room is left for supposing that the action may be still continued.

When we mean to assert that an action is accomplished, we introduce before the expression of past tense the auxiliary verb "to have" in the present or general indicative. "I have walked," signifies, "I am in possession of the complete act." "I have (by my own exertions) assured myself of its completion."

Some English verbs have two variations of the radical word for expressing past time, "strive," has "strove," and "striven;" "weave," "wove," and "woven;" "break," "broke," and broken;" "do," "did," and "done." The completed act is expressed by the last of these forms, the words "striven," "woven," "broken," and "done." Mr Tooke considers this contrivance as a redundancy, because one word for past time is sufficient for every purpose. In verbs which have the preterite in "ed," the same word is used for the simple description of an event in a train of progress at some past period, and for being conjoined with the verb "have," to signify that the act is completed. The insertion of that verb is sufficient for marking the distinction. "He walked," and "he has walked," are equally distinct from one another as "he did," and "he has done." In some verbs in which the preterite is formed by a change of the vowel, the same simplicity is observed: "struck" is used for both these varieties in the expression of past events.

That form of the past tense which is conjoined with the verb "to have," some grammarians consider as originally and properly the passive participle. In this sentence, "I have driven a nail into the wall," they consider the verb "have" as governing the noun "nail" in the accusative, and "driven" as the passive participle agreeing with the noun. In this form of the past tense, the same word is always used as for the passive participle. Therefore the sentence is considered as signifying in etymological analysis, "I have a nail (which is) driven into the wall," transferred by use and common consent to signify that the action is performed by the individual mentioned in the nominative. This theory receives apparent support from the structure of some phrases in the Italian language, which show that the passive participle is really the word employed, as its inflections are varied and made to agree with the noun in gender and number. Such is the phrase *Ho aperte le vostre lettere*; "I have opened your letter." This analysis of such phrases would have great probability, if the facts uniformly corresponded with it. But it is not a constant rule. It is often left even in the Italian to the option of the speaker. We may say *Ho aperto* or *aperte le vostre lettere*, *e veduto* or *veduta ivi la vostra cortesia*. The French say *J'ai donné*, not *donnée occasion*. *Il a tué*, not *tués*, *ses ennemis*. *Donnè* and *tué* therefore merely signify a past action, and, like any other part of the verb, introduce or govern the subsequent noun. They cannot be considered as agreeing with it like a passive participle. If it is convenient to have a separate name for that part of the verb, it may with sufficient propriety be called a *Preterite Gerund*. The peculiarity of its nature will appear in the most convincing light, when we turn our attention to neuter and intransitive verbs, which, having no passive voice, cannot be said to have a passive participle. When we say "he has gone," "I have come," the words "gone" and "come" cannot be past participles agreeing with nouns, as no nouns are introduced after them. There is no sufficient reason why the introduction of a noun should alter the nature of the word. In the phrase "I have struck," the word "struck" signifies action, and, as a part of the active verb, it may govern the accusative case with as much propriety as any other part of it. When we say "I struck my enemy," and "I have struck my enemy," the word "struck" is in both instances equally active in its meaning. There are certain occasions in which the past participle in the French language is used to agree with the governed noun; but these are altogether peculiar, and cannot give any room for supposing that this is the original construction of this form of the preterite, afterwards transferred to an active meaning; for it only takes place when the substantive noun has been previously introduced, and then referred to by means of the relative *que*. The French say *Il a* TUÉ *plusieurs hommes*; but, *Les hommes qu'il a* TUÉS. This was a subsequent arrangement, admitted after a long discussion of the French academy. There is some affinity betwixt this gerund and the past participle, though their syntax is not identical. Both signify an event completed. The participle is only the past tense, transferred to the adjective or participial application, by which a past action is treated as a quality introduced for describing an object. Its active application is of prior date, and is in constant use.

It is not necessary to treat particularly of the other forms of past tenses, as they are regulated by the same principles, whether they are formed of combinations of words, as in the modern languages of Europe, or combinations of syllables, as in the ancient languages. Some observations connected with the general subject of their varieties will be suggested by certain forms of the subjunctive mood.

### 4. *The Future.*

The signification of the future tense requires no illustration. The remarks which we have to make on this subject will therefore be confined to its etymology. Our conceptions of future events are mere deductions from known arrangements in the past or present, tending to modify their character. Hence all the contrivances for expressing futurity, that can be traced to their origin, are founded on the connection in which the future stands to the past and the present as an effect to a cause. They are derived from verbs signifying resolution, obligation, or other preparatory circumstances, and, with respect to etymology, are equivalent to the words employed in such English expressions as "I intend to go," "I must go," "I am likely to go," "I prepare to go."

Mr Tooke ingeniously derives the Latin future in *bo* from βȣλειν "to will" or "to be resolved." In *ibo*, for example, *i* signifies "go," *b* (from βȣλ) "will," and *o* (from εγω) "I." *Amabo* and *docebo* are formed by annexing the same letters to *ama* "love," and *doce* "teach.". The future in *am* he considers as an adaptation of the radical letters of *amare*, "to love." *Legam* is thus equivalent to *legere amo*, *audiam* to *audire amo.* By those who indulge a general scepticism in etymology, or who have other systems to support, these derivations may be thought improbable, and abundant opportunities are afforded of taking refuge in the obscurity of old derivations. It may be said, if *b* means βȣλω in *amabo*, what is meant by the *b* in *amabam?* Such objections can have no further effect, than to throw discredit on instances of etymology that are somewhat obscure. Let us therefore attend to some which are of recent formation, and which, as the successive steps of their change are easily traced, are superior to all objection. If general principles of analogy are there disclosed, by which the abbreviating contrivances of language have been conducted, the uncertainty of some antique instances is not to be much regretted. The former will also assist us to judge of the degree of probability to be attached to some etymologies otherwise uncertain.

In Italian, the future tense has undoubted marks of a derivation from the verb *avere* "to have." *Partiro* "I shall depart," is evidently derived from *partireho* "I have to depart." This is evinced by the identity of the terminations of the future with those of that verb in the present in all its persons and both numbers. *Ho*, *hai*, *ha*; *havemo*, *avete*, *hanno*: *Partir-o*, *partir-ai*, *partir-a*; *partir-emo*, *partir-ete*, *partir-anno*.

The French future is as evidently derived from the present of the verb *avoir.* In the verb *parler* it is *Je parler-ai*, "I shall speak," *tu parler-as*, *il parler-a*, *nous parler-ons*, *vous parler-ez*, *ils parler-ont*. These are the terminations of the present of the verb now mentioned, *J'ai*, *tu as*, *il a*, *nous avons*, *vous avez*, *ils ont*.

The French language has various modes of expressing futurity by combinations of entire words into set phrases. The verb *devoir*, which signifies to be obliged from duty, is employed for this purpose, as *Je dois faire cela*, "I am to do that." The same verb continues in other instances to retain its full original meaning. The verb *aller* is used for a similar purpose; as, *Je vais lui rendre mes respects.*

In the English language combinations of this sort are the only futures, and they are often used in such a manner as to express something more than futurity. We have thus a beautiful intermixture of their original meaning with their modern application. The verbs "will" and "shall" are most commonly used, but they are not indiscriminately applied to signify futurity. Each of these verbs is employed to signify the resolution of the speaker, or simple futurity, according to certain habits of collocation with certain nominatives. "Will" in the first person, and "shall" in the second and third, signify resolution. Simple futurity is expressed by "shall" in the first, and "will" in the two others. The simple future is as follows:

"I shall," "thou wilt," "he will."
"We shall," "ye will," "they will."

The future of determination is,

"I will," "thou shalt," "he shall."
"We will," "ye shall," "they shall."

The perplexities occurring in the use of these auxiliaries, in consequence of the tendencies of the Irish and Scotch being different from those of the English dialect, which is the acknowledged standard, may be avoided, if we always recollect that it is not the resolution of the *person spoken of* that they are at any time employed particularly to express, but of *the speaker*. "Will," therefore, is employed for simple futurity in the second and third persons, and is even appropriate where an event is mentioned that is opposite to the inclination of the person who is the subject of the assertion. We say, "if you become obnoxious to the criminal law, you *will* be punished." The word "will" does not here imply intention or even consent, yet it is appropriate, because "shall" would imply constraint or authority on the part of the speaker. It is also to be remembered that, in mentioning any thing future with respect to ourselves, although it should be the effect of our intention, this does not render it proper to use the auxiliary verb "will." "Will" in the first person always expresses emphatic resolution, implying the apprehension of difficulty or resistance from others. If another has said, "you shall not," a man replies, "I will;" but in expressing the common acts which are to fill up our future time, we say simply, "I shall go home," "I shall tell you the whole matter when we next meet."

But there are occasions, independently of provincial solecisms, in which "will" may be employed in the second and third person to express the resolution of the person spoken of, and "shall" in the first, the resolution of some other. Observing another person obstinate, we may say, "It seems you *will* do it, and cannot be prevented." If another person has said to us, "You do not admire my friend, but you *shall* treat him civilly," we may reply, "perhaps I may, but you are mistaken in telling me that *I shall.*" These last modes of speaking, however, are awkward, and require an uncommon emphasis to be laid on the respective auxiliaries, in order to express the full meaning of the speaker. It is therefore more elegant to employ more explicit phrases, as, "it seems you *are resolved* and cannot be prevented." "Perhaps I may, but you are wrong in supposing that *I am to be forced.*

Our language, like every other, has various words and phrases which express futurity along with something more, as "I intend," "I am obliged," "I am likely." We have also a phrase for expressing simple futurity in the use of the substantive verb followed by an infinitive, as "I *am to* go," "he *is to* come in my stead." We have the phrase, "to be about," which literally means to be somewhere in the neighbourhood of an action, and is by conventional application appropriated to the expression *of near futurity.*

### 5. *The other Tenses.*

It is unnecessary to consider particularly the other modifications of tense, such as the *plu-perfect*, and the *paulo-post futurum*, or to enter on an analysis of the phrases formed by the combinations of the auxiliaries "have," "do," "shall," "will," "had," "did," "should," "would," "shall have," "will have," "should have," "would have," to which grammarians add "can" and "could," with their combinations. All these are conducted on the same principles with the combinations already explained.

Combinations of meaning, which are expressed in our language by the junction of several words, are expressed in Greek and Latin by means of syllables added to the radical letters of each verb, and forming with them entire words; as *amarem*, "I should love" *amaverim*, "I could love," or "I would love," (translated in our grammars "I may have loved,") *amavissem*, "I should have loved."

Dr Adam Smith, in the comparison which he makes betwixt the ancient and modern languages, considers the former as deriving, from the use of syllabic variations, a great simplicity, compared with those which fulfil the same purpose by means of auxiliary verbs. He thinks it more natural, after men possess a word for representing an event, to express the modifications of that event, in respect to person, number, and time, by altering the word, or giving various terminations, than by inventing separate words for the modifications intended. He considers the formation of a separate word of this kind in the same light with the formation of the substantive verb, that is, as a great effort of abstraction, which could only be the result of refined metaphysical speculation. His observation, however, loses all force, when we recollect that a termination is as really a sign as a word is; and that the general employment of a termination or any other modification, on a number of analogous occasions, is the same kind of mental exertion as the prefixing of a sign of this variation in the form of a distinct word. It is not necessary to suppose that a general word in the form of an auxiliary verb is first contrived and perfected in all its parts, and then applied to use. It may first be used in a single form suggested in a moment of need, while we are using the verb descriptive of the event. It may be afterwards readily transferred to an association with a different verb; and this facility of association is the same, whether it is a subjoined syllable or a separate word. The distinction betwixt syllables and separate words is probably not fully acknowledged till mankind commit language to writing. The fact however is, that verbs, which previously existed as expressions for separate assertions, are afterwards adopted as auxiliaries; a circumstance which removes still farther the necessity of ascribing the invention of them to refined metaphysical speculation.

Dr Smith further considers this mode of expressing the modifications of the verb in the ancient languages as conferring on them a great advantage over the modern languages, in respect of brevity and force. But this brevity is often a deception, arising from the prejudices attached to the appearance of written language. That author adduces as an exemplification of his remark the Latin word *amavissem*, which expresses a modification of thought, which in English requires no fewer than four, being translated by the phrase, "I should have loved." The English phrase, however, is pronounced with equal facility and dispatch as the single word *amavissem;* it consists of the same number of syllables, and these have no greater character of perplexity or tardiness in the one case than in the other. The Latin syllables, in this instance, nearly correspond to the separate English words; *am*, signifies "love;" *av*, "have" with "ed;" *iss*, "should;" an *em*, "I."

Hitherto we have been occupied with those parts of the verb which serve as the copula in the composition of a sentence, and which, in technical language, are called *indicatives*. This appellation, however, if it is not a name for a mere form, if it has any scientific meaning, must be extended to some forms which have usually been considered as belonging to the subjunctive mood, as they are not confined to the purpose of subjunction, but sometimes form the only verb in a sentence: as *Illi potius quam alteri* CREDEREM. MALUERIM *te quam ullum alium imitari. Si cum hoste dimicâsset* PERIISSET. The words here marked in capitals have the full force of the indicative; that is, they convey affirmations; they indicate new connections of ideas, intended to be impressed on the mind of the person spoken to. They are therefore improperly distinguished by the title of *subjunctives*, if this implies that they are fitted only to maintain a subordinate rank in the composition of a sentence. Some further observations will be made on them in the sequel.

### SECT. IX. *The Subjunction of Sentences.*

EVERY improved language possesses various contrivances for the subjunction of certain sentences to others. In every continued discourse, some are distinguished as of greater importance, and holding a more eminent rank than the rest. These others may be equally necessary to the full elucidation of the subject; but their utility arises from their subserviency to the developement of the former. Some sentences are preparatory, and contain propositions which are said to be premised. Others are inserted as constituent parts of more prominent sentences. This last operation may be denominated *subjunction*.

A whole sentence is capable of being used as a noun, and applied to every species of syntax competent to the noun. Sometimes the sentence retains the same form as when it stands unconnected. It may, for example, be made the nominative to a verb. This use of sentences is of frequent recurrence in treating of the subject of language, as in treatises on universal grammar, in which sentences, as such, are the subjects of discussion. We can make a sentence by conjoining the three words "this is right," and we can then make it a nominative to the verb "is" by saying, "*This is right* is a short sentence." We can also make it an accusative to the verb "think," or the verb "say:" "He thinks or he says *this is right*."

Sentences may also be rendered parts of other sentences, by means of slight changes on some of the words composing them, or by the interposition of other parts of speech, contrived either for simple annexation, or for pointing out at the same time the particular relation in which the subjoined sentence stands to the whole.

Subjunction is of two kinds; subjunction to nouns, and subjunction to sentences.

#### 1. *Subjunction to Nouns.*

A sentence is subjoined to a noun, when it is employed for the same purposes of amplification or qualification as the genitive case or the adjective. This is done by using, instead of the nominatives "he," "she," "it," or "they," the relatives "who," "which," or "that;" as in the sentences, "Men who speak little are esteemed prudent:" "A man who commits murder deserves death:" "Men who speak ill of their neighbours are dangerous:" "Men who are capable of hypocrisy are not to be trusted." Here each of the sentences introduced by the relative "who," limits the assertion to a definite part of the general class of beings represented by the nouns "men," or "man."

It may be objected that the words, "who speak little," do not of themselves form a significant sentence. If this is the case, however, it depends entirely on the nature of the nominative "who;" and it may be remarked, that this nominative has the full meaning of the pronoun "he;" "he speaks little" is a complete sentence, though, in order to be made intelligible, it requires some previous knowledge of the person referred to by the word "he;" but the case is the same with innumerable entire sentences in language. "Who" implies the meaning of "he," and something more; it implies a mark that the sentence of which it is the subject is subjoined to a noun, and is thus an entire sentence, with something additional.

The author of the article GRAMMAR, in the *Encyclopædia Britannica*, ingeniously analyses the relative into the preposition "of" preceding the pronouns "he," "she," "it," or their plurals, or oblique cases. When thus analysed, this word "of" must govern, not the pronouns separately, which in fact are sometimes nominatives, but the subjoined sentences to which they belong. He shews that Mr Harris was deceived in supposing that the relative might be resolved into the third personal pronoun preceded by the conjunction "and." The phrase "Men who speak little," may be resolved into "Men *of they* speak little." Readers who are not accustomed to such analyses, and who regard the present habitudes of language as exclusively significant, may imagine that this analysis renders the sentence unmeaning. But, if we could suppose that the preposition "of" were one of those which govern nouns and sentences indiscriminately, we should find that the uncouthness of this paraphrase does not render it unintelligible. To these the words "before and after" belong. We can either say "before his dinner," or "before he had dined." It is sufficiently supposable that our language might have been so constructed as to put it in our power to say, not only "the time of dinner," but "the time of he dines;" and to say not only "men of few words," but "men *of they* speak little." In this paraphrase we shall have an intelligent analysis of the relative.

In sentences thus subjoined, the relative may sometimes be the nominative, as in the examples which we have given; or it may be the accusative; or it may be subjected to any other regimen competent to the noun. We may say, "A man *whom* the world admires." "A man *whose* veracity is unimpeached," or "A man *of whom* all are forced to speak well.

It is also to be remarked, that the noun to which such sentences or clauses are subjoined, may occupy any place in the larger sentence that is competent to a noun; it may form either part of the subject, or of the predicate. We may either say, "The man *who* loves his country deserves honour," or "the world respects Cato as a man *who* loved his country."

When we attempt to reduce sentences to a precise and uniform theory, the following question will arise. Is the verb, when thus subjoined by means of the relative, actually used for assertion? or is it deprived of this power by the relative? and ought the indicative of the verb to be on that account considered as applicable to other purposes besides assertion? It seems unscientific to maintain that the verb, separately considered, performs in this instance a different office, since the whole change of application is produced by the power of the relative. It would be most advantageous to consider the office performed by it in real assertions and in subjunctions of this kind as possessing some character in common, and to consider the modifications to which it is liable as consisting in the differences of the nominatives. If to any of our readers there should seem to be a gap in this part of our theory, we should be happy to have the means of supplying it pointed out. But to us there appears to be no impropriety in calling this general character by the name of *assertion*. An assertion may be first made, and may afterwards be mentioned for the sake of reference. An assertion may be used as the definition of an object. Of this object we may speak, either by a single name, or by using the terms of the definition introduced by the relative "which." It seems rather incongruous to maintain that the definition in that case loses its character of assertion. The most that can be said is, that its office has been previously performed, and that it is now in this respect dormant. Its adaptation to that original application, even in the present connection, is certainly still apparent.

It is worthy of remark, that the place of a sentence thus subjoined to a noun often admits of being supplied by a noun in the genitive, or by an adjective. The meaning expressed by the phrase, "A man who is capable of hypocrisy," may be expressed by the phrase, "A hypocritical man;" therefore a new theoretic question arises, does the adjective "hypocritical" imply the copula used in assertion? Nay, the whole meaning may be condensed into a single noun. Instead of either of the preceding phrases, we may say, "A *hypocrite* is not to be trusted." Does the noun "hypocrite" imply an assertion? Then it will follow, that the office of assertion is not peculiar to the verb, but is included in the noun itself. This is so far true, that every noun is susceptible of a definition containing the indicative or asserting form of the verb. A noun signifying a compound idea may be defined by an enumeration of the parts of which that idea consists. A noun signifying a simple idea may be defined by pointing out the relation of that idea to various others, whether by resemblance, connection, or contrast.

In the progress of human knowledge, combinations and distinctions of ideas are created, which are at first expressed in propositions and afterwards by single words; and these words are not understood till the processes of thought which gave origin to them, and which were first expressed by asserting propositions, are comprehended. Condensed signs, however, are not attached to all the results of these mental processes. This is only done when they are to be frequently referred to or treated as the chief subjects of discourse. When only occasionally mentioned, they are expressed in a more circuitous manner. Instead of a single word, we on some occasions use a noun with an adjective, as "an honest man," "a faithful servant;" or a noun governing another in the genitive, as "a man of consequence," "a man of probity," "a member of parliament." Sometimes these modes of annexation are accumulated, as, "a wealthy citizen of London," "a man of the highest reputation." On other occasions, when the combination of ideas is less familiar, we describe an object, by attaching to a noun a regular sentence by means of the relative, thus; "a man *who* has, in a certain circle, the highest character for understanding."

Sometimes the relative is employed to introduce a sentence which is not intended to form a descriptive definition of any object, but part of a narrative conveying new information; as, "Peter, *who* had all the time *listened* to my words, now presented himself before me." This has the same meaning with two sentences connected by the conjunction "and," viz. "Peter had all the time listened to my words, and now presented himself before me." The obliquity which this use of the relative produces is but slight, and promotes an elegant variety of diction.

### 2. *The Participle.*

In the use of the participle we have a method of subjoining a descriptive sentence to the noun, which, with respect to briefness and extent of regimen, is intermediate betwixt the use of the adjective, or of the genitive case, and that of the relative. It resembles the adjective in the manner in which it is introduced, but always follows the particular verb to which it belongs in the regimen which it possesses as introductory to other words. Hence it is capable of annexing a train of ideas to the noun. We say "a case *bearing* an analogy to the preceding;" "a man possessed of fine sensibility;" and, in a mathematical theorem, "the square of the side of a right angled triangle *subtending* the right angle is equal to the sum of the squares of the other two."

After the remarks which we have made on the possibility of resolving the meaning of any noun into a definition, we can have little difficulty with the participle. It is obviously resolvable into an indicative sentence introduced by the relative: "A man walking" is resolvable into "a man who walks."

A designation formed by the annexation of the participle to a noun, differs from the use of a noun which contains the whole meaning, by approaching nearer to the form of assertion. It prominently exhibits the analysis of that meaning which in the corresponding noun is more condensed, and, like the relative with the indicative mood, it enables us to extend considerably our specifications.

The participle may, like the relative and the indicative of the verb, be used for immediate assertion, as well as for definition. Thus Hume says of Charles V. "At last the emperor, *dreading* a general combination against him, was willing to abate somewhat of his rigour."

We formerly observed that the indicative mood of a verb might be resolved into the participle with the copula: that "he walks" might be resolved into "he is walking." And we have now remarked, that the participle may be resolved into the indicative mood introduced by the relative; that "a man walking" might be resolved into "a man who walks." The indicative is of earlier origin, and therefore less complex than the participle. The participle is an ulterior accommodation in language, though, when once contrived, it has in some respects no greater complexity than an adjective, or the genitive case of a noun.

Participles are varied in their form and meaning, as they often express something more than the subjunction of the general meaning of a verb to that of a noun. They are employed to express time, and also to give either an active or passive character to the object expressed by the noun.

There are in most languages two participles, one of which has been called the present participle active, and the other the perfect participle passive. The former is distinguished in English by the termination "ing:" the latter, sometimes by a change in the vowel of the verb, but most frequently by the termination "ed."

The participle in "ing," however, is often used without any implication of tense, and therefore may be applied to the past or the future, as well as the present. When we say "Yesterday, the public attention was excited by an aeronaut ascending;" if the word "ascending" were necessarily present, it would contradict the expression of past time contained in the verb "was." Grammarians avoid that absurdity, by observing that the act was present at the time expressed by the verb, and therefore may be mentioned in the present tense, as the principal verb of the sentence gives its own tense to all the subordinate words. But this statement will not apply, otherwise we might as well use the expression, "The public attention was excited by an aeronant who *ascends*," or "who *is ascending*." And we might say, "I thought that he *ascends* in a beautiful style." These phrases would be condemned as not only chargeable with bad grammar, but with incongruity and absurdity. It is therefore necessary to allow that the participle in "ing" is not restricted to any tense.

This participle, though generally active, is not confined to that voice. It is passive in such phrases as the following. "The house is *building*." "I saw a man *carrying* to prison." "I heard of a plan *forming* for his rescue." "A large sum of money is *owing*." The French sometimes use the passive participle *du* on the same occasions on which the English use the word "owing."

The participle in "ed," and others called perfect participles, belong essentially to the preterite tense. But with respect to voice they are not exclusively passive. The words "gone," "landed," "departed," "strayed," "decayed," "well behaved," "drunk," "mistaken," are active participles. The participle in *us*, corresponding to it in Latin, is also sometimes active; as in *tacitus* "silent." Although these words may appear to express quiescent qualities, they are such qualities as the action produces in the agent, and not in an object acted on.

### 3. *Subjunction to Verbs or to Sentences.*

An assertion is sometimes employed for the purpose of being subjoined to a verb. This is for the most part effected by the interposition of the parts of speech commonly called conjunctions, and which are to be considered in the sequel under the name of sentential prepositions.

Some assertions introduced in this manner are subjoined to the verb by a regimen bearing an exact resemblance to that of a noun governed in the accusative. The conjunction "that" is indeed interposed; a word not expressive of any particular relation, but merely a general sign of subjunction. Its sole office in this application is, to shew that the sentence which it introduces is subjoined. It is ingeniously and justly considered by Mr Tooke as the same word with the *pronoun* or *adjective* "that." Their identity of form is not the effect of accident, which sometimes produces an ambiguous coincidence in signs, which are of different origin, and intended to perform totally different offices. This is merely an instance of a word single in its origin and meaning, and applied on different occasions. It is in fact an adjective, agreeing with the sentence as a whole. In the sentence "I believe that he is come," we take the subjoined part "he is come" as an object, and say with respect to it "I believe that." Hence it is in Latin *quod*, which is also the relative: or *uti*, or *ut*, which Mr Tooke with great probability derives from the Greek word ὅτι. This last is closely connected in its etymology with the article ὁ, ἡ, το, and the relative ὅς, ἡ, ὅν, and is in reality the neuter gender of ὅστις. The circumstance of being made introductory to a sentence is a variety of application. Hence it is on some occasions of this sort subjected to a variation in its form. When placed before a sentence, it is commonly called a *conjunction*, and thus is ranked along with some other words which have a similar destination. This form of subjunction is extremely familiar in all sorts of language, colloquial, historical, and poetical. "I hope *that* you are well." "The general saw *that* the enemy was too powerful for an attack in the open field, and concluded *that* it would be more prudent to harass him by the well-timed operations of partisans." In our language the conjunction is sometimes dispensed with: as, "I hope you are well." All these instances, whether introduced by the word "that" or not, as well as the corresponding ones in Latin and Greek, are placed in the same situation with a noun in the accusative. Thus, in the following Latin phrases, the verbs *dicit*, *vult*, and *timet*, have the same regimen. *Quid dicit? Dicitne nihil? Dicit quod sapis. Quid vult? Vult ut huc venias.—Quid timet? Timet ne discedas.*

This mode of subjunction is sometimes performed by the infinitive of the verb. "I suppose him to be sincere" is equally good English with "I suppose that he is sincere." In Latin it is far more common. *Dicit te sapere* is more agreeable to common use than *Dicit quod tu sapis.* This interchange of phraseology will be more particularly illustrated under the head of the infinitive mood, which will be delayed till we have finished the consideration of some other parts of speech subservient to the same end.

Sentences are also subjoined to verbs by the medium of conjunctions signifying particular relations. Some of them express hypothetical representation, as "if," "suppose," "provided;" others causation, as "because," "since;" others concession, as "though," "granting;" others time, as "while," "when," "after," "before;" others alternation, as "whether," and "or," (not the same application of the word "or" which is made of *vel* in Latin, but one corresponding to the Latin *an.*) These words, like the preposition, are interposed betwixt the verb and the words standing for the governed object, and they express a specific relation of the one idea to the other. They bring along with them various modifications of the form of the verb which they introduce. These will come into view under the next head, the Subjunctive Mood, which has received its name from the frequency with which it is thus applied. We shall naturally be led to inquire into its various forms and uses as compared with those of the indicative, and thus trace the comparative adaptation of both to the purposes of subjunction.

### 4. *The Subjunctive Mood, and other Forms of the Verb allied to it.*

The moods of the verb are different in different languages. Sometimes a mood in one language comprehends two or more of those in another. One of the most frequent is the subjunctive, such as it exists in the Greek, Latin, and French languages. In the English it is sometimes expressed as the indicative, sometimes by means of auxiliaries. The various applications of it, and the variety of translations which its parts receive into English, as adapted to the occasions on which it is used, render it a matter of some interest to discover what properties are common to it on all occasions. It so happens that we have exactly that number of varieties of it in Latin which corresponds to the number of the tenses in the indicative, and hence they have been distributed into tenses under the same names; the present, the preter imperfect, the preter perfect, the pluperfect, and the future.

This mood has been called subjunctive, from the circumstance of its being used in assertions which are subjoined by the relative and by various conjunctions. But this office is not peculiar to this mood. It is sometimes performed by the indicative, preceded by the relative or by some of the conjunctions, such as "before," "after," "when," "where," "while," "if," and the words by which these are translated into other languages. On some occasions of subjunction the two moods are used indiscriminately; *Si hic adest*, and *Si hic adsit*, are equivalent. We also, say, *Qui vinum amant*, or, *Qui vinum ament.*

It is equally true that the subjunctive mood is not restricted to this office, but may with equal propriety be on certain occasions used indicatively, that is, for expressing the leading assertion in a sentence; as, *Si cum hoste dimicásset*, PERIISSET. In this instance, the subjunctive mood in Latin when used subjunctively is translated into the English indicative, "if he *had* fought with the enemy," whereas that which conveys the assertion, which is the ultimate object of the sentence, receives a peculiar translation by means of the auxiliaries "would have:" *periisset* "he would have perished." This is remarkable in most instances, though not in all, of the translations of Latin subjunctives into English. When used subjunctively, they are translated by the English indicative; when used indicatively, they are translated by a peculiar phraseology.

They are translated indicatively, when introduced by the words, *qui, quoniam, cum, quanquam, si, etsi, quasi.* This takes place in all the tenses: *si venias* "if you come;" *si venires* "if you came;" *si veneris* "if you have come;" *si venisses*, "if you had come;" *si veneris* "if you shall come."

On some occasions they are translated into English by peculiar auxiliaries. *Uti* or *ut*, and *ne*, are the words which chiefly give rise to a translation different from the indicative in the subjunctive mood which they introduce, and this takes place only in the present and preter imperfect: *ut eas* "that you may go:" *ut ires* "that you might go." Yet *uti* appears to have originally been equally extensive in its meaning with the word "that," by which it is translated. It is not merely applied to denote the *purpose* of an asserted event, but to intimate other forms of subjunction: as *odisti ut amas*, "you hate as you love;" *ut veniebat* "as he came," or "when he came." *Ut* with the present and preter imperfect subjunctive, (as *ut amet* and *ut amaret*,) may be supposed to have been originally fitted for any general subjunction, and afterwards applied to express the subjunction of a purpose; or, *ut* may have been adopted for variety as a synonymous word with *quod*, in order to introduce a more special phraseology by performing a certain department of the same office. *Ut venias* may originally signify "that you come," and may be used as a noun in the ablative. *Quâ causâ hoc mihi dixisti? Hâc causâ, ut iterum venias.* In English, the same word "that" by which *quod* is translated is on such occasions used for translating *ut*, but the verbal expression is then varied by the introduction of the auxiliary "may." The production of the effect is expressed by the production of the *power*. This is sufficiently natural, as the effect implies the power. It is an accidental pleonastic idiom, probably adopted for the sake of distinguishing this form of subjunction from the form of it expressed by the particle "that" with the simple indicative.

The same observations apply to the introduction of the imperfect subjunctive in Latin, by means of the word *ut*. It gives the verb the same relation to the past which the former gives it to the present. It expresses the purpose, and it is to be remarked, that in both instances it renders the verb in the subjoined phrase significant of something subsequent in order and in time. The tense called the present subjunctive when introduced by *ut* is future, and the imperfect expresses something subsequent to a past event.

The present and the future subjunctive are sometimes used imperatively: as, *audiant meum sermonem*, "let them hear my discourse;" *doceas filios sapientiam*, "teach your sons wisdom." These have every appearance of being instances of ellipsis, in which *obsecro* or *precor te ut* is understood. The Italians often use the *infinitive* imperatively; as *non stringere la mia mano cosi*, "not to grasp (that is, "do not grasp") my hand so tight." This part of the verb expresses the simple act, or a connection which may be subjoined to another part of speech; and custom assigns to it the additional circumstances conveyed, as suited to the different occasions on which it is introduced.

The future subjunctive is applied imperatively, most probably on the same principles as the future indicative, and it is often translated by that part of the English verb; as *ne occideris*, "thou shalt not kill" The Latin phrase has however the additional advantage of being originally subjunctive, and thus possessing the same fitness to be used imperatively by ellipsis as the present tense of the same mood.

All these tenses are also occasionally used indicatively, and the application of them is so contrived that they express some modification of the simple assertion.

This more rarely happens with the present than with the others. Yet we have instances of such an application. Thus, in the ninth book of the Æneid, Nisus says to Euryalus,

*Si quis in adversum rapiat casusve Deusve*
*Te superess* VELIM.

"If chance or Providence should render the enterprise unfortunate, I wish (or I should wish) you to survive."

In like manner, in the 7th book, Juno, dismissing Alecto from the superior regions, says,

*Te super æthereas errare licentius auras*
*Haud pater ipse* VELIT *summi regnator Olympi.*

This part of the subjunctive, when thus employed, is translated by the auxiliaries, "can" "may," "should," and "would," and generally refers to future events.

The preter-imperfect subjunctive, when used indicatively, is translated by "should "or "would." *Illam si amaret, in matrimonium* DUCERET, "If he loved her, he would marry her." The preterperfect is used on similar occasions, and translated in the same manner. MALUERIM *illum quam ullum alium imitari,* "I would rather imitate him than any other man." It is a remarkable circumstance, that these three subjunctive forms, called the present, the preter-imperfect, and the preter-perfect, when used indicatively, are often applied to the future. This cannot be considered as accidental; for, when translated into the English language, which adheres to no form of expression as an appropriate version of the Latin word, but varies it as occasion seems to require, they retain the form of the past tense "would," and "should," even when the event spoken of can apply only to the future. It might therefore seem interesting to inquire what peculiarity the meanings of these expressions have, which should render them analogous to the past tense. We clearly see that there is a foundation for such an inquiry, when we advert to the import of some English phrases. "I may go," and "I might go," are radically future in their application. "I should go," is equally future with "I shall go," though not otherwise synonymous. "I can go," and "I could go," are also future, as applied to the verb "go." The analysis of these phrases is comparatively easy, as they consist of auxiliaries. We at once recollect that the future of a verb may be expressed by the present of a verb preceding it signifying preparation for futurity; and, as the present is only one instant, and therefore has been said by some metaphysicians to have no existence, we consider it as including some adjoining portion of time, (most generally a part of the past,) at least as great a range as gives us scope for that short exercise of memory which we confound with consciousness, and which is necessary for reviewing any event and enabling us to describe it. There seems to be no impropriety in describing by a past tense a present action at least that is to be discontinued. If the present may be thus delineated, it follows that the verb preparatory for the future may also be used in the preterite tense. "I might go," is future, as applied to the verb "go," though the preterite of the verb "may." For the purpose of tracing the source in this phraseology, it is of importance to observe that "may" and "might," which are different in their own tense, impress different characters on the future event which they are employed to introduce. Both of them express an uncertain or conditional futurity. But "may" signifies a state of greater preparation, and expresses a belief in the probability of the condition being obtained, and the consequent contingency taking place. "I may if you will," expresses greater readiness than "I might if you would." The latter phrase is either a hesitating way of intimating that we are partially prepared, on which account it would on some occasions be reckoned less polite; or signifies a hesitation, originating in our modified hopes respecting the condition, and then it is a more diffident manner of making a proposal. But the question recurs, why should the past tense be preferred for this uncertain mode of speaking of futurity? We should be happy to present a satisfactory solution of that problem. Although we had none to offer, we should have thought it unfair to decline stating the query. Perhaps this form of expression is used, because these uncertain expectations consist of images which possess the same sort of dimness with any object which retires to a distance in time or place, and consequently with an event which fades from the view by taking its place among ideas of distant recollection. Or, if this explanation is objected to as a refinement too subtile to have given origin to expressions so common, perhaps the choice of the past tense of the auxiliary on such occasions has proceeded from its signifying that the state of things preparatory for the future is discontinued: this want of extension to the present may conventionally be held equivalent to a less confident mode of representing a contingent futurity. But, though this explanation of the English phraseology now under review should be thought in some degree plausible, it might still be asked, How are such principles to be applied to the Latin subjunctive tenses? Do these tenses imply in their etymological structure all the force of the English auxiliaries? Did they possess that force in the intentions of the persons by whom they were first employed? Or are they mere general modes of stating a connection of ideas applicable to conditions and other subjunctions, as well as to conditional assertions? The difference betwixt these two methods of explaining them is perhaps merely verbal. If the subjunctive is an instrument intended to be applied indiscriminately to all connections of ideas, whether actual or hypothetical, the purpose fulfilled by it is the same, whether it consists in the want of some character belonging to the indicative, or in the possession of a superadded character, including the meaning of an additional sign. Even if it were acknowledged to be of subsequent invention, and on the whole more complicated in its form than the indicative; this is to be accounted for, not by its expressing more ideas, but by its later use, as applied to the purposes of human language. The English auxiliaries express something indefinite with regard to the events described; and the same thing is done by the subjunctive form of the Latin verb. But the variety of the English auxiliaries, as applied to translate the same Latin word, leads us to regard the Latin subjunctives as of less special meaning, and therefore partaking more of the character of general marks of annexation, which admit of being applied to a variety of purposes, the particulars of which are left to be inferred from the tenor of the discourse. If we knew the etymology of the ancient subjunctive forms, some light would be thrown on their history, but very little on their intrinsic nature. Words derived from the names of particular kinds of objects often become much more general; and, though they receive subsequent limited applications which render them again particular, they do not denote the same kinds of objects by which they were first suggested. The expedients adopted for varying general signs, and fitting them for expressing different particular meanings with precision, are entirely arbitrary, and often consist in an advantage taken of accidental original synonymes. This last stage of variation is that which has given the Latin language the form in which it is found in the writings of the classics. The varieties of phrase are not in general founded on corresponding differences in the direct etymological origin of the words. The indicative uses of the subjunctive mood therefore may on the whole be considered as elliptical.

The pluperfect subjunctive, when used indicatively, expresses a conditional assertion concerning the past. This is the meaning of it in the example already mentioned, *periisset*, "he would have perished." Sometimes it may be translated by "ought to have." Thus in the fourth book of the Æneid, after Dido's voluntary death, her sister says, *eadem me ad fata* VOCASSES, "You *ought to have* invited me to share your fate." This is a conditional preterite, and may be considered as implying "If this had been the character of past events, all would have been well." The past is subjoined to an implied regret, and resembles such an ellipsis as the following English phrase. "If I had but seen him before he died!"

The future subjunctive is justly considered as differing slightly in tense from the future indicative, by expressing the "future completion of an event." But it is not on that account deprived of the peculiar character of the subjunctive mood; nor can we think, with some, that it differs from the future indicative in tense alone. It is not used, in general, for the simple and unconditional assertion of this species of futurity. It is not probable, for instance, that it would be used for expressing the assertion in the following sentence: "As soon as you have finished your letter, I *shall have* finished mine." That the tense in this sentence may be literally expressed in Latin, the passive voice is preferred, as it supplies an indicative tense of this sort by the combination of the future indicative of the substantive verb with the past participle. *Quum literas tuas scripseris, meæ etiam* FINITÆ ERUNT. This combination is denominated in our grammars a future *subjunctive* of the passive voice. The cause of this denomination is, that it is similar in tense. It unquestionably belongs to the indicative mood, while the others coupled with it in our grammars are subjunctive. The future of the subjunctive is indeed like its other tenses used indicatively; but like these others it is limited to uncertain and hypothetical assertions.

The subjunctive mood of the verb is on the whole a generic form applied chiefly to two less general uses, viz. subjunction, and the assertion of uncertain or conditional connections betwixt different objects. The property which these two uses of the verb have in common is uncertainty. There is one use of this mood which we have not hitherto mentioned, as it did not require to be separately illustrated, to wit, interrogation; as in this phrase, *An sit quies scelerato?* This will be considered as an instance of subjunction by those who allow, what we shall afterwards more fully state, that an interrogative sentence implies the imperative of the verb "to tell." *Quis est* signifies *Dic mihi quis est*. From this it follows, as well as from the obvious nature of a question, that uncertainty is also involved in that application of the subjunctive. Its imperative application has been already stated to be an instance of subjunction by ellipsis.

In Dr Gregory's memoir *On the Theory of the Moods of Verbs*, contained in the 2d vol. of the Edinburgh Philosophical Transactions, there are some apposite observations on the application of the subjunctive mood to a great variety of phrases mutually analogous, which had occasioned some difficulty. That author considers the moods of the verb as formed for giving a direct representation of the feelings, intentions, or present actions of the speaker, and resolves them into a variety of affirmations in the first person singular. *Oro* or *jubeo* is, according to this theory, implied in the imperative; *dico*, in the indicative; *opto*, in the expression of wishes, and a variety of others on different occasions, as suited to the various applications of the subjunctive. From the great diversity of feelings and purposes which may actuate a speaker, he infers that the real moods are too numerous to be expressed by separate modifications of the verb without rendering language cumbersome and complicated; but that those which are most common are expressed in this manner, for the sake of giving a condensed force to the utterance of human thought.

The view which we have given of the moods of verbs, and of language in general, differs from the principles now mentioned. We have considered language as not originally directed to the object of expressing spontaneously and naturally our own thoughts. It executes our purposes, by arranging the signs of thought in that order which is in our opinion best fitted to influence another person; an object which may be sometimes most successfully accomplished by concealing our own sentiments. To express our mode of thinking is indeed a very frequent object of language, and naturally has certain contrivances adapted to it; but to tell that we are speaking or asserting, seems to constitute no part of its object in addition to the use of the signs fitted for performing that office. The author, therefore, acknowledges that his principles have not so full an application to the indicative as to the other moods.

With whatever degree of vehemence or delicacy men wish to express their feelings, they are provided with means adapted to their object. Significant gestures and tones independent of language may be employed. When it is thought proper to exhibit the same animation in the form of written language, syllabic imitations of involuntary exclamations are committed to writing, and are afterwards employed by rule. We sometimes execute the same purpose by placing our communicable ideas in such a point of view as tends to produce in others the feelings which occupy our own minds, sometimes by describing in more deliberate and explicit language the manner in which we are affected. Language is on other occasions fitted for expressing the feelings of the speaker by elliptical turns of phrase, in which more is at first meant than is verbally stated. These phrases are afterwards appropriated to the expression of specific feelings. Moods of the verb which were originally of a more general meaning may, by transpositions of words, or by an abruptness in the manner of their introduction, be subjected to such diversities as to become characteristic of the most vehement, the most rapid, or the most subtile modifications of sentiment. For example, instead of telling that we wish for the occurrence of a particular event, we may express the ardour of our wishes by the exclamation "oh." "Oh that he would return!" Or, without such an exclamation, we may say, "That he would return!" or, "That he would but return!" The Romans may be supposed to have at one time been in the habit of using the word *uti* in this manner, *Uti rediret!* But as this might have been ambiguous from being too general, and might be supposed by the hearer to signify some purpose entertained in the performance of another act, as, *uti rediret, veniam ei polliciti sunt*, another particle *nam* is introduced, to indicate that this kind of event is abruptly mentioned as an object of the wishes of the speaker. It may not be easy to shew why a particle equivalent to the English word "for" was preferred to any other; but, when habitually used in this connection, it becomes appropriate. It is thus that *utinam* becomes equivalent to "oh that," or "I wish that."

The Greeks have an optative mood adapted to the expression of wishes, though it appears not to be applied exclusively to that object.

The brevity and force thus created by means of the moods of verbs are effects of the contrivances of language which abound in all the different parts of speech. When a combination of ideas or an assemblage of thoughts or feelings becomes habitual, it receives an appropriate condensed expression. We complain of tediousness when an idea, which might have been expressed by a single word or a short phrase, is slowly brought out by means of a long series of words or of sentences. But when we have an unusual assemblage of ideas to express, no circumlocution is to be spared which may be necessary to give our language perspicuity, and the beauty of felicitous contrivance is often conspicuous in the invention of means for exhibiting thoughts, which servile imitators would either not have conceived, or not have attempted to express. Language is happily used, where those phrases and words which are rendered intelligible and appropriate by established usage are employed judiciously for expressing complicated ideas. They may be placed in a connection with each other fitted to create combinations which are still more complicated, and possess a character of novelty which is rendered necessary by the purpose of our discourse. In fine, the skill of a writer may occasionally be discovered by the use of simple signs, in such a fortunate succession as to the express, apparently by accident, some novel but well defined state of feeling and of thought. The expedients suited to these purposes are therefore not confined to the use of particular moods of the verb, and the act is not characteristic of their nature.

### 5. *The Infinitive Mood.*

We had occasion, in describing other parts of speech, to mention the *Infinitive* of the verb. We observed, that it is not an original word, nor the earliest form of the verb, but consists of the imperative in composition with a sign derived from some different source. In explaining the uses of the subjunctive mood we observed, that in the Latin language that mood with the introductory particle *ut* may have its place supplied by the infinitive. *Volebat ire* is equivalent to *volebat ut iret.* We shall now enquire more particularly into its nature and uses.

Both its etymology and application shew that it expresses merely the specific idea conveyed by the particular verb to which it belongs, in such a way that it can be used as a noun, by becoming the subject or predicate of a sentence, or part of either. It does not, like the indicative, appear to contain the copula, except when substituted for that mood by ellipsis, as it frequently is by Sallust and other authors in depicting scenes of bustling activity or striking interest. Hence it has by some been denied the properties of the verb, and considered as in all respects nothing more than an abstract noun. It is formed in Latin by adding to the radical letters of the verb, as existing in the imperative, the termination *re.* From *ama* we have *ama-re;* and from *doce, doce-re.*

This termination, being identical with the radical letters of *res* "a thing," seems to be exactly the same original sign, and in this application it retains the same meaning. *Ama* signifies "love;" *ama-re*, "love-thing," i.e. "love" considered as "a thing," or object of thought. In English the infinitive consists of the radical letters of the verb preceded by the word "to;" as "*to* love" and "*to* teach." Mr Tooke considers the infinitive as possessing the character proper to the verb, though he does not tell us in what this consists. He describes the word "to" as having the power to confer the verbal character on a noun. At the same time he considers it as originally the same with the verb "do," and as meaning "act," "effect," or "consummation." These suggestions are extremely obscure. It is not easy to conceive what influence the additional idea of "effect" or "consummation" could have, to impress the character of a verb on a word which is otherwise a noun. We must therefore leave the opinions of that author in the same ambiguous state in which we find them. On some occasions in the English language this prefixed word is dispensed with. As "we saw him *go* away," and "we bid him *write* to us when he arrived at the end of his journey." In whatever light the infinitive mood of the verb may be considered, we find that this form of it, as existing in the English language, has the same meaning and uses with the words formed by such terminations as the Latin *re*, and receiving the same appellation in other languages.

The following is the question which claims our present attention. Is the infinitive mood of the verb properly and in all respects a noun? Is *amare* "to love," for example, a word of the same signification and uses with *amor amoris* "love?"

We shall obtain the most advantageous view of the nature of this part of speech, by taking in detail a survey of the circumstances in which it resembles the noun, and those in which it deviates from it.

It resembles the noun in being used as a nominative to a verb; as in the following Latin sentence from Cicero, as well as in the translation of it into English: *Loquor de docto homine et erudito, cui* VIVERE *est* COGITARE. "I speak of a man of learning and erudition, for whom *to live* is *to think.*" It is also, like the noun, capable of being governed by an active verb; as *Oblitus est* SCRIBERE, "He has forgot *to write.*" On some rare occasions in the Latin language, an adjective is employed to agree with it as with a noun. Thus Cicero says, *Cum* VIVERE *ipsum turpe sit nobis;* also, *Totum hoc displicet* PHILOSOPHARI. Persius says, VELLE *suum cuique est.* Petronius, *Meum* INTELLIGERE *nullâ pecuniâ vendo.* In these instances *vivere* is used in the same manner as *vita*; *velle* as *voluntas; philosophari* as *philosophatio*, if such a noun existed; and *intelligere* is used as *intellectum*, the accusative of the noun *intellectus.* Sometimes it is employed as the genitive of a noun; thus Cicero says, *Tempus est* ABIRE, a phrase equivalent to *tempus est abeundi.* Sometimes as an ablative. Thus in Plautus, *Ego sum defessus* REPERIRE, *vos defessi* QUÆRERE.

In other respects, however, it differs from the noun. The concordance of an adjective with it in the manner now mentioned is a rare occurrence even in the Latin language, and does not take place in the English and others. The additional idea which the adjective would express is connected with the infinitive by a different sort of syntax. In Latin, *meum intellectum*, or *meam intelligentiam*, is more consonant to general usage than *meum intelligere.* We should not in that language say *bonum intelligere.* If *bonus* were employed, it would be along with *intellectus*, or some other noun; and, if the infinitive *intelligere* were employed, the additional idea would be conjoined by means of a part of speech which we have not yet considered, the adverb; in this instance, *benè intelligere.* In English we should not say, "my to understand," but "my understanding;" nor "a good to understand," but "a good understanding," or "to understand well."

When an agent is mentioned along with an action in the infinitive, it is not in the form of a noun in the genitive, as it would be if the act were expressed by a noun. We do not say *illius amare*, as we should say *illius amor*. Nor is it put in the nominative. Though we say *ille amat*, we do not say *ille amare*. The syntax of the infinitive is in this instance peculiar; the agent is put in the accusative: *Illum amare*. This arrangement does not arise from the regimen of a preceding word expressed or understood governing the noun in the accusative. The combination of the noun in this form with the infinitive sometimes constitutes a phrase which is used as a nominative to a verb. In the Greek language this combination is sometimes even used as a noun in different oblique cases in which it has an adjective agreeing with it. Thus Anacreon says,

Σὺν Τῼ δε ΠΙΝΕΙΝ ῾ΗΜΑΣ
Εὔδουσιν ἁι μέριμναι.

The accusative here only intimates that the noun and the infinitive occupy the place of a subjoined sentence. In English, when the phrase is to bo employed as a nominative to a verb, we use the noun preceded by the particle "for," which may be reckoned equivalent to an oblique case in Latin. We say, "*for a man to tell a lie* is a sign of cowardice." We sometimes find this differently expressed in low and provincial dialects. "To," for example, is employed instead of "for;" as, "*To you* to deceive me was unbecoming." At other times the noun in the objective case is used without any preposition, as, "But *him* to think that he was entitled to any credit was ridiculous."

When an *object acted on* is mentioned in connection with an act expressed by the infinitive, or when the name of an object referred to, and usually governed by a verb in some oblique case, is introduced, it is not put in the genitive as when it follows a noun signifying the same action. In this respect the infinitive retains the regimen of the verb to which it belongs. We say *amor uxoris*, for, "the love of one's wife," or, if the person entertaining this affection is already mentioned in the genitive, the object of it is introduced by a preposition in such a phrase as *amor illius erga uxorem*. But when the infinitive *amare* is used, it governs *uxorem* in the accusative. We say, *Illum amare uxorum*, "for him to love his wife." Sometimes an ambiguity might thus be created, because both the agent and the object are mentioned in the same case, and, on account of the common practice of inversion in the Latin language, the order in which the words are placed does not strictly follow that of their syntax. Hence the ambiguity of the famous response of the Pythian oracle to Pyrrhus, *Aio te Romanos vincere posse*, which admits of being translated, "I say that you can overcome the Romans," or "I say that the Romans can overcome you." In general, however, the connection renders the meaning of such sentences evident, and their perspicuity is assisted by the name of the agent being placed before the infinitive, or nearest to it, while the accusative signifying the object acted on either comes after, or is at a greater distance before it. The same thing takes place in the English language, although in it the infinitive differs a little in its mode of formation, as it consists of the prefixing of a separate word. When we use the noun "desire," we say, "the desire *of food*," *of money*," or "*of fame*." But "*to* desire *food*, *money*, or *fame*." The production of this mode of transition seems to us to be the great power conferred on a noun by the word "to" prefixed as the sign of the infinitive. In this therefore, according to Mr Tooke, the nature of a verb should consist. It might appear, however, that this is not common to all verbs, and therefore is not the characteristic circumstance which, when added to a noun, makes it a verb. In neuter and intransitive verbs it scarcely appears. Yet it is not always lost even in these. Every verb admits of a transition of discourse to some other ideas expressed by nouns, if not by direct regimen, yet through the medium of prepositions, and this is generally more or less altered when a word from being a noun receives either the form of assertion, so as to become a verb, or is transformed into that part of speech called the infinitive of the verb. Let us take, for example, the word "struggle," which is used both as a noun and as a verb. We say, "his struggles were strenuous and incessant." When we use it as a verb, we say, "he struggled with a powerful antagonist." We often also use such expressions as, "His struggles with his antagonist were obstinate." But in this last phrase we are conscious of a slight defect; and, although the brevity and manifest meaning of it may in general enable it to pass without censure, an accurate writer will prefer the introduction of a verb for the purpose of completing the series of words demanded by the syntax. It will be felt more strictly agreeable to the import of the different materials of language to say, "the struggles *which he maintained* with his antagonist were obstinate." It is also to be remembered, that even the least transitive verbs differ from nouns by having all qualifying ideas conjoined with them, not by adjectives but by adverbs, and that in this particular the infinitive mood follows the law of the verb; we say, "a *violent* struggle," but "to struggle *violently*." It is only in these peculiarities of transition, and in receiving adverbs instead of adjectives, that we can perceive any difference betwixt the infinitive of a verb and the corresponding noun. The former of these differences depends, in a great measure, on the character of particular verbs, and both of them seem too slight to confer on the infinitive the same rank with the asserting verb, and to divest it of the character of a noun. This is more especially the case when we consider that it is often used without an adverb, and without any such transition as has now been described, but is never independent of some character of syntax which is common to it with the noun. With this statement of the facts, we leave the argument to the consideration of our readers. We deprecate, in the mean time, any premature attempt to improve, in this or any other instance, the nomenclature of grammar.

The infinitive mood, in consequence of resembling in some particulars the noun, and in others the verb, is rendered fit for performing, in a manner peculiar to itself, the office of the subjunction of sentences to verbs. It may be made a question whether connections of words formed by means of it ought to be called sentences; but they certainly contain the meaning of sentences. We have already remarked that every noun may be resolved into a sentence, by means of a definition. But by the use of the infinitive, we have the parts of the sentence in a more distinct state than if they were all implied in a noun, though not so explicitly as in a definition, or even in a sentence formed by the subjunctive mood. It has thus a character intermediate betwixt the noun, with its regimen of genitives or the accompaniment of adjectives, and such subjoined sentences as have been already described. The same connection of ideas may be expressed by any one of the three following modes of diction.

1. By nouns alone, as in this sentence, "he wishes his son's *departure*."

2. By the infinitive mood, as when we say, "he wishes his son *to depart*."

3. Or by a sentence subjoined in the subjunctive, thus, "he wishes *that* his son *would depart*."

Here the verb "to wish" is that to which the other ideas are subjoined; and the verb "to depart" is that which is variously implied in the subjoined series of words.

The preference of one of these to another will sometimes be dictated by convenience, according as the intention of a writer is to study brevity, or to indulge in minuteness of detail; and sometimes there will be so little foundation for any particular preference, that the choice will be left to fancy, to habit, or to the love of variety. Sometimes a sentiment expressed in one of these modes in one language requires a different one when translated into another. *Credo te sapere* may be translated "I believe you to be wise;" but *dixi te sapere* cannot be translated "I said you to be wise;" the infinitive is here to be laid aside, and instead of it, a sentence must be subjoined by means of the word "that." "I said that you were wise."

We generally find it more eligible to use an infinitive than a noun, when we have occasion to connect with the meaning of the word any considerable variety of circumstances. We say "murder is a heinous crime;" but when we mention the agent and the object, we prefer using the infinitive mood, we say, "for a son *to murder* a parent is a heinous crime." This is a more complete expression than "the murder of a parent by a son." Indeed this last phrase evidently requires a verb or a participle to make it complete; thus, "the murder of a parent *committed* by a son, is a heinous crime;" and, as this makes the phrase verbose and tedious, it is better to say, "for a son to murder a parent is a heinous crime." In the Latin language, this idea would be most conveniently expressed by the subjunctive mood preceded by the particle *ut*. *Ut filius parentem interficiat nefas est*. It is but seldom that the mention of the agent is combined with the use of the infinitive, when the combined phrase is to be made the nominative to a verb. Such expressions as *filium interficere parentem nefas est*, are sometimes used, but they are inconvenient and ungraceful, and therefore not common.

The infinitive mood is varied in respect of tense. That form which is called the present infinitive is in reality of no tense. It is pure, absolute, and aoristic. It may be employed without the implication of time, and it admits of being applied equally to past, present, and future transactions. The remarks which we have made on that part of the *indicative* mood called its present tense, will suggest sufficient proofs of this fact; and the subjects are so nearly analogous, that it is unnecessary to bring forward particular illustrations of this point.

The infinitive in the past tense is, in the Latin language, fully expressed by the termination *isse*, which is nearly allied to the pluperfect subjunctive, a circumstance probably arising from the coincidence of their use as consisting in a subserviency to subjunction.

The future infinitive, both in Latin and in English, is formed by circumlocution. In Latin the general infinitive of the substantive verb is, for this purpose, conjoined with the future participle. *Iturum*, or *iturus esse*. In English it is constructed on similar principles. We say "to be about to go." We sometimes merely use the general aoristic infinitive after a verb which implies a reference to futurity, as "I expect him to go." In expressing such ideas, however, we frequently reject the infinitive as not well fitted for our purpose, and in its stead employ a sentence in the future indicative, subjoined by the word "that;" as I expect that he will go."

Similar principles are discovered in the formation of the tenses of the infinitive in the passive voice.

### 6. *The Gerund and Supine.*

The *Gerund* is a part of speech nearly resembling the infinitive, but tending more strongly to the noun, both in form and syntax. Like the noun, it is governed by prepositions, which the infinitive, at least in the Latin and English languages, is not. We say "much harm is done to the constitution *by drinking*." In Latin this idea is expressed by the ablative of the gerund (*potando*.) The infinitive is sometimes thus used without a preposition, as in a passage already quoted from Plautus, *Ego sum defessus reperire, vos defessi quærere*; but the gerund is, in almost every instance, better adapted to such purposes. Such passages contribute to show to what extent the infinitive may be used as a noun; but the infrequency of that mode of employing it, and the frequent use of the gerund, prove to us that differences in the forms of words, or parts of speech, often consist in a different extent of adaptation to particular purposes, and that the characters of some pass almost insensibly into those of others.

The gerund differs from the infinitive in not admitting the mention of the agent in equally close syntax. It does not even, like the noun, admit of the annexation of this or any other idea by a genitive or an adjective, nor has it any power analogous to that which the infinitive has of taking an accusative before it, to signify the agent. The gerund therefore is employed only when no mention of the agent is required, or when this is done by connecting it with some other word in the sentence, as when we say "*men* hurt themselves *by drinking*."

The gerund takes the regimen of the verb with respect to the nouns which it introduces. In Latin we say *potando vinum*; and in English, "by drinking wine." The same word may however be also used as a noun, and then it may take an adjective and govern the genitive; as "by *the* drinking *of* wine." The difference betwixt the word in "ing," in these two modes of employing it, is analagous to the difference betwixt the Latin gerund in *dum*, and the noun in *-tas*, or in *atio* or *itio*, formed from the verb. Instead of the preceding phrase, we may employ *potu*, or *potatione vini*. The Latin word called the gerund also admits of being used as a noun; we can say *potando vini*, as well as *potando vinum*.

The gerunds now mentioned have no accident of tense conjoined with them. We formerly observed, however, that the preterite form of the English verb, as used after the auxiliary "to have," has the nature of a preterite gerund. "Gone" is the name of an act completed. In the phrase "I have gone," it occupies the place of a noun governed in the accusative. In verbs of the transitive kind, while it is thus governed, it governs in its turn another noun, in the same manner as the other parts of the verb to which it belongs. We say "I have *given* them my promise." This is the nature of the word separately considered; but it is never used as a gerund in any other connection, and therefore grammarians have neglected to ascertain its proper character.

The word called a *supine* in the Latin language is, in structure and use, similar to the gerund, though not possessing all its inflections, and more limited in its application.

## Sect. XII. *Interrogation.*

Interrogation is a part of the object of language, performed by means of the verb, which remains to be considered. We have mentioned it (at p. 7.) in enumerating the forms of imperative influence which mankind, by means of language, exert on one another. Its peculiar object is, to obtain information from the person addressed. Mr Harris considers it as a modification of the use of the verb, and constituting a distinct mood, although the verb when thus applied should not possess a distinct form. It is a direct request, and therefore implies the imperative in a very prominent degree. "What is your name?" is another mode of saying "tell me your name." Interrogative words and interrogative arrangements of words are abbreviations implying the subaudition of the imperative of the verb "to tell." "Who is there?" means "tell me the person who is there."

Interrogative words implying a request for the particular mention of one circumstance that must be *selected* as true, from many others that are imaginable, have a close etymological connection with the relative, and sometimes consist of it unaltered. *Quis* in Latin is different from *qui*, but is evidently derived from it, and the variation which it receives is intended to intimate that the imperative of the verb "to tell" is understood; or rather it is so altered as to express this imperative distinctly and fully. In the Italian language, we have an instance of the employment of a different sort of word; "what do you want?" is expressed by *cosa volete?* which literally translated is "thing you want." But on most other occasions, in every language, the interrogative words are more or less allied to the relative. From *qui* in Latin, we have *quis? qualis? quando? quo? quorsum?* and from "who," and "which," in English, the words "when?" "where?" and "whence?" are evidently derived.

There are other questions which may be denominated *alternative* in their nature, because the speaker supposes two opposite statements, one of which must be true and the other false. A subject and a predicate are connected in a question, and the only reply that it admits of is, either an assertion of a connection betwixt the subject and this predicate, or betwixt it and a predicate which is completely the reverse. This may be also done by single words of affirmation or negation, rendered completely significant by their reference to the question. Interrogations of all kinds, however, imply the meaning of the imperative of the verb "to tell." The words of which they consist are a sort of subjoined sentences to this imperative, and are in some degree elliptical in their first creation, though generally rendered precise by receiving a peculiar form.

## CHAP. VII.

### *Of Adverbs.*

The term *Adverb* is considered by Mr Tooke as expressive of no character by which a part of speech can be distinguished. He considers the adoption of it as an artifice by means of which, under the colour of scientific order, grammarians have brought together a variety of words, originating in abbreviations and corruptions, and possessing in no other respect any common property. In this opinion we cannot acquiesce, although we are sensible that some confusion has arisen from the unskilfulness of grammarians in ranking among adverbs some words which ought to have been included under a different head.

Adverbs are words expressly formed for the purpose of subjoining an idea to that which is contained in an adjective or a verb. They are all capable of being annexed to verbs, and some of them to no other part of speech. From this circumstance the whole class has derived its designation. They never express an idea in so close subjunction as a noun governed by a verb in the accusative; they rather resemble nouns which are governed in the ablative, or phrases consisting of a noun with a governing preposition. They sometimes are employed to qualify the character of an idea expressed by an adjective or a verb. At other times they superadd some circumstance of relationship to objects which are capable of being separately conceived.

We cannot concur with those recent grammarians, who consider as instances of corruption the formation of adverbs by means of alterations made in the forms of words belonging to different parts of speech. They are words skilfully devised for fulfilling a definite object. They do not, as has been supposed, always arise from abbreviation. Although they are capable of being expressed by a plurality of words, this property is common to them with all parts of speech. Some of them are evidently abbreviations, while others have marks of being used as single words previously to any phrases into which they can be resolved. We have not even any demonstrative evidence that all of them are derivatives, and that none are original words.

Adverbs are divided into different species. Some express intensity, remission, or other modifications of attributes expressed by adjectives and verbs. Such are the adverbs "very" and "much;" as "very good" "much better," "much obliged;" also their comparative and superlative forms, as "more" and "most." The words "slightly," "little" "less," and "least," are of a similar nature. Some have considered the comparative and superlative degrees of nouns as condensed combinations of adjectives in their positive state with the adverbs "more" and "most," because they can be resolved into phrases thus constructed. "Richer" and "richest," are "more rich" and "most rich." But these adverbs may in their turn be resolved into other phrases containing adjectives. "More" is "in a greater degree," and "most" "in the greatest degree;" and, from the first consonant being common to them with the positive adjectives *magnus*, *multus*, "many," and "much," and their terminations being characterised by the consonants *r* and *st*, it appears evident that "more" and "most" are derivatives. The Latin word *maximè* is evidently derived from *maximus*, in the same manner as a great variety of adverbs is derived from adjectives.

Adverbs expressing modifications of qualities are generally derived from adjectives. Such are adverbs in *è* and *iter* in Latin, as *longè ingenuè*, *breviter*, *feliciter*. In English they are formed by the addition of the termination "ly," as in "shortly," "considerably," "wonderfully." This termination seems, as Mr Tooke remarks, to owe its origin to the word "like," of which it is an alteration, or, as he terms it, a corruption. It is sometimes used as an adjective termination in composition with a substantive, as in "princely," "kingly," which mean "prince-like" and "king-like." The adoption of it for distinguishing the adverb is entirely conventional, and the most profound investigation of its meaning will not lead us to a satisfactory conclusion on the nature of this part of speech. Yet the use made of this termination, and the nature of the adverb, are sufficiently apparent. They imply a notification that the idea expressed by the compound word is to be annexed in syntax, not to a substantive noun, but to an adjective or a verb. They are also capable of being attached to other adverbs; as "very nobly," "surprisingly well," "too uniformly."

The adverbs just mentioned are called *adverbs of manner*. Some of them merely express a general reference, and have the same relation to the words called demonstrative pronouns which others have to different adjectives.

Such are the adverbs "thus," "so," and "as." In Lancashire, instead of "thus" and "so," it is common to say "i' this'n," and "i' that'n."

There are numeral adverbs as well as adjectives. Such are "once," "twice," and "thrice." These belong to the cardinal numbers, as expressing repetition. There are also adverbs which signify a mere reference to repetition, such as "first," "secondly," and "thirdly," and belong to the ordinal.

There are adverbs of local situation, as "here," "there;" and of local aspect, as "hence," "thence," "hither," "thither," "upward," "forward."

Adverbs of time, as "now," "formerly," "soon," "afterwards," "immediately."

It is unnecessary to enlarge on the nature of these words, or to point out the phrases into which they are resolvable, and of which they often are abbreviations.

The adverbs of *Affirmation* and *Negation* have been reckoned different in their nature from all the others. When the subject, the predicate, and the copula, are arranged in the order of assertion, no separate word is necessary to affirmation; but sometimes an adverb is conjoined, to call the attention of the mind with greater emphasis to the truth of the assertion. Such are the adverbs "indeed," "truly," and "certainly." If a question is asked which admits of an answer by the simple affirmation or negation, the answers in the affirmative may be given in English by such adverbs as "certainly," "even so;" or in Latin by *etiam*, *imo*, or *utique*. Sometimes a peculiar word, and one which is never used as an adverb in a sentence, is applied to this object. The English word "yes," is of this kind. "Yes," is considered by Mr Tooke as derived from *ay-es* "have" or "enjoy," and meaning "have or entertain that belief." The English "yea," the German *ja*, and the corresponding words in the northern languages, are derived from a similar source. It is therefore to be considered not as an adverb, but as an abbreviation for a sentence. The adverb "certainly," and others equivalent to it, become by ellipsis contractions for the same sentence. If we keep out of view the etymological origin of the words used on such occasions, and consider them all as containing an equally full expression of the meaning of the speaker, we must reckon them abbreviations for sentences; but wherever they are introduced into the body of a sentence, they are adverbs possessing the same properties as other words of that class. They signify that the assertions to which they are applied are not hypothetical, but in conformity to the nature of things.

The negative adverb expresses the absence of this conformity. The same word is in some languages either used singly as an answer to a question, or annexed to a verb in the formation of a sentence. The Latin words *minimè*, *nequaquam*, and *non*, are used in both of these ways. But in English the word is on these occasions subjected to a slight change. The adverb is "not." The negative answer is "no." This last is said to be of prior date, and derived from a verb signifying "I deny," or "I am averse;" but, whatever its etymological origin may be, it is, like the word "yes," a contraction for a sentence, with this difference, that the sentence for which it stands implies the force of the adverb "not," and thus reverses the meaning. "Not" has the same general character with the other adverbs: it modifies the verb, and thus forms part of the predicate.

A negative sentence is the reverse of the corresponding affirmation. Yet there is no general difference of character betwixt affirmations and negations. Affirmations are often as directly opposite to each other as to negations. "He is without," and "he is within," are directly contrary. Many assertions can be made equally well in the negative and in the affirmative form. "He is at home" is an affirmative sentence, and the same idea is expressed by these negations, "He is not from home," and "He is no where but at home."

## CHAP. VIII.

### *Of Prepositions.*

Differences of opinion have been entertained on the nature of *Prepositions*. It is easy to give a character which will apply to them all; but it has been found difficult to give one which will apply to them exclusively. Mr Tooke has been considered by some as solving every difficulty, by pronouncing them abbreviations of nouns or verbs. This author shews that many of them are of the same nature with some of those words which are called conjunctions, and considers that circumstance as proving the inaccuracy of this instance of grammatical distinction. In so far as *the idea expressed* has been represented as a ground of distinction, this author is correct. But when we abandon that system, and take the circumstances of syntax as the foundation of our classifications of words, we shall find that some distinctions which were formerly improperly accounted for are referable to satisfactory data.

The classification of the short words called particles appears to us defective, and we shall in the present instance introduce a slight variation from the common usages of grammarians. We shall apply the term preposition to a more extensive genus than our predecessors have done, by including under it some words hitherto called conjunctions. Those words which are usually called prepositions, we distinguish by the appellation of *Nominal prepositions*, because they are introductory to nouns; and the others by that of *Sentential prepositions*, because they are introductory to sentences.

### Sect. I. *Nominal Prepositions.*

Nominal *prepositions* have been described by many grammarians as "words which signify the mutual relations of objects." But these relations are equally expressed by every part of speech. Mr Ruddiman with greater propriety describes the preposition as "An indeclinable part of speech signifying the relation of one *substantive* to another." We prefer saying that it signifies "a relation subsisting betwixt the idea expressed by one substantive noun and that expressed by another." It is to be observed that, with the exception of the preposition "of" in English, and some rare expressions already alluded to under the head of the genitive case, a verb, adjective, or participle, is interposed between the first of the nouns and the preposition. The preposition "of" is as frequently employed immediately after a noun in English as the genitive case is in Latin; but such phrases as "Newcastle-*on*-Tyne," and "Ashton-*under*-line," are in very small number. The prepositions "on," "under," and all the others except "of," subjoin a noun to an adjective, a participle, or a verb; as "fit *for* use," "good *at* singing," "depending *on* his fidelity," "connected *with* the government." "He has gone *from* home, *along* the road, *to* a distant place."

Mr Tooke has shewn great learning and ingenuity in proving that the prepositions, both in ancient and modern languages, are derived from nouns or verbs. *Chez* he derives from *casa*, "a house." *Avec* from *avez que*, "you have that:" *Sens* in French, and *senza* in Italian, from *assenza* "absence:" The Latin *sine* from *sit ne*, i. e. *ne sit*, "let it not be:" The Italian *fuori*, the Spanish *affuera*, the French *hors*, (formerly *fors*,) from the Latin *foris*; and this from the Greek word θυρα, in the Doric dialect φορα, "a door or gate." "Through" is derived from a Teutonic word *thuruh*, signifying "a door or passage." *Ad* he derives from the past participle of the verb *agere*, by these steps of transmutation, *agitum*, *agtum*, *agd*, *ad*. He considers the English "to" as the same word with the verb "do;" and "till" as derived from "to while." "For" comes from a Gothic word signifying "a cause;" "of" from *afora*, "progeny;" "by" from *be-on*, "to be;" "with" from *withan*, "to join;" "betwixt" from the imperative "be," and *twos*, the Gothic word for "two." "Before," "behind," "besides," are from the same imperative, conjoined with nouns which are either still separately used, or have left familiar traces in different forms. "Beneath" is from an old word *neath*, signifying "bottom;" "under" from *on* and *neder*; "beyond" from *geond*, which has the same meaning with "gone" or "past." The termination "ward," which is used both in forming adverbs and prepositions, is from the Saxon verb *weardian*, "to look at," which also gives origin to the word "regard." "Athwart" comes from *thweorian*, "to wrest or twist;" "among" is from *gemengan*, "to mix;" "along" means "on long," i. e. "on length;" "round" and "around" come from a word signifying "a circle;" "near" from *neahg*, "neighbouring;" "instead" is "in station," or "in place;" "down" is from *dufen*, "to dive or dip;" "up," "upon," "over," "above," he derives from *ufa*, "high." The same sort of investigation has been with considerable success applied to the Greek prepositions by Mr Bonar, in the 5th volume of the Transactions of the Royal Society of Edinburgh, and by Professor Dunbar in a separate work on the subject.

The grammatical system founded on these etymologies is in a great measure the contrivance of Mr Tooke. Some of his etymologies have been called in question by Mr Bonar and others. The author of the article Grammar in Dr Rees's *Cyclopædia* attempts to controvert the greater part of them in support of a different system, in which he traces the modern languages of Europe to an Oriental origin. Some of Mr Tooke's etymologies however are unquestionable; and it is of great importance to observe, that the author has shewn that all prepositions are resolvable, *with regard to their meaning*, into nouns or verbs. The same ideas may be expressed by all these parts of speech. This property is independent of any opinion that may be formed regarding their particular etymology. "From," for example, may have its place supplied by the noun "beginning." "The figs came from Turkey," means "The figs came *beginning* Turkey." "The lamp fell from the ceiling," "The lamp fell *beginning* the ceiling. "The lamp hangs from the ceiling," "The lamp hangs *beginning* the ceiling."

Mr Tooke's opinion was, that prepositions represent objects in the same manner as nouns. This is denied by other authors, who proceed on the presumption that nouns are the names of *things*, but prepositions the names of the *relations* of things. And some have derided the absurdity of pronouncing things and their relations to be the same. It might however be maintained that, as variety is essential to the existence of human knowledge, its objects wholly consist in relations. If there should be any difficulty in conceding that point, it ought to be remembered, even in a grammatical view, that the relations of things may be expressed by nouns as well as by prepositions, and that therefore no distinction betwixt these two parts of speech can be founded on such data. Mr Tooke, however, is not content with observing this coincidence betwixt nouns and prepositions. He considers prepositions as invariably derived from *concrete* nouns, or verbs containing these, and insists that they are the names of substantial material objects. The preposition "through," for example, being according to him derived from a word signifying "a door," carries along with it the full meaning of that concrete noun. This statement has been supposed to favour the system of materialism, and perhaps it was so intended; but it is in itself too inaccurate, or at least imperfect, to lead to any general conclusion. If the whole meaning of the concrete noun is retained in the prepositions thus derived, it is only in the form of allusion. A language is not pure and perfect till the allusion itself disappears, and till the word is employed to express an appropriate and well-defined degree of generality, independently of the concomitant ideas contained in the subject from the name of which it has been borrowed. "Through" expresses only one property of a door, and a property in which it resembles many other objects which have different names. This preposition is indeed equivalent to a noun, but it is to a more general one than that which suggested the term. The noun to which it is nearly equivalent is "passage," or "medium."

It is from its properties in syntax that the preposition must take its rank among the parts of speech. In this respect it deviates from the noun. When, instead of the preposition, we employ simply a substantive noun, as in the examples formerly mentioned, in which the noun "beginning" was substituted for the preposition "from," the sentence labours under an awkward chasm. The meaning may be fully understood, but it appears to be imperfectly expressed. There seems to be as great a deficiency as if in an affirmative sentence we should omit the copula, saying, like a lisping child, or an unpractised foreigner, "That man good," instead of "that man is good." In order to complete the syntax, we must either use an additional word along with the noun thus substituted, or supply its place by a different part of speech. The force of those Latin prepositions which govern the accusative is, on the whole more completely expressed by a word which has the regimen of an active verb. This character will apply to all the prepositions of the English language, as they all govern the noun in the same form. Those Latin prepositions which govern the ablative must be considered as less transitive in their regimen. (See our observations on the Ablative Case, at p. 23.)

The part of speech to which the preposition is most nearly allied in the mode in which it is introduced, will differ according to the sort of words to which it is immediately subjoined. When it is subjoined to a verb, the verb will govern it nearly in the same manner as it governs the gerund of another verb in the ablative. *Trans* will be represented by *transeundo*; *per* by *perforando*, or *permeando*. The English preposition "from" might be represented by the Latin gerund *linquendo*; the Latin *a*, *ab*, or *abs*, by *abeundo*. The prepositions imply no such specification as is signified by any of the verbs with which, for the sake of pointing out the properties of their syntax, we have here combined them. It was necessary to make gerunds by combining them with verbs, and thus appearing to add to the ideas which they express rather than to explain them, because we have no verb exactly corresponding to the simple preposition. The preposition itself is the gerund, though indeclinable.

If the preposition is introduced by the substantive verb alone as the first word of the predicate, it will possess the syntax of a participle agreeing with the nominative which precedes. *Sub* will have the regimen of *subjacens* or *subjunctus*. *In* will approach to the participle *habitans* or *in-*

*clusus*, though more general in the idea which it conveys. "Out of," when used in such a sentence as "He is out of town," will also have the power of a participle, though we cannot name any word in that form to which, with respect to generality, it makes any approach. This cannot always be expected. If the office of a preposition were to be performed with equal advantage by the gerund or participle of a verb in present use, there would be in some respects no occasion for the prepositions themselves.

Here we trace the peculiarities of this part of speech. It is usually more general than any other to which it is allied. It is marked by a peculiar brevity, and by the absence of inflexion. Without the formality of significant terminations, prepositions possess all their force. They thus correspond to the rapidity of human thought, and to the subordinate rank of the ideas which they convey. They have been called the pegs and nails of language. This account of them is severely censured by Mr Tooke, and is inaccurate when intended to intimate that they differ from other words in not expressing ideas. Yet it is certainly true that the ideas which they express might often be left to be inferred from the other words of the sentence. They are not the central ideas in discourse. The preposition *secundum*, "according to," implies all the ideas expressed by the noun "harmony" or "agreement;" the word "from" those expressed by the noun "beginning;" "above" those of the noun "top;" "below" those of the noun "bottom." But such ideas are never interesting on account of any general properties of their own. We never have occasion to write dissertations on "tops," "mediums," "beginnings," "endings," "outsides," or "insides." Yet the frequent recurrence and consequent familiarity of these ideas, together with their subordinate character, render it desirable for us to express them with rapidity, by endowing them with all possible brevity of form. Words possessing this character render language copious and minute without incumbrance. They are the Ε'πεα πτερεεντα, the winged words, of discourse. Whether we consider them as always derived from other parts of speech of greater length, which a large proportion of them undoubtedly is, or suppose it possible that they have occasionally consisted of syllables thrown in at random, and afterwards adhered to as significant, in the same manner as almost all original words must have been produced, we see, in their general form and application, their excellent adaptation to the completion of language.

## Sect. II. *Sentential Prepositions.*

The *Sentential Preposition* is a sort of words generally numbered among conjunctions, and forming in elementary grammars more than one half of that list. But the conjunctions, as thus classified, are not susceptible of any common definition; and this proceeds not merely from their coincidence in use with words of a different kind, but from their dissimilarity to one another. That this disadvantage may be diminished, if not entirely remedied, we here give a separate consideration to those words which have the power of introducing subjoined sentences in the same manner as the words called prepositions have with respect to nouns. We denominate them *sentential prepositions*, in contradistinction to the others, to which we have given the designation of *nominal*. In some instances the same word serves for a preposition of both kinds. "After" is a nominal preposition in the phrase "after dinner," and a sentential preposition in the phrase "after we have dined." In other instances the word employed as a nominal preposition undergoes some slight alteration, or receives some addition, to distinguish its application as a sentential preposition. The Latin *cum*, ("with,") sometimes retains the same form when used for subjoining a sentence, and sometimes is transformed into *quum*. *Ante* and *post* are converted into *antequam* and *postquam*.

The nature of the general sentential preposition "that" in English, and *quod* and *ut* in Latin, has been already discussed. *Quam* is another, like these, of very general meaning. It is sometimes translated "as," sometimes "than." It then performs the part of a relative, and has the same relation to an antecedent adverb which the relative noun has to the noun antecedent. *Quam* has the same relation to *tam* as *qui* has to *ille*. *Tanquam*, from *tam* and *quam*, may be called a sentential preposition, but it differs from *quam* in being more particular, as including the antecedent adverb. Of this last kind are also the sentential prepositions *antequam* and *postquam*. *Antè* and *post* are used adverbially, and the Roman authors often disjoin them from the subsequent *quam;* as, Ante *autem huc venerat* quam *sperâssem*. It might appear that *quam* should be considered as giving the subjoined sentence the character of a noun, and the word *ante* or *post* as a preposition governing or introducing it in that state. It is however more agreeable to the analogy of language to consider *ante* and *post* as adverbs, and the compound words *antequam* and *postquam* as synonymous with *anteaquam* and *posteaquam*, formed from the adverbs *antea* and *postea*. Adverbs in general might be resolved into nouns in the ablative case; and a special sentential preposition, or one which implies the meaning of an antecedent adverb, would, on this principle, be resolved into the ablative of an antecedent noun and that of the relative. *Antequam* is equivalent to *tempore* ANTERIORE *illi tempori* QUO. *Ut* is also used as a relative; *sic* is often its antecedent when it introduces the indicative mood, and *ita* when it introduces the subjunctive. *Ut* has sometimes in itself the force of *sicut* or of *ita ut*, and, when no antecedent adverb is expressed, may always be considered as implying by ellipsis the meaning of one. The sentential prepositions *dum* and *quum* have the same relatien to *tum;* "when," "while," and "where," to the adverbs "then" and "there." The resemblance and near relation subsisting betwixt "when," and the adverb "then," have led many grammarians to give to both the common designation of adverbs. *Postquam*, *antequam*, and other analogous words, have also been denominated adverbs; and thus the whole of this part of grammar has been involved in confusion: but we shall see the difference clearly if we recollect that the words now mentioned are not attached to verbs to modify their meaning, or exhibit in themselves any concomitant circumstance, but to introduce a subjoined sentence. The word "as" is used both for an antecedent adverb, and a sentential preposition. It is an adverb in the phrases "*as* good," "*as* soon," and a sentential preposition after the adverb "so," "He did not come so soon *as* I expected." All special sentential prepositions might be resolved by an analysis similar to that which we have given of *ut* and *antequam*. We have not antecedents in the form of adverbs for them all, but we may express them by ablatives of nouns or of gerunds. *Si*, "if," implies the meaning of *ea conditione*, *eo casu*, or *supponendo*. *Quanquam*, *etiamsi*, *etsi*, "though," "although," (words of nearly the same meaning with *si*, and differing slightly in the occasions of their application,) imply the force of *concesso* or *concedendo*.

It is in fine to be observed, that the special sentential preposition and the sentence subjoined by it, taken as a whole, occupy the place of an adverb, or of a noun in the ablative case. In some instances we find single words in this form equivalent to such sentences. *Citò* is equivalent to *priusquam multum temporis preterierit*. In the following sentence, "He was appointed to the office *till the propriety of the continuance of that measure should be ascertained;*" the whole subjoined ideas marked in italics may be fully expressed by the single adverb "provisionally." When *ita* is used without any subjoined regimen, it is an adverb implying a reference to some assertion previously made, or some connection of ideas exhibited at the instant of speaking: When it is employed as the antecedent to *ut*, with a subjoined sentence, the whole sentence along with the *ita* and *ut* occupy the place of an adverb, or the ablative of a noun.

The following is Mr Tooke's account of the etymology of some English words belonging to this part of speech. "If" is from *Gif*, the imperative of *Gifan* "to give." The old synonyme "an," from *Anan* "to grant." "Unless," from *Onlesan* "to dismiss." "Though," from *Thafigan* or *thafian*, to "allow." "Without," from *Wyrthanutan*, to "be out." "Lest," from *Lesan*, "to dismiss." "Since," from the participle of *Seon*, "to see." "As" is *es*, a German word for "it," "that," or "which."

Some words are used as sentential prepositions which still retain the form of gerunds or participles; as "supposing," "provided," "providing that," "granting that." "Seeing," was formerly used in the same manner.

## CHAP. IX.

### *Of Conjunctions and Miscellaneous Particles.*

*Conjunctions* connect words or sentences on equal terms, without regimen or subjunction. They continue the syntax of the introducing word to that which they introduce. General words of this description are not numerous, and the purposes to which they are applied do not admit of great variety. One kind of them may be termed *Conjunctions of union*, as they unite the meanings of the words which they connect. Such are the English word "and," and the Latin *et*, *ac*, *atque*. Another kind may be termed *Conjunctions of alternation*, as *aut* and *vel* in Latin, and "or" in English. The negative "nor" is a conjunction combined with a negation. It might appear in its etymology the reverse of "or," but in meaning it is the reverse of "and." It is equivalent to "and not." In Latin this is also its etymology. It is not *non vel* or *ne vel*, but *nec* from *ne ac*, and *neque* from *ne* and *que*.

Sometimes the first of the nouns or verbs connected by conjunctions is preceded by a peculiar word. "Both" is used to precede words connected by "and;" "either" those connected by "or;" and "neither" those connected by "nor." It is natural to ask to what head "both," "either," and "neither" are to be referred. In the English language, their etymology might strongly lead a grammarian to refer them to the class of adjectives when they precede nouns, and thus make them equivalent to *ambo*, *uter*, and *neuter*. When they precede verbs, they might be reckoned adverbs, and in English would be equivalent to adverbs formed by adding the termination "ly" to the adjective, as if we said "bothly," eitherly," neitherly." They perform the office of an adverb referring to concomitance. In Latin the same word is used both as the preceding and the conjoining word. Et *ille et alter;* Et *venit et vidit.* It will be found, on the whole, that conjunctions are near akin to adjectives and adverbs. They are necessarily frequent in the use of language, and therefore have received an abbreviated form.

Some miscellaneous particles may be called *special conjunctions*, as including a more particular character of mutual relation betwixt the ideas contained in the words or sentences which they connect. Such are the words "also," "farther," "moreover," "but," "likewise," "yet," "notwithstanding," however."

## CHAP. X.

### *Of Interjections.*

The term *Interjection* is applied to those words which express by short exclamation certain overpowering emotions of mind. Such as *'Αι αι! Heu! Atat! Proh!* "Ah!" "Oh!" "Alas!"

This part of speech is treated by Mr Tooke with great contempt, as a brutish inarticulate sound which has as little to do with speech as the neighing of a horse, the barking of a dog, coughing, groaning, shrieking, or any other involuntary convulsion with oral sound. These words, however, though at first involuntary, are afterwards uttered from design. A man desirous of impressing another with a particular passion, first contrives to excite it in his own mind, and then utters the sound by which it is expressed. Hence corresponding syllables are committed to writing in works which depict human passions and manners. They belong to language, as language must include every sound addressed by one man to another, from the highest to the lowest state of mental cultivation. Interjections may be considered as a mixture of involuntary expression with social discourse. In the use of this part of speech, man is seen to rise from the character of an animal impelled by passion to that of a reflecting being, who displays intelligence and address in influencing his fellow creatures.

Sometimes words belonging to other parts of speech, and expressing definite ideas, are introduced abruptly to express emotion, and numbered among interjections; as "Amazing!" "Wonderful!" "Prodigious!" "Shocking!" "Horrible!" "Mercy!" "Pitiful!" "Woe's me!" Whether we call such exclamations as these interjections, or abbreviations by ellipsis, is of little importance. Their meaning is never ambiguous.

In the introductory part of this article we described language as essentially imperative; and the slightest reflection will shew, that interjections, in so far as they partake of the nature of social discourse, possess an imperative character.

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Books of merit on universal grammar are but few. But numerous observations on the subject are to be found in all good and complete grammars of particular languages, and in the larger Dictionaries. Some parts of it are also occasionally discussed in books of metaphysics. The principal English and French works on this subject are the following: Monboddo's *Treatise on the Origin and Progress of Language*; Harris's *Hermes*; Beauzée's *Grammaire Générale*; *Grammaire Générale et Raisonnée*, par M. M. de Port Royal; Condillac's *Grammaire* in his *Cours d'etudes*; Tooke's *Diversions of Purley*; Beddoes *on the Nature of Demonstrative Evidence*; Pickbourne's *Dissertation on the English Verb*; Mr Dunbar's *Analysis of the Greek Verb*; Dr Gregory *on the Theory of the Moods of Verbs in the* 2d vol. of the *Transactions of the Royal Society of Edinburgh*; Mr. Bonar's *Essay on the Greek Prepositions*, in the 5th vol. of the same work; Dr. Jamieson's *Hermes Scythicus*; Beattie's *Essay on the Theory of Language*; Hutton's *Dissertation on the Theory of Language*; Dr Adam Smith's *Essay on Language*, (published with his *Theory of Moral Sentiments*); Mr Stewart's *Philosophical Essays*, Part I. Essay 5th; and the article *Grammar* in the *Encyclopædia Britannica*, and that of Dr Rees.*

* The Editor is indebted for this valuable article on Grammar to Henry Dewar, M. D. F. R. S. E.

GRANADA, a celebrated city in Spain, and capital of the province of that name, is pleasantly situated on two small hills, at the extremity of a beautiful and extensive plain. It was built by the Moors in the tenth century, and was finally reduced by the Spanish armies in 1492, after a siege of more than twelve months. At that period it is said to have covered a space three leagues in circumference, and to have contained 400,000 inhabitants, a statement unquestionably far above the truth. Its walls were defended by more than a thousand towers; and it was farther protected by two fortresses, on the summits of the two adjoining hills, each of which was capable of containing 40,000 men. These fortresses still remain, but the walls and gates of the city are demolished, and many of its finest structures in a state of decay. It nevertheless exhibits evident proofs of its former magnificence; and its appearance from a distance is described as peculiarly majestic. The plain before it is above 30 leagues in circumference, and about 1200 miles above the level of the sea, but so completely inclosed by mountains of stupendous height, as to have all the appearance of a delicious valley. It is watered by five rivers, and intersected by numerous rivulets and canals; covered with the richest meadows, forests of oak, plantations of orange trees, and sugar cane, fields of corn and flax, orchards of fruit-trees, and all kinds of vegetables; bounded on the north by the lofty Sierra Nevada, with the mountains of Elvira, and on the other side by successive amphitheatres of hills, agreeably planted with vines, olive, mulberry, lemon, and orange trees. It contains within its circuit not less than 52 towns; and in its centre appears the Soto de Roma, which is a beautiful wood of elms, white poplars, and ash trees, full of game, especially pheasants, more than a league in length, and half a league in breadth, and formerly the retreat of the Moorish kings. At the termination of this fertile plain, the city of Granada is perceived from a considerable distance, extending in the form of a half moon from the river, along the gradual ascent of a hill, its streets rising above each other, exhibiting a profusion of turrets and guilded cupolas; the summit of the whole crowned by the palace of the Alhambra, and the back ground composed of the majestic Sierra Nevada, covered with snow. But the splendid illusions, created by this distant view, are sadly dissipated by a nearer inspection of its fallen grandeur. It was formerly divided into four quarters, which may still be considered as distinctly marked, namely, the quarter of Alhambra, which principally contains that immense citadel on the mountain of the sun, and where the splendid palace of the Moorish kings is still in existence, and in a state of sufficient repair to impress the spectator with the most lively idea of its original beauties; the quarter of Albayzin, a kind of suburb on the rising ground, separated from the town by a rampart, and containing about 4000 houses; the quarter of Antiquerula, which has the appearance of another suburb built upon the plain, was peopled by the settlers from Antequera, and is principally occupied by dyers and silk-weavers; and the quarter of Granada which covers the commencement of the plain, and a part of the valley between the two mountains, and is the best built and best inhabited part of the town. The river Darro runs through the middle of the city, and empties itself into the Xenil, which passes near the walls. The extent of the whole town is much the same as it was in the time of the Moors, but it is thinly inhabited in proportion to its buildings; and the present population is only about 60,000. The streets are generally narrow, and the houses very inferior in their appearance to those of many other cities in Spain. Even those which surround the market-place are very despicable, few of the upper apartments having glass in the windows, and the shops below being very indifferently supplied with goods. But there are many fine buildings, handsome squares, extensive gardens, and beautiful fountains in different parts of the city. The El Campo is a large square at the entrance of the town, on the road from Antequera, and is partly occupied by an hospital, which is a large and handsome building. The Plaza Mayor in the middle of the town is very spacious; and is used for public shows, particularly the bull-fights. The Biva Rambla, a handsome area, 400 feet by 200, is embellished by an elegant jasper fountain, and has on one side the Alcaxeria, and on the other the Chancery; the latter of which has a very handsome front, ornamented with alabaster columns, and a range of windows with gilt balconies; and the former, an immense edifice without ornament, formerly the bazar of the Moors, still contains about 200 shops: these shops are so very small, that the owner, sitting in the centre, is able to reach whatever his customers may require, without rising from his seat. The cathedral is a very splendid but irregular building. It has a handsome dome resting on 12 arches, supported by 12 pilasters; and against these columns are placed the statues of the twelve apostles, in gilt bronze, as large as life. The vault is full of paintings, and two rows of gilded balconies run round it above the arcades. In this church are some of the best pictures and statues by the celebrated Spanish artist Alonzo Cano, and his pupil Pedro de Mena. The palace of the archbishop stands close to the cathedral, and is a very extensive mansion, and of a handsome appearance. But the most interesting and splendid object in Granada is the Alhambra, the ancient fortress or palace of the Moorish kings, described in a former article: (See Alhambra.) Though this noble structure is fast hastening to decay, and likely to become in a few years a heap of ruins, it is still viewed by travellers with the strongest sensations of wonder and delight. In a higher situation on an opposite hill, is another palace, called the Generaliffe, which was used as a retreat in the intense heats of summer. The rooms are floored with marble, and have streams of the clearest water rushing through them. It is surrounded by gardens, groves and orchards, planted with orange, lemon, and cypress trees, and provided with a multiplicity of transparent pools and crystal fountains. Most of the houses have fountains and baths in their courts, which, besides supplying water for domestic uses, moderate by their coolness the extreme heat of the climate in the summer season. In imitation of the Moors, the present inhabitants spread an awning over these courts to keep off the sun, and live there all the summer, eating their meals and receiving their visitors amidst its refreshing coolness. The environs of the city are delightful, and the shady walks on the banks of the Xenil, with others more wild and romantic on the Darro, afford the most refreshing and pleasing retreats. The sides of the hills around the city abound with caves resembling the trogledyte habitations in Abyssinia. They were originally employed as granaries for corn, but are now inhabited by gipsies, who are very numerous in the south of Spain, and are said to bear a great resemblance to the same class of people in England. Granada contains an university and an academy for mathematics, but they have no library, few masters, and scarcely any students. There is a royal manufactory for saltpetre and gun-powder; and several for woollen cloths and serges, which are said to employ about 7000 persons, and to consume 460,000 pounds of wool annually. Silk stuffs, such as velvets, sattins, and taffetas of a very durable quality, are made in the city, and a considerable quantity of ribbons, in the manufacture of which the spring shuttle used at Coventry is generally adopted, the only kind of machinery observed in the manufactories of the place. See

Jacob's *Travels in Spain*; Townsend's *Travels in Spain;* Laborde's *View of Spain;* and Murphy's splendid work, entitled, the *Arabian Antiquities of Spain*, Lond. 1815. (*q.*)

GRANADA, a province of Spain, sometimes called Upper Andalusia, is bounded on the east and south by Murcia and the Mediterranean, and on the west and north by Andalusia. It is situated between 36° 20′ and 38° North Latitude, and between 5° 5′ and 1° 30′ West Longitude from Greenwich. It is of a very irregular figure, approaching to the shape of a pyramid, with its base to the east on the kingdom of Murcia, and its apex to the south-west, towards the straits of Gibraltar. It is 58 leagues in length from the east to the south-east; and in breadth, in some places 8, in others 18, and at its base 28. The principal towns are Granada, the capital, already described, Malaga, Almeria, and Amunecar, three sea-ports on the Mediterranean; Guadix, Motrel, Morbella, Velez-Malaga, Baza, Vera, Ronda, Loxa, Santa-Fe, Huesca, Antequera, and Alhama. Its rivers are the Verde, Xenil, Las Feguas, Guadalentia, Guadavar, Guadalmeja, Rio de Almeria, Rio Frio, Guadelmerina, Darro, Guadix, Bravata, Marchan, &c.

The Moors having acquired possession of Spain, after the bloody battle of Xeres in 711, in which Roderigo, the last of the Gothic princes, was slain, Granada became a part of their empire in the south of the peninsula; and, in 1013, was chosen by Almanzor as the royal residence, instead of Cordova. In 1051, the family of Almanzor were deprived of the sovereignty by Joseph ben Taschphen, King of Morocco, who filled the throne with dignity and splendour. After his death, the kingdom was divided among a number of pretenders; but, in 1146, was again united under a prince of the family of the Almohades. Mahomed the First, one of the greatest of the Moorish princes, laid the foundation of a new dynasty in 1232, and raised the kingdom of Granada to its greatest degree of prosperity. While he kept on foot a powerful army for the defence of his dominions, he was equally attentive to promote the welfare of his subjects by the arts of peace. He regulated the revenues, administered justice, cultivated science, endowed hospitals, and laid the foundation of the Alhambra, the glory of Mahommedan Spain. Mahomed the Second succeeded his father, and was distinguished, above all the monarchs of his race, as the protector of science, and the patron of arts and commerce. His court was the resort of astronomers, physicians, philosophers, orators, and poets; and his own compositions in verse are celebrated by Arabian writers for their epigrammatic humour. He was succeeded in 1302, by his son of the same name, who resembled him in his love of literature, and his patronage of the fine arts; but, while he was engaged in war with the King of Arragon, an insurrection in his capital transferred the crown to his brother Almasser, a young prince of 25 years of age, celebrated for his progress in mathematical and astronomical learning; but who, yielding to the turbulent dispositions of his subjects, was in his turn supplanted, in 1314, by Ismael, Prince of Malaga. The kingdom of Granada, hard pressed by the Christian states in the north of Spain, and thus torn by a succession of intestine commotions, was fast approaching to its fall. Its sovereign Albohassen, availing himself of the discontents created in Castile by the accession of Ferdinand and Isabella, marched a hostile army into their dominions in 1482. Ferdinand, having procured a truce of three years, and quieted his rebellious subjects, became the aggressor in his turn; and aided by the dissensions among the Moorish chiefs, pushed his conquests with such rapid success, that in the course of two years, he had reduced the power of Abo Abdeli, the eldest son of Albohassen, within the city and plain of Granada. Having occupied the surrounding country with his troops, and built the city of Santa-Fé, he was preparing to invest the Moorish capital, when the besieged prince, more afraid of his subjects than of the enemy, proposed to capitulate, and submitted to the power of Ferdinand. In defiance of the terms expressly stipulated for the protection and toleration of the vanquished, the Moors were finally banished to the sterile regions of their ancestors; and their empire in Spain completely terminated in the year 1492. But for a considerable period after the conquest of Granada, a few scattered bands, who had taken refuge in the mountains, maintained an unavailing struggle with their conquerors, displaying the most heroic spirit in their sufferings, and unshaken constancy to their chiefs. Under the sway of the Mahommedan princes, which comprehends a period of nearly eight centuries, the kingdom of Granada was the seat of opulence, arts, and learning, while the other states of Europe, under the spiritual domination of Rome, were sunk in the deepest mental barbarism. The Omniades in Spain, following the example of Almamon, the seventh caliph of the Abassides, exerted themselves so sedulously in the advancement of knowledge, that they are said to have collected 600,000 volumes, and to have established 70 public libraries in the cities under their dominion. The Arabian writers enumerate, in 1126, 150 authors natives of Cordova, 52 of Almeria, 76 of Murcia, and 53 of Malaga, besides those of Seville, Valencia, and Granada, where the spirit of literature was preserved in full vigour nearly four centuries. In this last mentioned city, where it principally flourished, there were at that time two universities, two royal colleges, and a public library, stored with the productions of the best Greek and Arabic writers. The love of learning was so general in Granada, that, in spite of the prohibitions of Mahomed, it extended to the female sex; and we find recorded the names of the poetess Naschina, the historian Mosada, and the mathematician Leila. Their physicians, though imperfectly acquainted with anatomy, as their religion prohibited all dissections of the human frame, acquired great celebrity. Botany was one of their favourite studies; and they made some progress in the operations of chemistry. They chiefly excelled in the various branches of mathematics, namely, astronomy, arithmetic, geometry, trigonometry, and optics; but they were little acquainted with physics, and, though they were instrumental in preserving many Greek authors, they were as little acquainted as the nations of Christendom at that period, with the classical authors of Greece and Rome. Among the Arabians, in short, in the south of Spain, human genius is said to have produced more prodigies in a few centuries, than it has done in the history of ages in all the rest of the world. All the great modern discoveries, paper, printing, the mariner's compass, glass, gunpowder, &c. are affirmed to have been there anticipated and again forgotten; and in the exercise of fancy and invention they are considered as having far surpassed all former and succeeding ages. Agriculture formed the principal occupation of the Saracens in Granada; and, while it was stimulated by the demands of an extensive population, it was improved by the aids of science. They were particularly attentive to the application of manure, which they preserved in pits, that none of the salts might be lost; and they carried the practice of irrigation to a very great extent. But, as their bigotry forbade the sale of their superfluous grain to the neighbouring nations, they pursued its cultivation no farther than was requisite for their own subsistence; and directed much of their attention to the culture of fruits, which generally formed their principal aliment. To them Spain is indebted for the introduction of an infinite variety of fruits, and of its best horticultural productions, for the sugar-cane also, and the cotton-tree. Their commerce was not less extensive, and the luxuries of India were brought from Alexandria to Malaga at an early period. The silks of India, and the porcelains of China, were soon imitated, and even excelled by the Moors. They were skilled in the manufacture of woollen, cotton, and flax, but, above all, in the art of dyeing of leather. They made some progress in working mines, especially of lead and iron; and their articles of steel, particularly the swords of Granada, were preferred to all others in Spain. In their architectural plans and ornaments, they were deficient in taste; but their joiners and inlayers of wood worked with the utmost nicety; and they painted and gilded their stucco work with singular skill. Upon the banishment of this ingenious people, the arts and sciences departed with them; the magnificence, commerce, and manufactures of Granada rapidly decayed; and the indolence, poverty, and barbarism, which succeeded in their place, continue, in no small degree, to overspread the face of the most highly gifted region in the world.

Granada is beautifully diversified with majestic mountains, extensive plains, and delightful vallies. A chain of mountains, named the Alpuxarres, extends through the province from west to east. The loftiest points of the whole range are those of the Sierra Nevada, near the city of Granada, one of which, called Mulhacen, is 12,762 feet above the level of the sea; and all above 9915 feet are covered with perpetual snow. The mountains towards the south gradually decline in height, till at the Sierra de Gador, near Almeria, where they rise to the elevation of 7800 feet. At this extremity near Macael is the celebrated rock called Filabres, which is four miles in circumference, two thousand feet in height, and which consists of one entire and solid piece of white marble. The secondary mountains are of various kinds; but many are composed of marble of different colours, black, white, red, and flesh colour. About two leagues from Granada, on the banks of the Xenil, is a quarry of green serpentine beautifully veined, and capable of receiving a fine polish. There are many sorts of alabaster in the mountains which environ the city, some of which are as brilliant and transparent as oriental cornelians. There are also quarries of jasper, and a variety of precious stones. In the mountains of this province are several mines of silver, copper, and lead, some of which were formerly worked by the Moors. Gold is found in the sands of the river Darro; but of late the quantity has been small. Mineral waters, both cold and hot springs, are very abundant in the province; but few of them have been analysed: They are chiefly chalybeates, and sulphureous. But one of the most remarkable circumstances in the mountains of Granada is the quantity of bones, of men and other animals, found on their summits, especially at Concud, where there is a hill entirely composed of them, lying under a stratum of limestone.

The climate of Granada is cold in the mountainous districts; extremely hot and sultry in the vallies; but it is tempered in the plains by the coolness of the waters, which are conveyed in all directions. The country is exposed to a number of winds, particularly on the coast; one of which especially, called Solano, is attended with the most pernicious effects. It is a hot wind, which blows from Africa, dries up the plants as soon as it touches them, affects the body with the feelings of strong fever, and throws the mind into a state little better than madness. Murders and assassinations are observed to be most frequent during its prevalence.

In this province agriculture is in a more flourishing state than in any other district in the south of Spain; and the Vega of Granada, already described, is the finest and richest plain in the kingdom. The principal mode employed for aiding the crops is the irrigation of the soil. Streams are conveyed along the upper side of every field by means of embankments, in which sluices are cut, which convey the water into small gutters; and these are allowed to run at short intervals, so as to flood the whole field with ease in the hot season. Great attention is paid to the preservation of manure, which, according to the old Moorish practice, is collected in large pits, well rammed, to prevent leaking; and, when once well rotted, is distributed over the land, in a state almost liquid. It is not applied, however, to the production of corn, but is used in the gardens, the melon grounds, and the mulberry plantations. Yet, without any manure, and by the mere assistance of irrigation, the most abundant crops of grain are raised, especially of wheat, barley, and maize. On land capable of being properly watered, the annual produce of wheat is said to be fifty bushels per acre. Great quantities of rice are cultivated in the lower grounds near the rivers, and subject to floods; and frequently a crop of hemp, or flax, is taken from the land before the rice is sown. But the Spanish farmers pay more attention to the breeding and fattening of cattle, than to the cultivation of grain or fruits. They make no hay; but the grass grows most abundantly in winter, when the cattle are fed in the uplands; and after harvest, which is generally in June, the stubble fields furnish subsistence to the flocks and herds. The flax and hemp are very cheap; and the latter, having a remarkably strong fibre, is thought to make the best sail cloth. There are very extensive plantations of mulberry trees, which are cultivated solely for the sake of the leaves, as the food of the silk worm. The white mulberry, grafted on the wild stock, is considered as the best for that purpose, and as making the worms yield a finer silk than the red or black species: The tops are cut off to increase the quantity of leaves. As much silk is annually raised in the plain of Granada as furnishes employment to 1500 persons. The manufactures in the city alone are calculated to require a supply of 100,000lbs. It is estimated, that 1500 worms produce about one pound of silk; and it is found, that a mulberry tree, of ten years of age, will scarcely supply food for as many of these insects as yield seven pounds. The mountains round the city of Granada are well calculated for vines, but so little attention is paid to their cultivation, that the wine produced from them is of a very inferior kind, and generally acquires a disagreeable taste from the sheep skins with tarred seams in which it is brought from the vineyards; but, in other parts of the province, excellent wines are made, especially the Tierno, Moscatel, and Malaga. The grapes often grow in bunches of eight, ten, and even fourteen pounds weight, and great quantities are dried in the sun for exportation. Olive trees are numerous; but oil is not produced in sufficient quantity for the consumption of the inhabitants. Sugar canes are cultivated in many parts, but especially around Malaga; and are as large and juicy as those of the West Indies.

The commerce of Granada with the other provinces, consists chiefly in exchanging corn, wine, and dried fruits, for oil and silk. Its trade with foreign countries is carried on from the ports of Almeria and Malaga, (see ALMERIA and MALAGA,) and consists in exports of wine, dried fruits, oil, anchovies, lemons, almonds, lead, kali, sumach; and in imports of cloths, ironware, mercery, lace, &c.

The inhabitants of this province, like the Andalusians in general, are considered as the Gascons of Spain, vain, talkative, boastful, and licentious. The women are represented as sufficiently seducing, handsome in their figure, and peculiarly attractive as dancers. The language is mixed with so many Arabic words, and the pronunciation so guttural and vitiated, that a Castilian often finds it difficult to understand the speech of an Andalusian. See the works referred to under the preceding article. (*q*)

GRANADA, NEW, a division of Spanish America, lying between 2° and 8° of North Latitude; is bounded on the north and east by Caraccas and Cumana, on the west by Popayan, and on the south by Peru. It extends in length about 300 miles, and nearly as much in breadth. It is so far elevated above the level of the sea, that, though approaching almost to the equator, its climate is remarkably temperate. Its vales and level districts are not inferior in fertility to the richest spots of America. Its mountainous tracts abound in mines of gold, silver, lead, copper, and in precious stones of various kinds. Its forests afford a variety of excellent timber, adapted particularly for ship-building. Its principal towns are Bogota or Santa Fé de Bogota, the seat of government, and the see of an archbishop, situated nearly in 4° North Latitude, and containing 40,000 inhabitants; Flonda, a pleasant little town on the river Magdalena, about 60 miles north-west of the capital, the principal port for the commerce of the interior provinces, and containing about 10,000 inhabitants; Merida, a considerable manufacturing town in 8° 11′ north latitude, situated in a well-watered valley, about 20 leagues south of Lake Maracaiba, and containing 11,000 inhabitants; Neyva, 107 miles south-west of the capital; Maraquita, 59 miles north-west; St. Miguel, 94 miles north-east; Caguan, south of Neyva and Tunia in 5½° North Latitude; all small settlements, rather in a declining state. There are likewise several missionary stations, especially towards the south of the province, called Los Llanos, and several villages of the Indians. Antioquia, perhaps rather a separate province, is also generally comprehended in that of New Granada. It is situated towards the west, bounded by Carthagena on the north, by Popayan on the south, and on the west by Choca. It is mountainous, and abounding in mines; temperate, well watered, and rich in pastures. Its capital, of the same name, in the valley of Nori, is situated in 7° 14′ North Latitude.

A few manufactures of cotton cloths, carpets, counterpanes, and woollens, chiefly for the purposes of internal consumption, are carried on in the province. Several of its native productions, especially chocolate, tobacco, and cotton, all of excellent quality, might be collected in great abundance for exportation; and the river Magdalena, which runs through the province into the Atlantic, and is navigable as far as Florida, 160 leagues from its mouth, affords a commodious outlet to the European markets. But agriculture and trade are said to have greatly declined of late years in the province; and its present unsettled state, struggling for independence of the mother country, though likely to issue at length in its prosperity, must obviously be extremely unfavourable to every kind of cultivation or commerce. Its chief support is derived from the produce of its gold mines. These indeed can scarcely be called mines, as the metal is not generally procured by digging into the earth, but is mingled with the soil near the surface, from which it is separated by repeated washings. This work is commonly performed by Negro slaves, who cannot bear the chill air of the mines, but are more able than the Indians to support the labours of the field. In some districts, the metal is found in large grains; and on some spots, particularly near Pamplona, single labourers have collected in one day a quantity equivalent to 1000 pesos. One of the governors of Santa Fé procured a mass of pure gold estimated to be worth 740*l.*, which was deposited in the royal cabinet of Madrid as the finest and largest specimen ever found in the New World.

Granada, or Santa Fé, as it is sometimes called, gives name to an extensive viceroyalty, which is sometimes confounded with the province, properly so denominated. This kingdom of New Granada was originally established in 1547, and was governed by a royal audience, with a captain-general as president. In 1718, it was formed into a viceroyalty, which was suppressed in 1724, and finally restored in 1740. It comprises the provinces of Carthagena, Panama, Santa Martha, Maracaibo, Porto Bello, Antiognia, Choca, Granada Proper, Veragua, Mariquita, Rio de la Hacha, Giron, Neyva, and the Llanos, which form the northern division, under the jurisdiction of the royal audience at Santa Fé; and the southern districts, Jaen de Bracamoros, Loja, Cuenza, Macas, Riobamba, Popayan, Quito, Guayaquil, &c. which are under the jurisdiction of a governor and royal audience at Quito, who are subordinate to the viceroy of New Granada. This extensive territory, when first subjected to Spain in 1536, was more populous, and its inhabitants more civilized, than any other portion of America; but the amount of its whole population is now calculated by M. Humboldt only at 1,800,000. Nothing is wanting for its prosperity, but the revival of industry and commerce; and nothing prevents it from enjoying these benefits, but the impolitic restrictions and oppressive system of its European rulers. See Robertson's *History of America*, vol. iii.; Playfair's *Geography*, vol. vi.; Pinkerton's *Geography*, vol. iii.; and Humbolt's *Account of New Spain*. (*q*)

GRANGE, JOSEPH-LOUIS LA,* a celebrated mathematician and natural philosopher, was born at Turin, on the 25th of November, 1736. He was the son of Joseph Louis la Grange, treasurer of war, and of Marie-Therese Gros, only daughter of a rich physician of Cambiano.

His father was rich, and had made an advantageous marriage: but was ruined by hazardous undertakings. Let us not, however, lament the situation of M. la Grange. He himself viewed it as the first cause of all the good fortune that afterwards befel him. "Had I been in possession of a fortune," said he, "I should not probably have studied mathematics." In what other situation would he have found advantages that could enter into comparison with those of a tranquil and studious life, with that splendid series of discoveries in a branch of science considered as the most difficult, and with that personal respectability which was continually increasing to the very last period of his life?

His taste for mathematics did not appear at first. He was passionately devoted to Cicero and Virgil, before he could read Archimedes and Newton. He then became an enthusiastic admirer of the geometry of the ancients, which he preferred to the modern analysis. A memoir which the celebrated Halley had composed long before, to demonstrate the superiority of the analytic method, had the glory of converting him, and of teaching him his true destiny. He devoted himself to this new study with the same success that he had in the synthesis, and which was so decided, that at the age of 16 he was professor of mathematics in the Royal Military School. The extreme youth of a professor is a great advantage to him when he has shown

* This excellent life of La Grange is taken, with a few slight abridgments, from the eloge of the Chevalier Delambre, with whose kind permission it is here published. As we have not been able to get a copy of the original eloge, we have been obliged to make use of the translation in Dr Thomson's *Annals of Philosophy*, vol. iii. ED.

extraordinary abilities, and when his pupils are no longer children. All the pupils of M. la Grange were older than himself, and were not the less attentive to his lectures on that account. He distinguished some of them, whom he made his friends.

From this association sprung the academy of Turin, which in 1759 published a first volume, entitled Acts of a private Society. We see there the young La Grange directing the philosophical researches of the physician Cigna, and the labours of the Chevalier de Saluces. He furnished to Foncenex the analytical part of his memoirs, leaving to him the task of developing the reasoning upon which the formulæ depended. In these memoirs, which do not bear his name, we observe that purely analytical method, which afterwards characterised his great productions. He had discovered a new theory of the lever. It constitutes the third part of a memoir, which was very successful. Foncenex, in recompense, was placed at the head of the Marine, which the king of Sardinia formed at that time. The two first parts have the same style, and seem written by the same person. Do they likewise belong to La Grange? He never expressly laid claim to them; but what may throw some light on the real author is, that Foncenex soon ceased to enrich the volumes of the new academy, and that Montucla, ignorant of what La Grange revealed to us during the latter part of his life, is astonished that Foncenex interrupted those researches which might have given him a great reputation.

M. la Grange, while he abandoned to his friend insulated theorems, published at the same time, under his own name, theories which he promised to develope further. Thus after having given new formulæ of the *maximum* and *minimum* in all cases, after having shown the insufficiency of the known methods, he announces that he will treat this subject, which he considered as important, in a work which he was preparing, in which, would be deduced from the same principles all the mechanical properties of bodies, whether solid or fluid. Thus at the age of 23 he had laid the foundation of the great works, which have commanded the admiration of philosophers.

In the same volume he reduces under the differential calculus the theory of recurrent series and the doctrine of chances; which before that time had only been treated by indirect methods. He established them upon more natural and general principles.

Newton had undertaken to submit the motions of fluids to calculation. He had made researches on the propagation of sound; but his principles were insufficient, and his suppositions inconsistent with each other. La Grange demonstrates this. He founds his new researches on the known laws of dynamics, and, by considering only in the air the particles which are in a straight line, he reduces the problem to that of vibrating cords, respecting which the greatest mathematicians differed in opinion. He shows that their calculations are insufficient to decide the question. He undertakes a general solution by an analysis equally new and interesting, which enables him to resolve at once an indefinite number of equations, and which embraces even discontinued functions. He establishes on more solid grounds the theory of the mixture of simple and regular vibrations of Daniel Bernoulli. He shows the limits within which this theory is exact, and beyond which it becomes faulty. Then he comes to the construction given by Euler, a construction true in itself, although its first author had arrived at it by calculations which were not quite rigorous. He answers the objections of D'Alembert. He demonstrates that whatever figure is given to the cord, the duration of the oscillations is always the same: a truth derived from experiment, which D'Alembert considered as very difficult, if not impossible, to demonstrate. He passes to the propagation of sound, treats of simple and compound echos, of the mixture of sounds, of the possibility of their spreading in the same space without interfering with each other. He demonstrates rigorously the generation of harmonious sounds. Finally, he announces that his intention is to destroy the prejudices of those who still doubt whether the mathematics can ever throw a real light upon physics.

We have given this long account of that memoir, because it is the first by which M. la Grange became known. If the analytical reasoning in it be of the most transcendent kind, the object at least has something sensible. He recals names and facts which are well known to most people. What is surprising is, that such a first essay should be the production of a young man, who took possession of a subject treated by Newton, Taylor, Bernoulli, D'Alembert, and Euler. He appears all at once in the midst of these great mathematicians as their equal, as a judge, who, in order to put an end to a difficult dispute, points out how far each of them is in the right, and how far they have deceived themselves; determines the dispute between them, corrects their errors, and gives them the true solution, which they had perceived without knowing it to be so.

Euler saw the merit of the new method, and took it for the object of his profoundest meditations. D'Alembert did not yield the point in dispute. In his private letters, as well as in his printed memoirs, he proposed numerous objections, to which La Grange afterwards answered. But these objections may give rise to this question: How comes it that, in a science in which every one admits the merit of exactness, geniuses of the first order take different sides, and continue to dispute for a long time? The reason is, that in problems of this kind, the solutions of which cannot be subjected to the proof of experiment, besides the part of the calculation which is subjected to rigorous laws, and respecting which it is not possible to entertain two opinions, there is always a metaphysical part which leaves doubt and obscurity. It is because in the calculations themselves, mathematicians are often content with pointing out the way in which the demonstration may be made; they suppress the developments, which are not always so superfluous as they think. The care of filling up these blanks would require a labour which the author alone would have the courage to accomplish. Even he himself, drawn on by his subject and by the habits which he has acquired, allows himself to leap over the intermediate ideas. He defines his definitive equation, instead of arriving at it step by step with an attention that would prevent every mistake. Hence it happens that more timid calculators sometimes point out mistakes in the calculations of an Euler, a D'Alembert, a La Grange. Hence it happens that men of very great genius do not at first agree, from not having studied each other with sufficient attention to understand each other's meaning.

The first answer of Euler was to make La Grange an associate of the Berlin academy. When he announced to him this nomination on the 20th of October, 1759, he said, "Your solution of the problem of isoperimeters leaves nothing to desire; and I am happy that this subject, with which I was almost alone occupied since the first attempts, has been carried by you to the highest degree of perfection. The importance of the matter has induced me to draw up, with your assistance, an analytical solution of it. But I shall not publish it till you yourself have published the sequel of your researches, that I may not deprive you of any part of the glory which is your due."

If these delicate proceedings, and the testimonies of the highest esteem, were very flattering to a young man of 24 years of age, they do no less honour to the great man, who at that time swayed the sceptre of mathematics, and who thus accurately estimated the merit of a work that announced to him a successor.

But these praises are to be found in a letter. It may be supposed that the great and good Euler has indulged in some of those exaggerations which the epistolary style permits. Let us see then how he has expressed himself in the dissertation which his letter announced. It begins as follows:

"After having fatigued myself for a long time and to no purpose, in endeavouring to find this integral, what was my astonishment when I learnt that in the Turin Memoirs the problem was resolved with as much facility as felicity! This fine discovery produced in me so much the more admiration, as it is very different from the methods which I had given, and far surpasses them all in simplicity."

It is thus that Euler begins the memoir, in which he explains with his usual clearness the foundation of the method of his young rival, and the theory of the new calculus, which he called the *calculus of variations*.

To make the motives of this admiration which Euler bestowed with so much frankness better understood, it will not be useless to go back to the origin of the researches of La Grange, such as he stated them himself two days before his death.

The first attempts to determine the *maximum* and *minimum* in all indefinite integral formulæ, were made upon the occasion of the curve of swiftest descent, and the isoperimeters of Bernoulli. Euler had brought them to a general method, in an original work, in which the profoundest knowledge of the calculus is conspicuous. But however ingenious his method was, it had not all the simplicity which one would wish to see in a work of pure analysis. The author admitted this himself. He allowed the necessity of a demonstration independent of geometry. He appeared to doubt the resources of analysis, and terminated his work by saying, "If my principle be not sufficiently demonstrated, yet as it is conformable to truth, I have no doubt that, by means of a rigid metaphysical explanation, it may be put in the clearest light, and I leave that task to the metaphysicians."

This appeal, to which the metaphysicians paid no attention, was listened to by La Grange, and excited his emulation. In a short time the young man found the solution of which Euler had despaired. *He found it by analysis.* And in giving an account of the way in which he had been led to that discovery, he said expressly, and as it were in answer to Euler's doubt, that he regarded it not as a metaphysical principle, but as a necessary result of the laws of mechanics, as a simple corollary from a more general law, which he afterwards made the foundation of his *Mechanique Analytique.* (See that work, page 189 of the first edition.)

This noble emulation, which excited him to triumph over difficulties considered as insurmountable, and to rectify or complete theories remaining imperfect, appears to have always directed M. la Grange in the choice of his subjects.

D'Alembert had considered it as impossible to subject to calculation the motions of a fluid inclosed in a vessel, unless this vessel had a certain figure. La Grange demonstrates the contrary; except in the case when the fluid divides itself into different masses. But even then we may determine the places where the fluid divides itself into different portions, and ascertain the motion of each as if it were alone.

D'Alembert had thought that in a fluid mass, such as the earth may have been at its origin, it was not necessary for the different beds to be on a level. La Grange shows that the equations of D'Alembert are themselves equations of beds on a level.

In combating D'Alembert with all the delicacy due to a mathematician of his rank, he often employs very beautiful theorems, for which he was indebted to his adversary. D'Alembert on his side added to the researches of La Grange. "Your problem appeared to me so beautiful," says he in a lettter to La Grange, "that I have sought for another solution of it. I have found a simpler method of arriving at your elegant formula." These examples, which it would be easy to multiply, prove with what politeness these celebrated rivals corresponded, who, opposing each other without intermission, whether conquerors or conquered, constantly found in their discussion reasons for esteeming each other more, and furnished to their antagonist occasions which might lead them to new triumphs.

The academy of sciences of Paris had proposed, as the subject of a prize, the theory of the libration of the moon. That is to say, they demanded the cause why the moon, in revolving round the earth, always turns the same face to it, some variations excepted, observed by astronomers, and of which Cassini had first explained the phenomena. The point was to calculate all the phenomena, and to deduce them from the principle of universal gravitation. Such a subject was an appeal to the genius of La Grange, an opportunity furnished to apply his analytical principles and discoveries. The attempt of D'Alembert was not disappointed. The memoir of La Grange is one of his finest pieces. We see in it the first development of his ideas, and the germ of his *Mecanique Analytique.* D'Alembert wrote to him: "I have read with as much pleasure as advantage your excellent paper on the Libration, so worthy of the prize which it obtained."

This success encouraged the academy to propose, as a prize, the theory of the satellites of Jupiter. Euler, Clairaut, and D'Alembert had employed themselves about the problem of three bodies, as connected with the lunar motions. Bailly then applied the theory of Clairaut to the problem of the satellites, and it had led him to very interesting results. But this theory was insufficient. The earth has only one moon, while Jupiter has four, which ought continually to act upon each other, and alter their positions in their revolutions. The problem was that of six bodies. La Grange attacked the difficulty and overcame it, demonstrated the cause of the inequalities observed by astronomers, and pointed out some others too feeble to be ascertained by observations. The shortness of the time allowed, and the immensity of the calculations, both analytical and numerical, did not permit him to exhaust the subject entirely in a first memoir. He was sensible of this himself, and promised further results, which his other labours always prevented him from giving. Twenty-four years after, M. La Place took up that difficult theory, and made important discoveries in it, which completed it, and put it in the power of astronomers to banish empiricism from their tables.

About the same time a problem of quite a different kind attracted the attention of M. la Grange. Fermat, one of the greatest mathematicians of his time, had left very remarkable theorems respecting the properties of numbers, which he probably discovered by induction. He had promised the demonstrations of them; but at his death no trace of them could be found. Whether he had suppressed them as insufficient, or from some other cause, cannot now be ascertained. These theorems perhaps may appear more curious than useful. But it is well known that difficulty constitutes a strong attraction for all men, especially for mathematicians. Without such a motive would they have attached so much importance to the problems of the brachystrochonon, of the isoperimeters, and of the orthogonal trajectories? Certainly not. They wished to create the science of calculation, and to perfect methods which could not fail some day of finding useful applications. With this view, they attached themselves to the first question which required new resources. The system of the world discovered by Newton was a most fortunate event for them. Never could the transcendant calculus find a subject more worthy or more rich. Whatever progress is made in it, the first discoverer will always retain his rank. Accordingly, M. la Grange, who cites him often as the greatest genius that ever existed, adds also, "and the most fortunate. We do not find every day a system of the world to establish." It has required 100 years of labours and discoveries to raise the edifice of which Newton laid the foundation. But every thing is ascribed to him, and we suppose him to have traversed the whole country upon which he merely entered.

Many mathematicians doubtless employed themselves on the theorems of Fermat; but none had been successful. Euler alone had penetrated into that difficult road in which M. Legendre and M. Gauss afterwards signalized themselves. M. la Grange, in demonstrating or rectifying some opinions of Euler, resolved a problem which appears to be the key of all the others; and from which he deduced a useful result; namely, the complete resolution of equations of the second degree, with two indeterminates, which must be whole numbers.

This memoir, printed like the preceding, among those of the Turin Academy, is notwithstanding dated B rlin, the 20th September 1768. This date points out to us one of the few events which render the life of La Grange not entirely a detail of his writings.

His stay at Turin was not agreeable to him. He saw no person there who cultivated the mathematics with success. He was impatient to see the philosophers of Paris, with whom he corresponded. M. de Caraccioli, with whom he lived in the greatest intimacy, was appointed ambassador to London, and was to pass through Paris on his way, where he intended to spend some time. He proposed this journey to M. la Grange, who consented to it with joy, and who was received as he had a right to expect by D'Alembert, Clairaut, Condorcet, Fontaine, Nollet, Marie, and the other philosophers. Falling dangerously ill after a dinner in the Italian style given him by Nollet, he was not able to accompany his friend to London, who had received sudden orders to repair to his post, and who was obliged to leave him in a furnished lodging, under the care of a confidential person charged to provide every thing.

This incident changed his projects. He thought only of returning to Turin. He devoted himself to the mathematics with new ardour, when he understood that the Academy of Berlin was threatened with the loss of Euler, who thought of returning to Petersburgh. D'Alembert speaks of this project of Euler, in a letter to Voltaire, dated the 3d March 1766: "I shall be sorry for it," says he; "he is a man by no means amusing, but a very great mathematician." It was of little consequence to D'Alembert, whether this man, *by no means amusing*, went seven degrees nearer the pole. He could read the works of the great mathematician as well in the Petersburgh Memoirs as in those of Berlin. What troubled D'Alembert was the fear of seeing himself called upon to fill his place, and the difficulty of giving an answer to offers which he was determined not to accept. Frederick in fact offered him again the place of president of his Academy, which he had kept in reserve for him ever since the death of Maupertuis. D'Alembert suggested the idea of putting La Grange in the place of Euler; and, if we believe the author of the *Secret History of the Court of Berlin*, (vol. ii. p. 414,) Euler had already pointed out La Grange as the only man capable of filling his place. In fact, it was natural that Euler, who wished to obtain permission to leave Berlin, and D'Alembert, who wanted a pretext not to go there, should both of them, without any communication, have cast their eyes on the man who was best fitted to maintain the eclat, which the labours of Euler had thrown round the Berlin Academy.

La Grange was pitched upon. He received a pension of 1500 Prussian crowns, about 250*l*., with the title of Director of the Academy for the Physico-mathematical Sciences. We may be surprised that Euler and La Grange, put successively in the place of Maupertuis, received only the half of his salary, which the king offered entire to D'Alembert. The reason is, that this prince, who at his leisure hours cultivated poetry and the arts, had no idea of the sciences, though he considered himself obliged to protect them as a king. He had very little respect for the mathematics, against which he wrote three pages in verse, and sent them to D'Alembert himself, who deferred writing an answer till the termination of the siege of Schweidnitz; because he thought it would be too much to have both Austria and the mathematics on his hands at once. Notwithstanding the prodigious reputation of Euler, we see, from the king's correspondence with Voltaire, that he gave him no other appellation than his *narrow-minded geometer, whose ears were not capable of feeling the delicacy of poetry*. To which Voltaire replies: *We are a small number of adepts who know one another: the rest are profane.* We see that Voltaire, who had written so well in praise of Newton, endeavours in this place to flatter Frederick. He enters out of complaisance into the ideas of this prince, who wished to put at the head of his academy, a man who had at least some pretensions to literature. Fearing that a mathematician would not take sufficient interest in the direction of literary labours, and that a man of literature would have been still worse placed at the head of a society composed in part of philosophers, of whose language he was ignorant; on that account he divided the situation, and put two persons in it, that it might be completely filled.

M. la Grange took possession of his situation on the 6th of November 1766. He was well received by the king; but soon perceived that the Germans do not like to see foreigners occupy situations in their country. He applied to the study of their language. He devoted himself entirely to mathematics, and did not find himself in the way of any person, because he demanded nothing, and he soon obliged the Germans to give him their esteem. "The king," said he himself, "treated me well; I thought that he preferred me to Euler, who was something of a devotee, while I took no part in the disputes about worship, and did not contradict the opinion of any one." This prudent reserve, if it deprived him of the advantages of an honourable familiarity, which would have been attended with some inconveniences, left him the whole of his time for mathematical labours, which hitherto had brought him nothing but compliments the most flattering and the most unanimous. This concert of praises was only once interrupted during the whole of his life.

A French mathematician, who to much sagacity united a still greater degree of selfishness, and scarcely gave himself the trouble to study the works of others, accused

M. la Grange of *having gone astray in the new route that he had traced, from not having well understood the theory of it.* He reproached him with *having deceived himself in his assertions and calculations.* La Grange in reply expresses some astonishment at these harsh expressions, to which he was so little accustomed. He expected at least to have seen them founded on some reasons either good or bad; but he discovered nothing of the kind. He shews that the solution proposed by Fontaine was incomplete and illusory in certain respects. Fontaine had boasted that he had taught mathematicians the conditions which render possible the integration of differential equations with three variables. La Grange shewed him, by several citations, that these conditions were known to mathematicians long before Fontaine was capable of teaching them. He does not deny that Fontaine discovered these theorems himself; "at least I am persuaded," says he, "that he was as capable of finding them as any person whatever."

It was with this delicacy and moderation that he answered the aggressor. Condorcet, in his *eloge* of Fontaine, is obliged to avow that, on this occasion, his friend deviated from that politeness which ought never to be dispensed with, but which perhaps he thought less necessary with illustrious adversaries, whose glory did not stand in need of these little delicacies. Every one can estimate the value of that apology, especially when applied to a man who, by his own acknowledgment, studied the vanity of others, that he might have an opportunity of wounding it. We must at least acknowledge, that he, who saw himself attacked in that manner when he was in the right, and who knew how to maintain politeness with an adversary who had himself dispensed with it, acquired a double advantage over him, besides victoriously repelling his imprudent attack.

It will not be expected that we should follow M. la Grange in the important researches with which he filled the Berlin Memoirs; and even some volumes of the Memoirs of the Turin Academy, which was indebted to him for its existence. All the space that can be devoted to this biographical account would not be sufficient even to convey an imperfect idea of the immense series of his labours, which have given so much value to the Memoirs of the Berlin Academy, while it had the inestimable advantage of being directed by M. la Grange. Some of these Memoirs are of such extent and importance, that they might pass for a great separate work, yet they constitute a part only of what these twenty years enabled him to produce. He had composed his *Mecanique Analytique*, but he wanted to have it printed at Paris, where he expected that his formulæ would be given with more care and fidelity. On the other hand, it was running too great a risk to intrust the manuscript into the hands of a traveller, who might not be aware of the whole of its value. M. la Grange made a copy of it, which M. Duchatelet undertook to deliver to the Abbé Marie, with whom he was intimately connected. Marie fulfilled with honour the confidence placed in him. His first care was to find a bookseller who would undertake to publish it; and, what it will be difficult to believe at this time, he could not find one. The newer the methods in it were, and the more sublime the theory, the fewer readers would be found capable of appreciating it; hence, without entertaining any doubts of the merit of the work, the booksellers were excusable in hesitating to print a book, the sale of which would probably be confined to a small number of mathematicians, disseminated through Europe. Desain, who was the most enterprising of all those to whom application was made, would not undertake to publish it, till Marie entered into a formal engagement to take all the copies of the edition which were not sold by a given time. To this first service, Marie added another, of which M. la Grange was not less sensible; he procured him an editor worthy of superintending the publication of such a work. M. Legendre devoted the whole of his time to the troublesome task of correcting the press, and was repaid by the sentiment of veneration for the author with which he was penetrated; and by the thanks which he received from him in a letter which I have had in my possession, and which M. la Grange had filled with expressions of his esteem and his gratitude.

The book was not yet published when the author came to settle in Paris. Several causes determined him to take this step; but we must not give credit to all that have been stated. The death of Frederick had occasioned great changes in Prussia, and still greater were to be apprehended. Philosophers were no longer so much respected as formerly. It was natural for M. la Grange again to feel that desire which had formerly conducted him to Paris. These causes, together with the publication of the *Mecanique Analytique*, were sufficient. It is not necessary to add other causes, which several publications that made their appearance in Germany, and particularly the anonymous historian of the court of Berlin, have noticed. We never, during a residence of 25 years in France, heard M. la Grange prefer the slightest complaint against the minister, who is accused in that publication of having disgusted him by a treatment full of haughtiness and contempt, which, out of respect for himself, it was impossible for M. la Grange to overlook. We might suspect that M. la Grange had sufficient generosity to forget or pardon bad treatment, which he punished in the only way worthy of himself, by leaving the country where his merit was overlooked; but when he was directly questioned on that subject by a member of the Institute, (M. Burckhardt,) he only gave negative answers, and assigned no other motives than the misfortunes which it was thought were about to fall upon Prussia. M. de Hertzberg was dead, and M. de la Grange, a senator and count of the French empire, could have no interest in concealing the truth. Hence we must consider his own statement as affording the only true reasons.

The historian, therefore, whom we have quoted, has been ill informed. But the spirit of calumny and satire, which has so justly rendered his work suspected, ought not to prevent us from extracting from it the lines, in which he explains, with that energy which is peculiarly his own, his opinion, which is that of all Europe, when he does justice to M. la Grange.

"I think," says he, (*Hist. Sec. de la Cour de Berlin*, 1789, tom. ii. page 173) "that there is at this moment an acquisition worthy of the king of France, the illustrious La Grange, the greatest mathematician who has appeared since Newton, and who in every point of view is the man that has the most astonished me;—La Grange, the wisest, and perhaps the only practical philosopher that ever existed, meritorious by his undisturbable wisdom, his manners, his conduct; the object of the most tender respect of the small number of men with whom he associates:—La Grange is misunderstood; every thing leads him to leave a country where nothing can excuse the crime of being a foreigner, and where in fact he is merely tolerated. Prince Cardito de Laffredo, Neapolitan minister at Copenhagen, offered him the most flattering conditions on the part of his sovereign. The Grand Duke, the king of Sardinia, invited him eagerly; but all their proposals would be easily obliterated by ours. I am very eager to see this proposal made, because I consider it as noble, and because I tenderly love the man who is the object of it. I have induced M. la

Grange not to accept immediately the proposals made to him, and to wait till he receives ours."

The author whom we quote appears to fear the opposition of M. Breteuil; but, according to M. la Grange himself, it was the Abbé Marie who proposed it to M. Breteuil, who on all occasions anticipated the desires of the Academy of Sciences, presented the demand to Louis XVI. and induced him to agree to it.

The successor of Fredorick, although he did not much interest himself in the sciences, made some difficulty in allowing a philosopher to depart whom his prodecessor had invited, and whom he honoured with his particular esteem. After some delay, M. la Grange obtained liberty to depart. It was stipulated that he should still give some memoirs to the Berlin Academy. The volumes of 1792, 1793, and 1803, show that he faithfully kept his promise.

It was in 1787, that M. la Grange came to Paris to take his seat in the Academy of Sciences, of which he had been a foreign member for fifteen years. To give him the right of voting in all their deliberations, this title was changed into that of *veteran pensionary*. His new associates shewed themselves happy and proud in possessing him. The queen treated him with regard, and considered him as a German. He had been recommended to her from Vienna. He obtained a lodging in the Louvre, where he lived happy till the Revolution.

The satisfaction which he enjoyed did not show itself outwardly. Always affable and kind when interrogated, he himself spoke but little, and appeared absent and melancholy. Often in companies which must have been suitable to his taste, among the most distinguished men of all countries who met at the house of the illustrious Lavoisier, I have seen him dreaming, as it were, with his head against a window, where however nothing attracted his attention. He remained a stranger to what was passing around him. He acknowledged himself that his enthusiasm was gone, that he had lost his taste for mathematics. When informed that a mathematician was employed at such a task, "so much the better," he would say; "I had begun it, now it will be unnecessary for me to finish it." But he merely changed the object of his studies. Metaphysics, the history of human nature, that of different religions, the general theory of languages, medicine, botany, divided his leisure hours. When the conversation turned upon subjects with which it was supposed he was unacquainted, we were struck by an unexpected observation, a fine thought, a profound view, which excited long reflections. Surrounded by chemists who were reforming the theory and even the language of the science, he made himself acquainted with their discoveries, which gave to facts formerly isolated that connection which distinguishes the different parts of mathematics. He undertook to make himself acquainted with this branch of knowledge, which formerly appeared to him so obscure, but which he found on trial *as easy as algebra*. People have been surprised at this comparison, and have thought that it could come from no one else than La Grange. It appears to us as simple as just; but it must be taken in its true sense. Algebra, which presents so many insoluble problems, so many difficulties against which La Grange himself struggled in vain, could not in that sense appear to him an easy study. But he compares the new elements of chemistry with those of algebra. They constituted a body, they were intelligible, they offered more certainty; they resembled algebra, which in the part of it that is complete presents nothing difficult to concieve, no truth to which we may not arrive by the most palpable reasoning. The commencement of the science of chemistry appeared to him to offer the same advantages, perhaps with somewhat less stability and certainty; but, like algebra, it has no doubt also its difficulties, its paradoxes, which will require, to explain them, much sagacity, reflection, and time. It has likewise its problems which never will be resolved.

In this philosophic repose he continued till the Revolution, without adding any thing to his mathematical discoveries, or even opening his *Mecanique Analytique*, which had been published for two years.

The Revolution gave philosophers an opportunity of making a great and difficult innovation; the establishment of a system of weights and measures founded on nature, and perfectly analogous to our scale of numbers. La Grange was one of the commissioners whom the Academy charged with that task. He was one of its keenest promoters. He wished to see the decimal system in all its purity. He was provoked at the complaisance of Borda, who got quarters of the *metre* made. He thought the objection of little importance which was drawn against the system from the small number of divisors that its base afforded. He regretted that it was not a prime number, as 11, which would have given the same denominator to all the fractions. This idea perhaps will be regarded as one of those exaggerations, which are hazarded by men of the best understandings, in the heat of dispute. But he mentioned the number 11 merely to get rid of the number 12, which more intrepid innovators would have wished to substitute, in place of the number 10, that constitutes the base of the whole of our numeration.

When the Academy was suppressed, the commission charged with the establishment of the new system was retained for a time. Three months had scarcely elapsed when, in order to purify that commission, the names of Lavoisier, Borda, La Place, Coulomb, Brisson, and Delambre, were struck out. La Grange was retained. In quality of president, he informed me, in a long letter full of kindness, that I should recieve official information of my removal. As soon as he saw me on my return to Paris, he expressed to me his regret at the dismissal of so many associates. "I do not know," said he, "why they have retained me." But unless the suppression had been total, it could scarcely have extended to him. The more losses the commission had sustained, of the more importance was it not to deprive it of the consideration attached to the name of La Grange. Besides, he was known to be wholly devoted to the sciences; he had no place either in the civil department or the administration. The moderation of his character had prevented him from expressing what he could not but think in secret; but I shall never forget the conversation which I had with him at that period. It was the day after the atrocious and absurd sentence, contrary to every thing like justice, had thrown all lovers of the sciences into mourning, by cutting off the most illustrious philosopher in Europe. "It has cost them but a moment," said he, "to cut off that head, and a hundred years perhaps will not be sufficient to produce another like it." Some months before we had had a similar conversation in the cabinet of Lavoisier, on account of the death of the unfortunate Bailly. We lamented together the dreadful consequences of the dangerous experiment which the French had attempted. All these chimerical projects of amelioration appeared to him very equivocal proofs of the greatness of the human mind. "If you wish to see it truly great," added he, "enter into the cabinet of Newton, employed in decomposing light, or in explaining the system of the world."

Already for some time he had regretted not having listened to the advice of his friends, who at the commencement of our troubles had recommended him to seek an asylum, which it would have been so easy for him to find. As long as the revolution seemed only to threaten the pension which he enjoyed in France, he had neglected that consideration, out of curiosity to be upon the spot of one of those great convulsions which it is always more prudent to observe at a distance. "It was your own choice," said he several times to himself, when he entrusted me with his regret. It was to no purpose that a special decree of the Constituent Assembly had ensured the payment of his pension. The decree was of no value, because the depreciation of the paper currency was sufficient to render it illusory. He had been named member of the *Board of Consultation*, appointed to examine and reward useful inventions. He had been appointed one of the administrators of the Mint. This commission offered him few objects to fix his attention, and could in no degree remove his apprehensions. It was again proposed to draw him to Berlin, and to restore him to his former situation. He had agreed to the proposal. Herault de Sechelles, to whom he had applied for a passport, offered him, for the greater security, a mission to Prussia. Madame La Grange would not consent to quit her country. This repugnance, which at that time he considered as a misfortune, was to him a source of fortune and of new glory.

The Normal School, of which he was named professor, but which had only an ephemeral existence, scarcely gave him time to explain his ideas respecting the foundation of arithmetic and algebra, and their application to geometry.

The Polytechnic School, the result of a happier idea, had likewise a more durable success: and among the best effects which it produced, we may place that of having restored La Grange to Analysis. It was there that he had an opportunity of developing those ideas, the germ of which was to be found in two memoirs that he had published in 1772, and the object of which was to explain the true metaphysics of the differential and integral calculus. To render these happy developements more easily understood, the professor associated himself with his pupils. It was then that he composed his Analytical Functions, and his Lectures on that Calculus, of which he published several editions.

It was then likewise that he published his treatise on the numerical solution of equations, with notes on several points of the theory of algebraic equations.

It is said that Archimedes, whose great reputation, at least with the historians, is founded upon the machines of all kinds, by means of which he retarded the taking of Syracuse, despised these mechanical inventions, on which he wrote nothing, and placed importance only in his works of pure theory. We may sometimes conceive, that the great mathematicians of our age entertained the same sentiments with Archimedes. They consider a problem as solved when it presents no analytical difficulty, when nothing remains to be done but differentiations, substitutions and reductions, operations which require merely patience, and a certain dexterity derived from practice. Satisfied with having removed all the real difficulties, they concern themselves perhaps too little with the embarrassments which they leave to the calculator, and with the long labour necessary in order to make use of their formula, even after it has been suitably reduced. M. la Grange had more than once attempted to abridge the usual calculations.

The general resolution of algebraic equations is subject to difficulties which are considered as insurmountable; but in practice every determinate problem brings us to an equation, all the co-efficients of which are given in numbers. It would be sufficient, therefore, to have a sure method of finding all the roots of such an equation which is called *numerical*. This was the object which M. la Grange proposed to himself. He analyses all the known methods, and shews their uncertainty and insufficiency. He reduces the problem to the determination of a quantity smaller than the smallest difference between the roots. This is something. We cannot too much admire the analytical skill displayed throughout the whole work. But notwithstanding all the resources of the genius of M. la Grange, we cannot conceal that the labour of his method is exceedingly great, and calculators will doubtless continue to prefer methods less direct indeed, but more expeditious. The author resumed this subject no less than four times. It is to be feared, that a commodious and general solution will never be discovered, or at least it must be sought for by other means. The author seems to have acknowledged this himself, as he recommends the method of M. Budan as the most convenient and elegant for resolving equations whose roots are all real.

The desire of multiplying useful applications induced him to undertake a new edition of the *Mecanique Analytique*. His project was to develope the most useful parts of it. He laboured at it with all the ardour and intellectual power which he could have applied at any period of his life. But this application occasioned a degree of fatigue, which threw him into a fainting fit. He was found in that state by Madame La Grange. His head in falling had struck against the corner of a table, and this shock had not restored him to his senses. This was a warning to take more care of himself. He thought so at first; but he was too anxious to finish his work. The first volume had appeared some time before his death. It had been followed by a new edition of his *Fonctions Analytiques*. So much labour exhausted him. Towards the end of March a fever came on, he lost his appetite, his sleep was uneasy, and his waking was accompanied by alarming swoonings. He perceived his danger; but, preserving his undisturbable serenity, he studied what passed within him, and, as if he were assisting at a great and uncommon experiment, he bestowed all his attention on it. His remarks have not been lost. Friendship conducted to his house on the 8th of April, in the morning, MM. Lacepede, Monge, and Chaptal, who took care to write down the principal points of a conversation which was his last. (We have scrupulously followed these notes, and the passages under inverted commas are faithfully copied from the manuscript of M. Chaptal.)

"He received them with tenderness and cordiality. I was very ill, my friends, (said he,) the day before yesterday; I perceived myself dying, my body became weaker, my moral and physical powers were gradually declining; I observed with pleasure the gradual diminution of my strength, and I arrived at the point without pain, without regret, and by a very gentle declivity. Death is not to be feared, and when it comes without violence, it is a last function, which is neither painful nor disagreeable." Then he explained to them his ideas respecting life, the seat of which he considered as spread over the whole body, in every organ and all parts of the machine, which in his case became equally feebler in every part by the same degrees. "A little longer, and there would have been no functions, death would have overspread the whole body, for death is merely the absolute repose of the body; I wished to die," added he with greater force, "I found a pleasure in it; but my wife did not wish it. I should have preferred at that time a wife less kind, less eager to restore my strength, and who would have allowed me gently to have finished my career. I have performed my task. I have acquired some celebrity in the mathematics, I have hated nobody, I have done no ill; it is now proper to finish."

As he was very animated, especially at these last words, his friends, notwithstanding the interest with which they listened to him, proposed to retire. He retained them, began to relate to them the history of his life, of his labours, of his success, of his residence at Berlin, where he had often told us what he had seen near a king; of his arrival at Paris, the tranquillity he had enjoyed at first, the anxiety occasioned to him by the Revolution, and how he had been finally rewarded by a powerful monarch, capable of appreciating his worth.

He had neither been ambitious of riches nor honour; but he had received both with respectful gratitude, and rejoiced at the acquisition for the advantage of the sciences.

La Grange had not lost all hope of cure; he believed only that his convalescence would be tedious. He offered, when he recovered his strength, to go and dine at M. Lacepede's country house with MM. Monge and Chaptal, and proposed to give them details respecting his life which could be found nowhere else. These details are irretrievably lost. We do not even know to what he alluded, nor what he could have added to the second volume of the *Mecanique Analytique*, which was then in the press. We have just learned that the Countess la Grange has put into the hands of M. Prony the complete manuscript of the second volume, in which will be found important additions, and sections entirely written anew. By the care of an editor so skilful, and so devoted to the memory of the author, the philosophical world is sure of obtaining with the greatest accuracy and dispatch what is wanting to complete the work, and perhaps even memoirs entirely new.

"During this conversation, which lasted more than two hours, his memory often failed him; he made vain efforts to recover names and dates, but his discourse was always connected, full of strong thoughts and bold expressions." This exercise of his faculties wasted the whole remains of his strength. Scarcely had his friends left him, when he fell into a fainting fit, and he died two days after, on the 10th of April, 1813, at three quarters past nine o'clock in the morning.*

M. la Grange was of a delicate but good complexion. His tranquillity, his moderation, and austere and frugal regimen, from which he rarely deviated, prolonged his life to the age of 77 years, two months, and ten days. He was twice married: first at Berlin, in order to be on a footing with the rest of the academicians, none of whom were bachelors. He brought from Turin one of his relations. He married her, and lost her after a long illness, during which he had bestowed on her the most tender and unremitted care. When he afterwards married, in France, Mademoiselle Lemonnier, daughter of the celebrated astronomer of that name, he said to us, "I had no children by my first marriage; I do not know if I shall have them by my second; but I scarcely desire them." What he principally wished was an amiable companion, whose society might afford him some amusement during the intervals of his studies, and in this respect he was very successful. Madame la Grange, daughter, grand-daughter, and neice, of members of the Academy of Sciences, was deserving of the name which he gave her. This advantage in her eyes making up for the difference of their ages, she soon felt for him the tenderest regard. He was so grateful that he could scarcely bear to be separated from her, and it was on her account alone that he felt any regret at relinquishing this life; and he was often heard to say, that of all his good fortune, that which he prized the most was, having obtained a companion so tender and attached to him. During the ten days which his illness lasted, she never quitted him for a moment, and was constantly employed in recruiting his strength and prolonging his existence.

He loved retirement; but did not insist upon his young wife following his example. On her account he went out more frequently, and indeed his high situations obliged him to shew himself in the world. It was often apparent that he continued the meditations in public which he had begun in his cabinet. It has been said that he was not insensible to the charms of music. In fact, in a numerous company he was not displeased at a concert. On one of those occasions I asked him what he thought of the music: "I love it," says he, "because it leaves me to myself. I listen to it during the first three measures, but I hear no more of it; I give myself up to reflection, nothing interrupts me, and in this way I have solved many a difficult problem." Hence the finest music must have been that during which he was inspired with the finest of his thoughts.

Though he had a venerable figure, he would never allow his portrait to be drawn. More than once, by a very excusable piece of address, persons have been introduced during the meeting of the Institute, to take a sketch of him without his knowledge. An artist sent by the Academy of Turin drew in this manner the outline, from which was constructed the bust that was exhibited for some months in the hall of the Institute, and is at present in the library. A cast was taken of him after his death; and some time before, while he slept, a picture of him was taken, which is said to resemble him very much.

Gentle and even timid in conversation, he took a pleasure in asking questions, either to draw out others, or to add their reflections to his own vast knowledge. When he spoke, it was always in a tone of doubt, and his first words usually were, *I do not know*. He respected the opinions of others, and was very far from laying down his own as a rule. Yet it was not easy to make him change them. Sometimes he even defended them with a degree of heat, which continued to increase till he was sensible of some alteration in himself; then he immediately resumed his usual tranquillity. One day, after a discussion of this kind, M. la Grange having left the room, Borda remaining alone with me, allowed these words to escape him: "I am sorry to say it of a man like M. la Grange, but I do not know a more obstinate person." If Borda had gone away first, La Grange might have said to me as much of our associate, who was a man of excellent sense and considerable wit; but who, like La Grange, did not easily abandon those opinions which he had adopted after a mature examination.

A gentle and good-natured irony was often remarkable in the tone of his voice; but I never saw any person hurt at it; because it was necessary to have well understood every thing that went before, to perceive the true intention of it.

Among all the master-pieces which we owe to his ge-

* The body of La Grange was deposited in the Pantheon, beside those of a number of unknown senators. We copied the following inscription from his stone tomb.

Joseph Louis La Grange<br>
Senateur, Comté de L'Empire,<br>
Grand Officier de la Legion d'Honneur,<br>
Grand Croix de L'Ordre Imperial de la Reunion,<br>
Membre de L'Institut, et de Bureau des Longitudes,<br>
Né à Turin Departement du Po, le xxv Janvier 1736,<br>
Decedé a Paris le x Avril 1813. Ed.

nius, his *Mecanique* is certainly the most remarkable and the most important. The *Fonctions Analytiques* hold only the second place, notwithstanding the fruitfulness of the principal idea, and the beauty of the developments. A notation less commodious, and calculations more embarrassing, though more luminous, will prevent mathematicians from employing, except in certain difficult and doubtful cases, his symbols and names. It is sufficient that he has proved the legitimacy of the more expeditious processes of the differential and integral calculus. He has himself followed the ordinary notation in the second edition of his *Mecanique*.

This great work is entirely founded on the calculus of variations, of which he was the inventor. The whole flows from a single formula, and from a principle known before his time; but the whole utility of which was far from suspected. This sublime composition includes all his other preceding labours which could be connected with it. It is distinguished likewise by the philosophical spirit which reigns from one end of it to the other. It is likewise the best history of that part of the science,—a history which could only have been written by a man perfectly master of his subject, and superior to all his predecessors, whose works he analyses. It forms a most interesting piece of reading, even to him who is not capable of appreciating all the details. Such a reader will at least find the intimate connection of all the principles on which the greatest mathematicians have founded their researches into mechanics. He will there see the geometrical law of the celestial motions deduced from simple mechanical and analytical considerations. From these problems, which serve to calculate the true system of the world, the author passes to questions more difficult, more complicated, and which belong to another order of things. These researches are only objects of pure curiosity, as the author announces, but they show the extent of his resources. Finally, we see there his new theory of the variations of arbitrary constant quantities of the motion of the planets, which had appeared with so much eclat in the *Memoirs of the Institute*, where it had shown that the author, at the age of 75, had not sunk from the rank which he had filled for so long a time in the opinion of all mathematicians."

GRANGEMOUTH. See Borrowstoness and Stirlingshire.

GRANITE. See Mineralogy.

GRANSON, or Grandson, is the name of a small town in the canton of the Pays de Vaud. It is situated on the western bank of the lake of Neufchatel, about a mile from the foot of Mount Jura, which here bears the name of Thevenon. In approaching this town from Yverdun, it appears finely situated above the lake, and is particularly distinguished by its lofty chateau crowned with five or six towers. At the entrance to the town there is an old church, which does not appear to be used. The road passes through an arch surmounted with a tower and spire. The number of houses in 1814, when we passed through it, was 100. The opposite bank of the lake of Neufchatel is a lofty ridge, finely wooded, with the grand range of the eastern Alps towering above it.

Granson is celebrated in the history of Switzerland, for the great battle which the Swiss gained over Charles the Bold, Duke of Burgundy, on the 3d of March 1476. The Duke's army, which was 6000 strong, occupied Granson, and the villages of Possine, Corsalette, Giez, Vallieres, and Tuileries, and was defended on the right by the lake, and on the left by Mount Arnou, and on the east by the Thevenon, and by entrenchments on every other point. The battle began near Concise and the Chartreuse of Lalance, and terminated in the complete defeat of the Duke of Burgundy, who lost all his baggage and jewels.

One of his diamonds, which was the largest then known, was found by a Swiss soldier, and sold for a florin to the curate of Montagny. This diamond was afterwards sold to Pope Julius II. for 20,000 ducats. Other two diamonds were found by the Swiss, one of which now forms part of the imperial treasury of Vienna, and the other belongs to the crown of France.

GRANTHAM, a town of England in Lincolnshire, is situated on the river Witham, near the ancient Roman road, called Ermine Street. The town, which is neat and clean, and contains many excellent houses, consists of four principal streets, called Westgate, Watergate, Castlegate, and Swinegate. The church, which is elegantly built of stone, consists of a nave, with spacious north and south aisles. It is lighted with handsome painted windows, and has been celebrated for the elegance of its spire, which consists of a quadrangular tower, containing three stories. At each angle of the parapet is an hexangular crocketted pinnacle, over which rises an octagonal spire, ornamented with crockets in the angles, and at these several distances encircled with windows having triangular heads. The height of the tower to the battlements is 135 feet, and from that to the top of the vane 138, making a total height of 273 feet. The nave, including the chancel and side aisles, is 116 feet long inside, and 80 feet broad. The church contains several handsome marble monuments. The front, which is octangular, is deemed a handsome specimen of ancient sculpture. The crypt under the aisle is used as a charnel-house, which contains great numbers of bleached sculls and bones The vestry has been fitted up to receive the library of the Rev. Dr Newcome, a native of Grantham, who bequeathed it for the use of the town and neighbourhood.

The guildhall was rebuilt in 1787, and contains a large apartment for an assembly-room. The free-school was founded by Richard Fox, Bishop of Winchester, and in the present school-house Sir Isaac Newton studied the classics for several years. Without the Spittlegate is the Grantham Spa, a mild chalybeate, containing a small portion of aërated iron.

A canal has some time ago been cut from Grantham to the river Trent, a distance of 30 miles, with a fall of 148 feet to the river Trent. In 1798, 114,734*l.* had been expended on the undertaking, and the tonange then amounted to 4381*l.* Corn and coals are the principal articles which it conveys. There is a race-course in the neighbourhood of Grantham, where races are held annually.

The following is the population of the borough and parish, according to the census of 1811.

| | |
|---|---|
| Number of inhabited houses | 673 |
| Do. of families | 776 |
| Do. employed in agriculture | 61 |
| Do. in trade and manufactures | 430 |
| Males | 1677 |
| Females | 1969 |
| Total population | 3646 |

See *Beauties of England and Wales*, vol. ix. p. 766.

GRANTOWN. See Moravshire.

GRAPHOMETER, is a name sometimes given to instruments similar to goniometers, or to particular modifications of the theodolite. See Goniometer.

GRATZ, or Graz, is the name of an ancient town in the duchy of Styria, situated on the river Muehre. The town of Gratz is well built, the streets spacious and well laid out, and the houses, which are almost all of stone, are neat and commodious. The town, properly so called, is very small, and is surrounded with walls, ditches, and fortifications; but the suburbs are very large, and have lately increased with rapidity. The suburbs lie round the town like distinct villages, and are intermingled with gardens and vineyards. The citadel is situated within the town, on a very steep hill, about 600 or 700 feet above the level of the river, and has a well communicating with the Muehre. It was once a place of considerable strength; but it has been so much neglected, that in the year 1797, it offered no resistance upon the approach of the French. One of the principal objects of interest at Gratz is the imperial mausoleum of Ferdinand II. who was born in this town in 1578. The architecture is not in the best style; but its interior is richly ornamented with sculpture. The life of the Emperor Leopold is represented on the roof, in several emblematic paintings. On the top of the mausoleum is an observatory, which was once well furnished with astronomical instruments. The emperor's second son John Charles, and Mary Anne, Duchess of Bavaria, his consort, are buried along with Ferdinand in the circular chapel in the lower part of the mausoleum.

The assembly-room and the theatre, which are both under one roof, form a very extensive building. The arsenal, the house of the states, and the private residences of the Count Sauran, Loibel, and Wermbrand, are the other buildings deserving of notice. The castle, which was formerly the residence of the Dukes of Styria, is now the dwelling of the governors, and the seat of the regency. The house in which Bonaparte resided is very spacious, and is now shown as one of the curiosities of the town. Gratz is the see of a bishop, who generally resides at it about eight months in the year.

At no great distance from the town are several handsome villages, and the intermediate space between them and the suburbs is covered by country houses, large and small, farm houses, and detached cottages, so that the whole of this tract, when seen from the citadel, forms a rich and pleasing picture, and not only occupies a plain of above 18 square miles, but encroaches even upon the neighbouring hills. These hills are of a moderate height, and are partly covered with wood, and partly occupied with fields, vineyards, and meadows, up to their very summits. The population of Gratz has been stated in some statistical tables at 40,000; but it probably does not exceed 33,000. The population of the circle of Gratz, one of the five circles of Styria, is 296,424. East Longitude, according to accurate observations, 15° 27′ 15″, North Latitude 47° 4′ 9″. See Styria.

GRASSES. See Agriculture *Index*.

GRAVE-Harmonics, in Music. See Harmonics, *Grave* and *Acute*.

Grave *Intervals*, according to Maxwell and Liston, are such as are lessened by the major comma; they are marked with the grave accent (\`), and are usually called by us, *Comma-deficient* intervals.

The Grave *Diesis* of Liston, $\mathcal{E}' = \mathcal{E} - c = 10\Sigma + m$, is the *Minor* Comma, which see.

The Grave *Limma* of Liston, $S' = S - c, = 36\Sigma + f + 3m$, is the Semitone *Minor*, which see.

The Grave *Tone* of Liston, (p. 14.) $T' = T - c, = 93\Sigma + 2f + 8m$, is the Tone *Minor*, which see.

Grave *Fourth* of Holden, or bearing fourth, has the ratio $\frac{16}{21}$, $= 240.06077\Sigma + 5f + 20m$; and is the *Lesser false* Fourth of the trumpet, which see.

Grave *Semitone* of Holden, or deficient semitone of the same author, (p. 341.) has the ratio $\frac{20}{21}$, $= 43.052904\Sigma + f + 4m$; its common log. $= .9788107,0093$; it is $+ 43.234017 \times \Sigma, = 3.92754 \times c, = .070389 \times$ VIII. M. Feyton mentions it as his *Semitone* E E♯, and it is the *Semitone* of Ptolemy's Diatonicum molle.

GRAVEL. See Medicine.

GRAVER. See Engraving.

GRAVESEND, is a town of England, in the county of Kent, built on a gentle declivity, on the banks of the Thames. It consists of several narrow streets, the best of which are the one on the great London road, and another at right angles to it, leading to the river. The church, which is dedicated to St George, was erected near the river between 1731 and 1733. It is built of brick, with stone quoins and cornices, and consists of a spacious nave and chancel, &c. The town-hall was erected in 1764, and has a poultry market below it. It is supported by six columns in front, and three arches behind. A neat little theatre, with a brick front and wooden sides, and a small projecting wooden portico, surmounted by a bust of Shakespeare, was built in 1808; and a handsome chapel in 1812, on the north side of the London road. A new wharf and crane were erected in 1767, and two batteries of 16 guns each have more recently been built, for the defence of the town. There is here a small manufactory for cables and ropes, and a yard for ship-building. Most of the outward bound ships are supplied with live and dead stock at Gravesend, and also with vegetables, for the cultivation of which about 80 acres of ground are appropriated. The town is often crowded with seamen and strangers, from the great quantity of shipping that usually lie at anchor in the channel near the town; and in summer many visitors are attracted by the accommodations of a new bathing-house, which was built by subscription in 1796. About 18 or 20 Gravesend smacks are employed in the cod and haddock fishing.

According to the population return for 1811, Gravesend parish contains

| | |
|---|---|
| Number of inhabited houses | 525 |
| Number of families | 698 |
| Do. employed in agriculture | 83 |
| Do. in trade and manufactures | 457 |
| Number of males | 1505 |
| Do. females | 1614 |
| Total population | 3119 |

See *Beauties of England and Wales*, vol. vii. p. 577.

GRAVIMETER. See Hydrometer.

GRAVITATION. See Astronomy, Chapters I. II. III. IV. V. of *Physical* Astronomy; and also the articles Attraction and Newton.

GRAVITY, Specific. See Hydrodynamics and Specific *Gravity*.

GRAY, Thomas, an eminent English poet, was born at Cornhill in London, on the 20th of December 1716. His father, Philip Gray, was a money scrivener of the city. His mother, whose maiden name was Dorothy Antrobus, was, owing to the bad usage of her husband, obliged to apply to an eminent civilian for his advice as to a separation from him. Our poet, their fifth child, owed his life to the affectionate courage of his mother, who, by opening a vein with her own hand, removed a paroxysm which attacked him in his childhood. To this parent's exertions he was also indebted for his education; so that, considering the unhappiness of her life, and the gratitude which her son owed her, we can easily conceive the truth of what Mason tells us, that Gray always mentioned his mother's name with a sigh. Gray was educated at Eton, under the protection of Mr Antrobus, his maternal uncle, who was a fellow of Peterhouse, Cambridge. At that university, Gray was admitted a pensioner in his 19th year. During his first four years residence there, he seems to have withdrawn himself from the severity of mathematical studies, while his enquiries centered in classical and modern literature.*

In 1738, he removed to the Inner Temple; but laid aside his legal studies to accompany Horace Walpole on a tour through France and Italy. An unhappy difference, however, with the blame of which Walpole has candidly charged himself, parted the travellers at Reggio, and their broken friendship, in spite of a formal reconciliation, seems never to have been entirely cemented. Gray returned to London in 1741, in the same year in which his father died. His mother, with a very small fortune, had retired to live with her sister at Stoke, near Windsor. Mr Gray, therefore, found his patrimony too small to enable him to prosecute the study of the law; and though his mother and aunt would undoubtedly have contributed all in their power to assist him, he could not brook the idea of becoming a burthen to them. Yet such was his delicacy, that he could not peremptorily declare to his relations his resolution of abandoning his profession: he therefore pretended only to change the line of it, and accordingly he went to Cambridge, where he took a bachelor's degree in civil law. In the same year in which he graduated, (1742) he lost his friend West, with whom his friendship had commenced at Eton, and had continued with unabated warmth after they had gone to different universities. The sorrow which the death of this amiable young man left upon our poet's mind, and the tenderness with which he honoured his memory, form one of the most interesting traits of his character.†

On his second return to Cambridge, he applied himself for about six years with the most intense assiduity to the perusal of Greek authors, and made himself a consummate scholar and critic in that language. In 1747, he appeared for the first time as an author, by the publication of his Ode on the prospect of Eton College, of which it would seem that at first little notice was taken. His Ode to Spring had been already written at Cambridge; and soon after the publication just mentioned, he sent to Dr Wharton of Durham, his poem on the Alliance of Education and Government, which he never pursued much farther. In 1749, he finished his Elegy, which he had begun seven years before, and which when published obtained immediate popularity.

In 1754 and 1755, he appears to have written his beautiful lines on the Pleasures arising from Vicissitude, his Ode on the Progress of Poetry, the Bard, and probably some of those fragments with which he seems to have amused himself, without much design of completion. About this period, he complains of listlessness and depression of spirits, which prevented his application to poetry; and from this time we may trace the course of that hereditary disease in his constitution, which the temperance and regularity of a whole life could not subdue. Next year, he left Peterhouse at Cambridge, where he had resided above twenty years, on account of some incivilities which he met with, and which Mason thus mentions. Two or three young men of fortune, who lived on the same staircase, had for some time intentionally disturbed him with their riots, and carried their ill behaviour so far as to awaken him at midnight. After having borne a considerable time with their insults, Gray complained to the governing part of the Society, and not thinking that his remonstrance was sufficiently attended to, quitted the College. He now removed to Pembroke Hall, which he describes "as an era in a life so barren in events as his"

In the July of 1757, he took his Odes to London to be published. "I found Gray (says H. Walpole) in town last week. He brought his two Odes to be printed. I snatched them out of Dodsley's hands, and they are to be the first fruits of my press." Although the genius of Gray was now in its firm and mature age, and though his poetical reputation was deservedly high, it is plain that these Odes were not favourably received. "His friends (he says) write to him that they do not succeed." Yet there were some better judges who admired them. Garrick wrote lines in their praise; and Warburton, while he bestowed his honest applause on them, shewed his indignation at those who condemned without being able to understand them. In this year Cibber died, and the laureateship was offered by the Duke of Devonshire, then Lord Chamberlain, to Gray, with a remarkable and honourable privilege to hold it as a mere sinecure. This offer he respectfully declined; and in a letter to Mr Mason, he gives some of his reasons for declining it. "The office itself (he says) has always humbled the possessor hitherto:—if he were a poor writer, by making him more conspicuous; and if he were a good one, by setting him at war with the little fry of his own profession: for there are poets little enough even to envy a poet laureat." In 1758, Gray describes himself "as composing for his own amusement the little book, which he calls a Catalogue of the Antiquities, Houses, &c. in England and Wales."‡ About this time, the study of architecture seems to have employed much of his time, in which his proficiency (as in every branch of study which he pursued) was accurate and deep. Early in the next year the British Museum was opened to the public, and he went to London to read and transcribe the MSS. which were there collected from the Cottonian and Harleian libraries. A folio volume of his transcripts was left among his papers. No other remarkable date occurs in the peaceful tenor of our poet's days, till in 1762, the professorship of modern history being vacant, by the advice of his friends, he applied to Lord Bute for the place, through the medium of Sir Henry Erskine. He was refused, and the professorship was given to another; and "so (says Gray) I have made my fortune like Sir Francis Wronghead."

In the summer of 1765, he took a journey into Scotland to improve his health, which was then weak, and to gratify his curiosity with the romantic scenery of the north. He went through Edinburgh and Perth to Glammis castle, the residence of Lord Strathmore, where he stayed some time. Thence he took a short excursion into the Highlands, crossing Perthshire by Loch Tay, and pursuing the road from Dunkeld to Inverness, as far as the pass of Killikrankie. Then returning to Dunkeld, he travelled on the Stirling road to Edinburgh. In Scotland, his general shyness to men of letters was felt and complained of; but he formed an acquaintance with Dr Beattie, which was kept up by subsequent correspondence. The university of Aberdeen was disposed to confer on him the degree of Doctor of Laws; but he refused it, lest it should seem a slight to his own university. At Dr Beattie's desire, a new edition of his poems was published by Foulis at Glasgow, whilst Dodsley at the same time was printing them in London. In both these editions the long story was omitted, and some Welch and Norwegian fragments inserted in their place.

* His productions during that period, were some Latin verses, entitled *Luna Habitabilis*, inserted in the *Musæ Etonenses*; a poem on the marriage of the Prince of Wales; and a Sapphic Ode to his friend West, both in Latin. A latin version of a passage of the *Pastor Fido*, and Fragments of Translations from Italius and Tasso.

† Richard West was the son of the Lord Chancellor of Ireland, and grandson by the mother's side of the famous Bishop Burnet.

‡ It was printed and distributed among his friends by Mr Mason after his death.

To his Odes, Gray now found it necessary to add some notes; "partly," he says, "from justice, to acknowledge a debt when I had borrowed any thing; partly from ill temper, just to tell the gentle reader, that Edward I. was not Oliver Cromwell, nor Queen Elizabeth the witch of Endor."

In 1768, the professorship of modern history became again vacant, and the Duke of Grafton, then in power, at the request of Mr Stonehewer, bestowed it on Gray. Soon after the Duke of Grafton was elected to the chancellorship of the university, and Gray wrote the Ode, that was set to music, on the occasion of his installation. "He thought it better that gratitude should sing than expectation." When this ceremony was past, he went on a tour to the lakes of Westmoreland and Cumberland, from which his letters are written in a style of the most picturesque description. "He that reads his epistolary narrative," says Dr Johnson, "wishes that to travel, and to tell his travels, had been more of his employment."

In the April of 1770, he complains much of a depression of spirits, and talks of an intended tour into Wales, which took place in autumn; but not a single letter is preserved in Mr Mason's book on this journey.

In May 1771, he wrote to his friend Dr Wharton, just sketching the outline of his tour in Wales, and some of the adjacent country. This is the last letter that remains in Mr. Mason's collection. He there complains of an incurable cough, of spirits habitually low, and of the uneasiness which the thought of the duties of his profession gave him, which, Mr. Mason says, he had now a determined resolution to resign.* He mentions also different plans of amusement and travel which he had projected, but which unfortunately were not to be accomplished. Within a few days after the date of this letter he removed to London, where his health more and more declined. His physician, Dr Gisborne, advised free air, and he went to Kensington. There he in some degree revived, and returned to Cambridge, intending to go from that place to Old Park, near Durham, the residence of his friend Dr Wharton. On the 24th of July, however, while at dinner in the college hall, he was seized with an attack of the gout in his stomach. The violence of the disease resisted all the powers of medicine. On the 29th he was seized with convulsions, which returned more violently on the 30th, and he expired on the evening of that day, in the 55th year of his age, sensible almost to the last, aware of his danger, and expressing no visible concern at the thought of his approaching death. His friend, Mr Mason, was at that time absent; and the care of his funeral devolved on the other executor, Dr Brown, the president of Pembroke hall, who saw him buried, as he desired, by the side of his mother, in the churchyard of Stoke.

Gray, independently of his poetical character, sustained that of a first-rate scholar. He was perhaps (says the Rev. Mr Temple, in the summary of his character) the most learned man in Europe. He knew every branch of history, natural and civil; had read all the original historians of England, France, and Italy; and was a great antiquarian. His skill in zoology was accurate; and in an interleaved copy of Linnæus which he had left behind, he had not only concentrated what other writers had written, but had altered the style of the Swedish naturalist into classical Latin.† Botany, which he had studied in early life, was also an amusement of his later years. In architecture he was eminently skilled; and in heraldry a complete master. To these accomplishments must be added his exquisite and scientific taste in painting and music. Walpole, in his History of Painters; Bentham, in his History of Ely; Pennant, in his Antiquities of London; and Ross, in his edition of Cicero's Familiar Epistles, were all respectively indebted to the learning of Gray.

As a man, the only blemish in his fine character seems to have been an excessive and half-affected delicacy. His genius as a poet is not of the most extensive, but of the highest cast. He is the only English poet who has divested elegiac poetry of its tædium; placed its sombrous images in a light of picturesque fancy; and given a tone of stedfast though subdued romantic feeling to the plain reflections of truth. Respecting his lyric poetry, the suffrages of criticism are certainly more divided. While by some his Odes have been extolled as the model of lyric poetry, they are esteemed by another school of taste to abound in over-wrought refinements, and obscurity of language. Our limits preclude dissertation; yet whatever justice there may be in the charge of obscurity which attaches to his Odes, the grandeur of thought, and the harmony of versification, which pervade them, will for ever support their general merit, and their rank in the first rate productions of our language, and the muse of England will be for ever acknowledged to have expressed

A Pindar's raptures in the lyre of Gray.

See Mason's *Life and Letters of Gray*; and Mitford's *Life*. (*n*)

GRAZING. See AGRICULTURE.

GREAT INTERVALS, in music, are the same with *major* or *greater* intervals, and are marked with the large Roman numerals; as I. II. III. IV. &c. See MAJOR *Intervals*. But Mr Holden has used this term in a different way. See his *Great* SIXTH, and *Great* THIRD (*ϱ*)

GREAT OCTAVE of the German theoretical writers on music, is that octave (or septave rather) which begins with C on the second leger line below the bass stave, and ends with B on the second line of that stave, or the *mi* of Guido. To this septave they exclusively apply the capital letters C, D, E, F, G, A, B, in their tablature or literal notation; and in the next octave above, the letters c, d, e, f, g, a, b are used. See SMALL OCTAVE, ONCE-MARKED, TWICE-MARKED, &c. *Octaves*; and Dr Callcott's *Musical Grammar*, Art. 34. (*ϱ*)

GREAT SCALE of M. Overend, approved by Dr Boyce, is a musical curiosity preserved in the library of the Royal Institution in London, in the Overend Manuscripts, vol. ii. pp. 113—133, 143—149, &c. It contains 86 notes within the octave, and was thought by the indefatigable musicians above named, to be capable of unravelling all the mysteries of the various ancient Greek scales of music, as Dr Pepusch had explained them diatonically, or by the use of the prime integers, 1, 2, 3, and 5 only, in their ratios; but to the various systems of those, who, according to Dr Wallis, used the higher primes 7, 11, 13, 17, 19, &c. in the ratios, and in consequence have *decimals* of schismas, or Σ's in our notation; or of those, who divided the major *tone*, or the minor *fourth*, into *aliquot parts*, for obtaining their intervals or degrees, this great scale has no near relation. See CHROMATICUM, DIATONICUM, GENERA, and GREEK *Music*. (*ϱ*)

* He had held his professorship of history nearly three years, without having begun to execute the duties of it, which consist of two parts; one, the teaching of modern languages; the other, the reading of lectures on modern history. The former he was allowed to execute by deputies; but the latter he was to commence in person, by reading a public lecture in the schools once at least in every term. He was at liberty to chuse his language, and chose the Latin, which Mr Mason thought somewhat injudicious; and although we do not find that he proceeded farther than to draw up a part of his introductory lecture, he projected a plan of very great extent, which, from his indolence and ill health, he would not in all probability have been able to execute. His death, however, prevented the trial.

† It is a circumstance not generally known, that he translated the Linnæan genera, or characters of insects, into elegant Latin hexameters.

# GREECE,

THE most celebrated country of antiquity, was of very inconsiderable extent, and scarcely equalled in size the half of England. It is comprehended between 36° and 41° of North Latitude; and is bounded on all sides by the sea, except on the north, where it borders upon Epirus and Macedonia. Thessaly, its most northern province, is an extensive and fertile vale, completely surrounded by lofty mountains; by Olympus on the north; by Ossa on the east; by Pindus on the west; and on the south by Oeta, at the foot of which lies the famous pass of Thermopylæ. The tract extending from the borders of Thessaly and Epirus, to the Corinthian isthmus, contains the provinces of Acarnania, on the east frontier of which runs the river Achelous; Ætolia, bounded on the south by the sea, but defended on every other side by mountains almost impassable; Doris, wholly a mountainous country; Locris and Phocis, both of small extent, but full of fertile plains; Bœotia, a well watered vale, bounded, except on the north-east, by the mountains Parnassus, Helicon, Cithæron, and Parnes; and Attica, a rocky and barren country, producing little grain or pasture, but yielding a variety of fruits, particularly figs and olives. The isthmus of Corinth, a mountainous ridge, at one place only five miles in breadth, leads farther south to the peninsula of Peloponnesus, which contains Achaia, a narrow strip of country on the northern coast, bounded on its inland frontier by a ridge of mountains, running along its whole extent from Corinth to Dyme; Argolis, a remarkably fruitful valley, included between two mountainous branches, stretching from Cyllene, the most northern of the Arcadian summits, and terminating, the one in the gulf of Argos, and the other at the promontory of Scylla; Elis, or Eleia, watered by the rivers Peneus and Alphcus, and less mountainous than the other provinces in Peloponnesus; Arcadia, the central state, consisting of a cluster of lofty mountains, the principal of which are Taygetus and Zarex; Messenia, the most level district in the peninsula, the best adapted for tillage, and most fruitful in general produce; and Laconia, traversed by two branches of the Taygetus and Zarex, between which runs the river Eurotas, watering several very fertile but not extensive vales.

The general aspect of Greece is rugged, but its climate is highly propitious; and both the summer heat and winter cold are preserved by the surrounding seas in an equable state of temperature. Some of its mountains contain valuable metals; others are composed of the finest marble; and many are covered to a great extent with a variety of useful timber. Its central plains produce corn, oil, and wine; its valleys afford the richest pasturage; and its long winding coast abounds with excellent harbours. The great variety in its surface gives occasion to considerable diversity both of produce and of climate in every season of the year. It has been remarked, as a peculiar feature in the topography of the most ancient cities of Greece, that every metropolis possessed its citadel and its plain; the former as a place of refuge in war, and the latter as a source of agriculture in peace. The most remarkable of its towns were,—in THESSALY, Gomphi, Metropolis, and Scotussa, north of the river Peneus; Atrax, Larissa, the city of Achilles; Magnesia, and Aphetæ the port of the Argonauts; Heraclea, named from Hercules, who is said to have thrown himself into the pile on the summit of Oeta, in its vicinity; Lamca and Hypata, on the banks of the Sperchens; Thaumaci, Halos, and Pthia, the country of the Myrmidones, Demetrias, Pheræ, Pharsalia, on the banks of the river Enipeus.—In ACARNANIA, Amphilochicum, Stratus, and Actium, at the bottom of the Ambraeian Gulf.—In ÆTOLIA, Chalydon, Chalcis, on the river Evenus; Thermæ, Lysmachia, Canope, Naupactus, Erythræ, and Antirrhium.—In DORIS, Cytinium, and three smaller towns of little note.—In LOCRIS, Amphissa, Opus, Cnemis, Narix, the native country of Ajax, Thronium, Nicæa.—In PHOCIS, Delphi, accounted the centre of Greece; Elatea, on the river Cephissus; Crissa, and Anticyra.—In BŒOTIA, Thebes, near the river Asopus; Platæa, Leuctra, Orchomenos, Haliartus, Coronea, Cheronea, Lebadia, Thespiæ; Ascra, the birth-place of Hesiod; Aulis, Delium, and Tanagra.—In ATTICA, Athens, with its harbour Piræus; Phalereus and Munichia, Marathon, Phylæ, and Decelia.—In MEGARIS, Megara, Eleusis, and Nycæa.—In ACHAIA, Corinth, Sicyon, Patræ, Ægium, Dyme, and Pallene.—In ARGOLIS, Argos, on the river Inachus; Mycenæ, the city of Agamemnon; Epidaurus, Nemea, and Tiryns.—In ELIS, Elis, on the river Peneus; Olympia, and Pisa.—In ARCADIA, Megolopolis, Tegea, Mantinea, and Pallantium.—In MESSENIA, Messene, Stenyclarus, and Pylos, the city of Nestor.—In LACONIA, Sparta, on the river Eurotas; Gythium, Selasia, Helos, Amyclæ.

It has been customary with most writers on the subject of Greece, to distribute its history into distinct periods or epochs; but few authors happen to agree in fixing upon the same points of division. If we proceed upon the principle of marking the degree of credibility in its records, there will then be only two portions to be contrasted; the one the period of uncertain, and the other that of authentic history.

The *first*, "the period of uncertain history," extends from the earliest accounts of the country, to the commencement of the first war with Persia, in the year B. C. 490; a period very variously computed, but, according to the lowest estimate,* comprising a space of nearly 700 years. Of this large portion of time, there are no documents really deserving the name of history; and the accounts which have been given of its events, were drawn up by writers who lived long posterior to the transactions of which they treat, and were compiled from scattered records and fragments, of which there are no sufficient data to ascertain the authenticity. Of this period, however, there may be specified four distinct subdivisions, which are marked by some peculiar historical features. The first, reaching from the earliest accounts of Greece to the commencement of the Trojan war, B. C. 900; a period of 200 or 300 years, and which, without scruple, may be termed "the fabulous age." The second, reaching from the expedition against Troy to the death of Homer, B. C. about 800; a period of at least 100 years, generally called "the heroic age," of which the only history is contained in the poems of the Iliad and Odyssey. The third, reaching from the death of Homer to the death of Lycurgus, B. C. about 700; a period of another 100 years, which may be denominated "the era of revolutions," and

* The Chronology of Sir Isaac Newton.

of which scarcely any species of history exists. The fourth, reaching from the time of Lycurgus to the first invasion of Greece by Persia, B. C. 490; a period of 210 years, which may be termed "the era of traditionary history," possessing a considerable degree of credibility.

The *second*, "the period of authentic history," extends from the first invasion of Greece by the Persians, B. C. 490, to its final subjugation by the Romans, B. C. 146; a period of 341 years, the history of which, luminous and connected beyond that of any other portion of Pagan antiquity, has been recorded by writers of the greatest ability, who were contemporary with the events which they relate, and in which many of them bore a distinguished part. These writers were all Greeks, and some degree of national partiality may be suspected to have guided their narrations; but their number, and their connection with different states, renders them in some measure checks upon one another. This period, also, may be subdivided into four portions, distinguished rather by political than historical characteristics. The first, reaching from the Persian invasion, B. C. 490, to the commencement of the Peloponnesian war, B. C. 430; a period of 60 years, the era of Grecian unanimity and triumphs. The second, reaching from the beginning of the Peloponnesian war, to the accession of Philip of Macedon, B. C. 360; a period of 70 years, the era of civil wars and intestine commotions among the states of Greece. The third, reaching from the accession of Philip to the death of Alexander the Great, B. C. 323; a period of 37 years, distinguished by the entire ascendency of Greece over Persia, and its own partial subjection to the foreign dominion of Macedonia. The fourth reaching from the death of Alexander, to the final subjugation of the Grecian states by the Romans, B. C. 146; a period of 177 years, during the greater part of which the destinies of Greece were directed by foreign influence, and were placed successively under the protection of Macedonia, Egypt, and Rome.

The early history of Greece, like that of most other countries, is involved in obscurity and fable. Its original inhabitants, generally considered as the descendants of Javan, son of Japhet, appear to have led a migratory and savage life, sheltering themselves in caves and huts, feeding upon acorns, clothing themselves with skins, and gradually associating in small bodies for their mutual support against the wild beasts of the woods and mountains, by which they were every where surrounded. Many different wandering hordes, of whom the Greek writers give no satisfactory account, seem to have successively overrun the country; sometimes mixing with the ancient inhabitants, and sometimes driving them from their possessions. These, in their turn, expelled and plundered others; and a state of petty piratical warfare characterised the first ages of every Grecian settlement. These plundering excursions became so general, that all the shores, both of the continent and the islands, are said to have been deserted, and the lands cultivated only at a considerable distance from the sea. From this state of barbarism, the inhabitants of Greece began to emerge at an earlier period than those of any other country in Europe; and this advantage they seemed to have owed entirely to their communication with the civilized nations of the East. Its islands were visited by the Phenician navigators, who introduced the knowledge of the precious metals. A people, named Pelasgi, apparently from Asia, extended their dominion over all the northern parts of the country; and various contemporary colonies from Egypt, (of whose migration the cause is not known, but for which the supposition of some political revolution may easily account,) appear to have founded the principal Grecian states. The island of Crete, which seems to have been occupied, and its inhabitants enslaved by some of these adventurers, first attained a considerable degree of civilization under Minos, above 1000 years before the Christian era;* and became the general foundation of legislation and jurisprudence to the other settlements. Of these, Sicyon and Argos are considered as the most ancient, and as having been founded nearly at the same time, about 80 years before the reign of Minos, and 1080 before the Christian era.

Sicyon, till a very late period, had little influence in the affairs of Greece; and its early history is as uninteresting as it is uncertain. Ægialeus is mentioned as its first king; but the list of his successors rests on no authority, and is not worthy of being transcribed. It seems to have been soon eclipsed by the neighbouring state of Corinth, which was noted, even in the days of Homer, for its commercial wealth. Among its early princes are numbered Sisyphus, Glaucus, and Bellerophon, whose exploits present a subject for poetry rather than materials for history. But the city of Argos, if not actually the oldest in Greece, was the first that acquired political eminence; and was founded by Inachus, or by his son Phoroneus, who is considered as having been the contemporary and brother of Ægialeus, the first king of Sicyon. Io, the daughter of one of the Argive princes, having been carried away to Egypt, her descendant Danaus, afterwards arriving at Argos, claimed the sovereignty, and extending his power over the whole of Peloponnesus, the inhabitants (called Pelasgi before his arrival) received from him the name of Danai. Perseus, one of his descendants, and the first Grecian who is celebrated as a warrior, founded the city of Mycenæ, which became for some time the capital of Argolis; but soon afterwards lost its pre-eminence. Contemporary with Perseus was Pelops, son of Tantalus, king of Phrygia, who, being driven from his native land by unsuccessful war, came with immense treasures into Greece; and, being accompanied by a band of Achaians from Thessaly, established himself in Laconia. Marrying Hippodameia, daughter of the chief of Pisa, he succeeded to the sovereignty of that territory; and, by his numerous family connections, as well as able conduct, acquired so much influence throughout the peninsula, that it derived from him the name of Peloponnesus. His daughter Astydameia was united in marriage with Sthenelus, the son of Perseus; and their son Eurystheus was the prince so often mentioned in Grecian fable as the rival and persecutor of his kinsman Hercules. Pursuing the children and adherents of that deceased hero into Attica, he was slain in battle, and succeeded in the sovereignty of Argos by his uncle Atreus, who uniting in his person the claims of both the houses of Perseus and Pelops, extended his authority over all Peloponnesus, and transmitted the Argian sceptre in its greatest glory to his son or grandson Agamemnon. Lacedemon, or Sparta, concerning the origin of which there is no certain memorial, had now become distinguished under its sovereign Tyndareus, whose sons Castor and Pollux died in the prime of life, and whose daughters, Clytemnestra and Helen, were given in marriage to Agamemnon and his brother Menelaus. Through these princesses, the domains of Tyndareus fell to the two sons of Atreus; and Menelaus was invested with the immediate command of the Lacedemonian territory.

Of the provinces without the peninsula, Thessaly (next to Crete, the most ancient scene of Grecian story,) first became celebrated for the wisdom of its princes, who extended their sway at an early period as far as the Corinthian

* The chronology of Sir Isaac Newton is here followed.

Isthmus. In that country, always famous for its horses, the Centaurs were first known, who are supposed to have been a band of foreign adventurers of superior attainments to the more southern Greeks of their time. From a port in Thessaly, sailed the expedition of the Argonauts under Jason, who may be considered as merely the leader of one of the most considerable piratical expeditions which had hitherto been undertaken. Bœotia, though a country originally subject to earthquakes and inundations, yet, from its great fertility, attracted at an early period the attention of adventurers; and a Phenician colony under Cadmus is understood to have founded its principal city of Thebes. The numerous fabulous stories relating to its history, comprehending the adventures of Bacchus, Amphion, Amphitryon, Hercules, Laius, Œdipus, Eteocles, and Polynices, serve at least to prove that it must soon have become a flourishing and powerful state; and the war, which it sustained against seven united potentates, the subject of the *Thebaid* by Statius, presents the first instance of a political league, and a regular warfare, recorded in the annals of Greece. Ætolia, though not inferior to the adjoining countries in early civilization, and though sufficiently celebrated in the histories of its heroes Tydeus, Meleager, and others, yet, from the dangers of its seas, being much excluded from the intercourse of more civilized nations, made little comparative progress in political improvement, and for several centuries, even after the Trojan war, had little communication with the rest of Greece. Phocis, Doris, and Locris, also afford no materials for history at this early period; and the only remaining state, whose origin is worthy of being narrated from tradition, is that of Attica. The first king of this country is said by some to have been Ogyges, whose name, however, is not mentioned by the older Greek historians, and who is conjectured at the utmost to have been only the leader of a band of Bœotians, who, having been driven from their own country by an inundation, had taken refuge in the adjoining districts of Attica. The first, at least, who introduced regular government and the arts of civilization among the Athenians, was Cecrops, the leader of a colony from Egypt, who introduced the worship of the goddess Athena, or Minerva; and thus gave a name, if not also a beginning, to the city of Athens. He is considered as the founder of the celebrated court of Areopagus; and, in consequence of his wise institutions, aided by the natural security of the country from invasion, strangers were attracted, population increased, and civilization made more rapid progress than in any other province of Greece. Of his successors, little is recorded even by tradition, till the time of Ægeus, contemporary with Minos, King of Crete, and the father of the renowned Theseus, whose romantic history bears no inconsiderable resemblance to that of the Gothic knight-errants, and whose wise measures as king of Athens laid the foundation of its future greatness. By the united influence of persuasion and authority, he consolidated, in one well-regulated government, the independent districts in Attica, and endeavoured to secure the stability of his improvements, by procuring the approbation of the Delphic oracle. Though well entitled, by his political regulations, to be ranked among the most illustrious patriots of ancient times, he is nevertheless represented, in his future history, as having forfeited the esteem of his subjects, and having at last died in exile. After him the sovereignty of Attica was held by Menestheus, a descendant of the royal family, and the leader of the Athenian troops in the Trojan war.

These petty states, each of which was governed by its respective sovereign, and all of them independent of one another, were continually at war among themselves, and exposed to the incursions of foreign barbarians. To obviate these evils, and to secure, as far as possible, the general tranquillity, an assembly was formed of deputies from the different countries of Greece. whose business it was to decide all disputes between the states of which the association was composed, and to concert measures of defence against their common enemies. This was called the council of the Amphictyons, from its supposed founder Amphictyon, one of the sons of Deucalion, and king of Attica; but its original constitution, and the period of its commencement, cannot be satisfactorily ascertained. It is supposed by Sir Isaac Newton to have commenced about a century before the Trojan war. Besides its primary object of establishing a kind of national law among the Greeks, its attention was principally occupied in managing the concerns of the Delphian oracle. But, though its decrees were respected, its power was not very efficacious. It contributed to restrain the violence of wars, but was not able to prevent their frequent occurrence. It derived its greatest consequence from the increasing fame of the oracle at Delphi; and the superintendence of the religious institutions of Greece became ultimately its principal office. It is not mentioned by Homer; but its existence seems to be implied in the ready union of the Grecian states against Troy. See Amphictyons, Cadmus, &c.

Frequent piratical excursions appear to have been carried on between the inhabitants of the eastern and western coasts of the Ægean Sea; and the rape of Helen by Paris, the son of Priam, may be considered, according to Herodotus, as an act of retaliation for some similar injury received from the Greeks by the Trojan people. An outrage, however, so nearly affecting one of the greatest princes of Greece, and aggravated by a breach of the rights of hospitality, was considered as demanding the united vengeance of the Grecian chiefs; and the hope of returning home enriched with the spoils of Asia, presented no small incentive to the expedition. The extensive influence also of Agamemnon king of Argos, and brother of the injured Menelaus, urged on the general confederacy; and, under his supreme command, the chosen warriors of every Grecian state, from the southern extremity of Peloponnesus to the northern regions of Thessaly, assembled at the port of Aulis in Bœotia. The fleet, consisting of 1200 open vessels, conveyed to the Trojan coast an army of 100,000 men, who speedily compelled the enemy to take refuge within the walls of their city; but, unable to surmount its strong and well defended fortifications, they attempted its reduction by excluding every kind of succour and supplies. Obliged, however, to detach large bodies from their army to procure subsistence for themselves, they were unable to prevent the Trojans from again taking the field, and receiving every requisite relief to their wants. In this way the siege was prolonged for the space of ten years: and even at the last, the house of Priam was not overthrown without the aid of stratagem and treachery. But, while the allied Greeks triumphed over Troy, it was to each of them a victory dearly purchased. Few of the princes, who witnessed the successful termination of their expedition, were permitted to enjoy, in their native country, the renown and repose which their exertions had earned; but, having made no provision for the administration of their affairs during their absence, were either murdered at their return by some usurper of their power, or compelled to reimbark with their adherents, in quest of distant settlements. The Athenian state, which seems to have made the nearest approach to a settled government, suffered least by the absence of the commander of their army; and regular magistrates supplied the place of their chief. In this city, Orestes, the son of Agamemnon, obtained an asylum; and, after remaining seven years in exile, found means to avenge his father's death, and to recover the throne of Argos, which he held with great power and reputation till his death. See ACHILLES, AGAMEMNON, AJAX, HOMER, TROY, &c.

Here terminates the history contained in the writings of Homer, who seems to indicate, that the concluding events which he records were within the reach of his own memory; and whose works, in fact, contain almost the only materials for an account of the heroic age. He affords at least the best and most authentic view of the political and domestic state of the Greek people, during the period which preceded his death; and to his poems we may refer for a description of the religion, government, arts, and manners of the early Greeks. The ancient Pelasgian inhabitants of Greece are said by Herodotus to have prayed and sacrificed to gods, to whom they gave no name or distinguishing appellation; and the works of Hesiod still more clearly prove that they drew their first notions on the subject of religion from Oriental traditions. Their future system of polytheism seems to have been imported by the Egyptian colonists; but to the principal divinities thus introduced, their own lively fancy soon added a multitude of other imaginary beings, presiding over every mountain and river, every season and production; and these were arranged by Hesiod and Homer into a kind of system of the most extravagant and inexplicable description. There is neither omnipotence nor omnipresence among the attributes which the last mentioned poet ascribes even to the father of the gods; neither perfect goodness nor perfect happiness in the heaven, which he assigns as their residence. An incomprehensible power, denominated Fate, is represented as directing all events; and it seems to have been the principal office of Jupiter to superintend the execution of its decrees. Idolatry, as denoting the worship of visible objects, was at this period unknown; and even temples appear to have been rare. Prayers were addressed as to invisible deities; and sacrifices, the only duty which they seem to have been considered as expecting from their worshippers, were offered upon altars erected in the open air. A few crimes are sometimes denounced as exposing to the vengeance of the gods, but morality in general finds very little support in the religion of this period. Soothsayers, who professed to foresee future events, were sufficiently numerous; but fixed oracles had not yet attained any extensive celebrity. The salutary doctrine of the immortality of the soul, and a future state of rewards and punishments, was taught in those days; but the ridiculous absurdities, with which it was clothed, tended, when men had learned to despise the fables, to throw contempt also upon the momentous truth which they had veiled. The form of government was monarchical, and in some degree hereditary; but the authority of the kings was extremely limited, and always controuled by established customs. It was the universal prerogative of the prince to exercise the judicial power, to superintend the institutions of religion, to command the armies, and to direct the ordinary business of the community; but, in any extraordinary or very important measure, he was required to consult, not only a council of the principal men, but also an assembly of the people; and a high degree of personal strength and accomplishments seems to have been always necessary to maintain his authority.

It is generally admitted that letters were introduced into Greece from Phœnicia by Cadmus, the founder of Thebes, at the lowest calculation 1045 years before Christ; but it is equally ascertained, that the use of writing had not become common till more than 400 years after his time; and nothing, in the whole history of the ancient Greeks, is more difficult to be explained than the high state of excellence, which the language had attained in the days of Hesiod and Homer, while so little of it could have been reduced to writing. In the absence of letters, poetry seems to have been invented, or at least to have been originally employed for the assistance of memory. Laws, among the early Greeks, were always promulgated in verse, and frequently sung in public. Morality was taught, and history related in the same manner. All, who wished either to instruct or amuse their fellow-citizens, were thus necessarily poets; and they who possessed so important a talent, were considered as sacred characters, favoured and inspired by the gods. The first poetry of the Greeks was uniformly accompanied mith music, and both stringed and wind instruments are mentioned by Homer. But, there are no means of ascertaining its peculiar features; and, however powerful may have been its effects, it appears to have been extremely simple and inartificial in its composition. Their agriculture appears to have been carried on with considerable regularity; and the practice of manuring, as well as ploughing and sowing, is expressly mentioned by Homer. Wine was made from the vine, and oil from the olive; but the principal source of wealth was found in pasturage; and cattle were made, in place of coin, the usual measure of the value of commodities. Commerce was chiefly carried on by an exchange of articles; and the foreign trade of the Grecian cities was principally in the hands of the Phenicians. There were Greeks, indeed, in the days of Homer, who pursued a kind of coasting traffic among themselves; but the profession of a merchant for gain was not held in much estimation, and was less respected than even that of pirate. Their navigation was very imperfect; and they used oars more frequently than sails. Their ships had no decks; and the largest that went to Troy, contained only 120 men. Anchors were unknown; and the vessels, when in port, were either moored to large stones on the shore, or were actually drawn out of the water upon the beach. The early Greeks, in short, were rather boatmen than seamen; and, indeed, to this day, the skill of the navigator is of little avail in their narrow and tempestuous seas. They had little knowledge of astronomy; and marked the length of the year by 12 revolutions of the moon, reckoning the months to consist of 29 and 30 days alternately. But, in progress of time, they learned to fix the seasons more correctly by the rising and setting of the stars; and had arranged them in constellations, much in the same manner, and with the same names as at the present day. They considered internal diseases as inflicted by the immediate hand of the Deity, and as therefore beyond the reach of human skill. Their medical art was thus restricted to the practice of surgery, which was held in high esteem; but which seems to have extended no farther than the extraction of a weapon, or any other extraneous body, from a wound, and the application of a few simples to stop a hæmorrhage, or to assuage inflammation. Their architecture was more improved than most other arts; and Homer speaks of houses built of polished stone, with large and numerous apartments. Other mechanic arts were not exercised as distinct trades; and even princes were frequently their own carpenters. Ornamental works, however, in metals, wood, &c. were not uncommon in those days; but the greater part of the trinkets and more luxurious utensils in use among the early Greeks appear to have been procured from the Phenician merchants. Their principal study, and most constant practice, was the art of war; and they seem to have improved considerably upon that tumultuary warfare, which is generally practised among barbarous nations. Their infantry were commonly heavily armed with helmet, breastplates, greaves, and shield; and were regularly drawn up in close ranks or phalanxes, marching in steady silence under their respective leaders. Cavalry were not yet employed in their battles; but chariots were generally used by the chiefs, as the means of conveying them more rapidly along the line, and of annoying more effectually a flying army. The skirmishing of the commanders, however, in front of the troops, and their mixing with the soldiers in the heat of the fight, left little room for the exercise of generalship; and their fashion of stopping in the midst of the action to strip the slain, sufficiently marks their want of military discipline and skill. They encamped with much regularity, sleeping under their cloaks, or sheltering themselves with huts; and generally fortified their post, when exposed to the attack of a powerful enemy; but, though a small guard might be placed at an outpost, they were unacquainted with the important precaution of stationing and relieving a line of sentinels. In the frequency of war, courage was regarded as the highest virtue; and the manners of the early Greeks were decidedly barbarous. Quarter was rarely granted to a fallen enemy; and the capture of a city was succeeded by the massacre of all the men who were able to bear arms, and by the captivity of the women and children. The spirit of hospitality, however, was generally diffused, and tended often to alleviate the miseries of military devastation. Women appear, as well as men, to have united the highest rank with the humblest occupations, but evidently enjoyed a greater degree of influence and freedom, than has been usual in subsequent ages among oriental nations. There has been supposed to exist, a striking resemblance between the manners and sentiments of the Greeks in the heroic age, and those of the Gothic nations of Europe, except that the latter displayed more generosity in war, and gentleness towards the female sex, than their ancient prototypes.

The period immediately succeeding the Trojan war, affords few lights to history, and is even involved in deeper obscurity than the heroic age. Supposing Homer to have lived within a century, or rather half a century of the Trojan war, his works may be allowed to supply a tolerable record of the previous events best authenticated by tradition, and of the most important occurrences which took place during his own life. His history terminates with the accession of Orestes to the throne of Argos; and total darkness thenceforth rests upon the historian's path, relieved only by a few uncertain glimmerings, till the first Persian invasion of Greece. About 80 years after the destruction of Troy, a great revolution took place, which dissipated ancient traditions, stopped the progress of civilization, and changed the governments, and even the population, of most of the Grecian states. The descendants and partizans of the celebrated Hercules had found a refuge in Doris from the persecutions of Eurystheus; but had never ceased to prefer their claims to the kingdom of Argos, and even to the dominion of all Peloponnesus. Twice had they attempted, without success, to make their way through the isthmus. But, at length, the great grand-son of Hyllus, the oldest son of Hercules, crossed the Corinthian gulf with a powerful armament, and speedily overran the whole peninsula, with the exception of Arcadia and Achaia, where Tisamenus, son of Orestes, made a resolute and successful stand. All the rest of the conquered country was divided among the princes of the Heraclides, and their allies from Doris and Ætolia; and the greater part of the old inhabitants either emigrated from the oppressions to which they were subjected, or were reduced by the invaders to a state of servitude. A new distinction of the Grecian people was the consequence of this revolution. The Pelasgian name, which had prevailed on the continent, and the Lelegian in the islands, had, at an early period, but for reasons not clearly ascertained, given place to the Æolian and Ionian; the latter designation being applied principally to Attica with its colonies, and the former to all the rest of Greece, both within and without the peninsula. Out of these two, four distinctions of the Grecian people arose, after the irruption of the Heraclides. In all the immediate establishments and distant colonies of these invaders, the Doric name and dialect prevailed. The Athenians rose to such pre-eminence, as to give rise to a new designation, namely, the Attic. Excepting them and the Megarians, who retained the Doric name, all the other Greeks, without the isthmus, claimed Æolic origin; and the Ionian name and dialect was retained only by those Ionians who had migrated to Asia and the islands. Except in the rugged province of Arcadia, nothing remained unaltered; and the Dorian invaders brought every thing back to that ruder state, in which they had lived among their native mountains. Disputes soon arose among these allied princes, respecting the partition of the conquered countries. Internal dissensions, occasioned by their turbulent subjects, were continually raging in their respective governments. The enterprising Arcadians seldom suffered them to rest from external hostilities. And, by all these concurring causes, Peloponnesus was rapidly falling back into that state of anarchy and barbarism, in which it had been before the time of Pelops and Hercules. Nothing tended so effectually to resist this tendency to disunion and turbulence, as the revival and regular establishment of the public games, by Iphitus, sovereign of Elis. These athletic games, as is evident from the writings of Homer, had been occasionally celebrated, under the superintendence of different princes; and at the funerals of eminent men, many traditions prevailed, that Eleia in Peloponnesus had frequently been the chosen scene of these contests, and the resort of princes from various parts of Greece. Iphitus, therefore, having procured a favourable response from the oracle at Delphi, established a regular festival for that purpose, to be held every four years at Olympia, in the territory of Elis. Solemn sacrifices were to be offered to Jupiter and Hercules, and games celebrated in honour of these divinities. In these games, all Greeks were free to partake; and, for a certain period, before their commencement, as well as after their conclusion, a general armistice was ordained to take place. The territory of Eleia, particularly, was to be at all times counted sacred, and secured from every hostile encroachment. This Olympian meeting, instituted about half a century after the return of the Heraclides, served as a common capital to the Grecian people, and contributed more effectually than could possibly have been anticipated, to the advancement of arts, science, and civilization, in all the different states. A general revolution in the government of every state, began about the same period to take place, from causes very imperfectly known. The republican spirit, which seems to have existed in all of them, even under their early monarchical constitutions, acquired so much strength, that, in a few ages, monarchy was every where abolished, and the name of tyrant applied to all who attempted its support, even under the mildest form. For a sketch of the peculiar political institutions, and separate history of the several states of Greece, we must refer to their respective names, which form distinct articles in this work, especially to ATHENS and LACEDEMON; and shall, at present, restrict our attention to those more extensive events which affected the Grecian people in general. The first important occurrence of this description, which communicated a new and powerful spring to the genius of the Greeks, and greatly influenced their future progress in every path of art and science, was the unparalleled struggle, which they so long and successfully maintained with the whole power of the Persian empire. See OLYMPIC GAMES.

In the reign of Darius, the son of Hystaspes, the power of the Persian arms was extended on every side of that vast empire. All was subdued to the west, as far as Macedonia. Amyntas, the king of that country, acknowledged subjection to the Persian monarch; and the Grecian islands soon began to feel his ambitious and overwhelming influence. Cyprus, Samos, Lesbios, Chios, and most other islands on the Asiatic coast, were either persuaded or compelled to admit his supremacy. Most of them, according to the uniform policy of the Persians, were nevertheless allowed to retain their own magistrates and laws. One of their own nation was appointed to preside as governor; and this person, whatever was his personal character, was always, from his official situation, denominated Tyrant by the Greeks. Athens itself, hard pressed by the powerful alliance which the Lacedemonians had formed against them, had begun to solicit the protecting aid of Persia; but Artaphernes, satrap at Sardis, having patronised the pretensions of the tyrant Hippias, whom they had driven from his power, they were filled with detestation of the Persian name, and the more readily consented to assist the Ionians in Asia, who had revolted against the authority of Darius. These, however, were speedily reduced; and the Persian monarch, in order to punish Athens and Eretria, who had given aid to the insurgent states of Asia, or rather in prosecution of his ambitious views for the enlargement of his dominions, sent a powerful army into Greece, under the command of his son-in-law Mardonius. Darius had previously dispatched heralds to each of the Grecian states, demanding earth and water as an acknowledgment of his supremacy; and, if wholly independent of each other, the greater part would probably have soon submitted to the Asiatic yoke. But, happily for Greece, its little commonwealths were at that period so united together by reciprocal treaties and obligations, and especially by a formal confederacy under the Lacedemonians, that a kind of general tribunal existed for the punishment of treachery or cowardice, which enabled them, in a great measure, to act as one nation. Macedonia, which had formerly paid homage, was more effectually subdued, and compelled to pay tribute to the Persian king. Thebes, by the influence of a faction, and a few other cities, particularly Ægina, made submission to his demands; but the Lacedemonians and Athenians were so indignant at the requisition of Persia, that, forgetting the law of nations and of humanity, they put the heralds to death with the utmost ignominy and barbarity. The Athenians, who had been at war with the Æginetæ, and were thus the more excited to adopt opposite measures to their hostile neighbours, accused them at Sparta of desertion from the common cause of Greece; and the chief persons of that state were instantly ordered to be seized as traitors to their country. Little progress was made by the invading army. The Persian fleet lost nearly three hundred vessels by a storm in doubling the promontory of Athos; and the land forces suffered so severely from the Brygians, a people of Thrace, that the season for military operations was lost, and the whole armament was led back to winter in Asia. A second army, under the command of Artaphernes, son of the late Satrap of that name, and of Datis, a Median nobleman, avoiding the circuitous march by Thrace and Macedonia, sailed from Cilicia in a numerous fleet, reduced every island and appurtenance of Greece in their way, and approached the frontiers of Attica, with the exiled tyrant Hippias as their guide, before any measures had been concerted by the Greeks for the general security. A messenger was now dispatched from the Athenians to Sparta, with the intelligence of the capture of Eretria, and, at the same time, with a request for assistance to themselves. The Lacedemonians readily promised their utmost aid; but, in conformity to a superstitious law, unworthy of their boasted political wisdom, declared that they could not take the field before the full moon, of which it then wanted five days. Immediate assistance from Sparta being thus denied, it became a question with the ten generals, whom the Athenians had chosen to command their army, whether they should venture to meet the enemy in the field, or apply their whole exertions to prepare for a siege. Opinions were equally divided, and the decision was, by ancient custom, referred to the polemarch Archon, who was persuaded by Miltiades to recommend an immediate engagement; a measure obviously contrary to all principles of defensive war, but rendered necessary by the dread of internal factions in the city. The Persian army, amounting, according to the lowest calculation, (though even that is probably overrated) to 100,000 infantry, and 10,000 cavalry, accustomed to conquer, and having frequently engaged the Greeks of Asia and Cyprus, advanced with confidence as to certain victory. The amount of the Athenian force has been stated as low as 9,000 heavy-armed infantry, and 1,000 Platæans, who had bravely hastened to share the desperate struggle for the freedom of their country. Various considerations,* however, make it probable, that the regular Grecian troops, now opposed to the Persians, were not much less than 20,000, with about an equal number of armed slaves. With this army, still fearfully inferior to the invading host, the genius of Miltiades, who was well acquainted with the nature of the Persian troops, seconded by the determined bravery of his soldiers, gained, on the plain of Marathon, a most decisive victory, and drove the routed Persians to their ships with great slaughter. But this distinguished commander, having failed in a subsequent expedition against the Ægean islands, which had submitted to the Persians, was, by the base machinations of party spirit, condemned to pay a fine of 50 talents, and died in prison of the wounds which he had received.

The death of Darius, the revolt of Egypt, and the disputes which arose about the right of succession to the throne of Persia, procured to the Greeks a respite of several years from any farther attempts against their independence. But Xerxes, the young Persian monarch, was sufficiently ardent to revenge the disgrace which the arms of his nation had sustained, and to prosecute those schemes of conquest which his predecessors had planned. Four years are said to have been employed in preparations for the punishment of Athens, and the reduction of Greece; and an army was collected, more numerous than had ever before, or than has ever since, been known in the annals of the world. To prevent the disasters, which might attend the conveyance of the armament by sea, as well as to provide for the future security of the intended conquest, a canal, navigable for the largest gallies, was, (according to the united testimony of all the Greek historians and geographers,) actually formed across the isthmus, which joins mount Athos to the continent of Thrace. Two bridges of boats also, the one to withstand the winds and the other the current, were extended across the Hellespont nearly between Abydos and Sestos, where the street is about seven furlongs in breadth. Early in the spring, the army

* See a very satisfactory statement in support of this opinion in Mitford's History of Greece.

moved from Sardis, the principal place of rendezvous; and seven days and nights are said to have been occupied in passing the bridges of the Hellespont. The land and sea forces met at Doriscus, near the mouth of the Hebrus, where, according to Herodotus, the Persian monarch reviewed his enormous army, which is said to have been composed of twenty-nine different nations. This historian (whose testimony, as he lived so near the time of the expedition, ought to be most worthy of credit, but whose detail of many incredible concomitant circumstances casts a doubt over his whole narration) estimates the effective strength of the infantry at 1,700 000 fighting men, and the cavalry at 80,000, exclusive of attendants and followers, whose number defied calculation. The fleet consisted of 1207 galleys of war, carrying about 277.600 men; besides transports, store-ships, and a variety of smaller vessels, amounting, at a gross calculation, to 3000, and their crews to 240,000. The land forces marched from Doriscus in three columns, every where adding to their numbers, by compelling the youth of the countries through which they passed, to follow their standards. They met again at Acanthus, where they were joined by the fleet, which then proceeded through the canal of Athos, into the bay of Therme, where the whole army coming up, formed an encampment, extending from Therme and the borders of Mygdonia to the river Haliacmon, near the confines of Thessaly. The Greeks, in the mean time, were slow in concerting any measures for their common defence; and many of the smaller republics readily made the required submission to the Persian monarch, whose sway had been experienced by many Grecian states to be much less oppressive than that of the domineering rule of the Spartan oligarchy, to which the greater part of them had long been subjected. The determined resistance of the Athenian people first arrested the progress of the Asiatic host; and to them chiefly belongs the honour of having preserved Greece from a foreign yoke. To this daring resolution they were prompted, not entirely by the love of freedom, but by the dread of certain punishment. The whole armament was ostensively prepared for their destruction, and their courage therefore was nearly that of despair. Their success at Marathon may have thrown a ray of hope through the gloomy prospect before them; and, at this critical moment, they happily possessed in Themistocles a leader of extraordinary talents, peculiarly fitted for conducting the arduous contest. Deputies from the confederated states at length assembled at Corinth, to consult respecting the conduct of the war; and an attempt was at first made to defend the passes into Thessaly. An army of 10,000 men from the different states, joined by all the Thessalian cavalry, was actually sent to occupy the vale of Tempe; and was competent to have defended the pass against any number of assailants. But the Grecian leaders, alarmed by the accounts which they received of the multitude of their invaders, and understanding that there was another opening into Thessaly, which they did not think themselves strong enough to occupy, were struck with a sudden panic, and, embarking their troops, returned to the Corinthian isthmus; while the Thessalians, now left to their fate, made an immediate submission to the demands of Xerxes. It was next resolved to make a stand at the pass of Thermopylæ, which afforded every possible advantage to an inferior force; but their mutual jealousies and selfish anxiety to reserve their strength for their proper defence, prevented the assembling of a sufficient body of troops; and not more than 4000 men, most of them Arcadian mountaineers, were collected to dispute the passage with the whole Persian army.

Xerxes having halted several days at Therme, to procure proper intelligence and guides, resolved to proceed by Upper Macedonia into Thessaly, and reached the neighbourhood of Thermopylæ without opposition. His fleet, after suffering immense loss by a storm in the bay of Casthanæa, entered the Pelasgian gulf; and the Grecian fleet, which was stationed off Artemisium to support the army at Thermopylæ, succeeded in capturing fifteen galleys, which had been dispersed by the tempest. This favourable event at once revived their spirits, and added greatly to the strength of their little navy. Xerxes, in the mean time, having fixed his head quarters at the town of Trachis, in the Malian plain, waited four days, in expectation that the Greeks would yield to his numbers, and leave him an uninterrupted passage. A herald also was dispatched to Leonidas, who commanded at Thermopylæ, requiring him to deliver up his arms; to whom the Spartan replied, with laconic brevity, "Come and take them." The Persian monarch, therefore, on the fifth day, ordered the Medes and Cissians of his army to bring Leonidas and his Greeks into his presence. These being quickly repulsed, the Persian guards, called "the immortal band," were marched to the attack. Their numbers were unavailing on so narrow a field; their short spears were very inferior in close fight to the longer weapons of the Greeks; and their repeated and courageous efforts, to which Herodotus bears ample testimony, made no impression. The assault was renewed on the following day, in hopes that wounds and fatigue might exhaust the little army of the Greeks; but still without the smallest prospect of success. A Persian detachment, however, having penetrated during the night by another pass, and surprised the Phocians, who had been intrusted with its defence, shewed themselves, on the morning of the third day, far in the rear of the Grecian army. Information of this fatal advantage being conveyed to Leonidas, it was immediately resolved that they should all retreat to their respective cities, and preserve their lives for the future wants of their country. Leonidas, however, in obedience to a law of Sparta, which forbade its soldiers, under whatever disadvantage, to flee from an enemy, resolved to devote his life to the honour and service of his country. Animated by his example, every Lacedemonian and Thespian under his command, determined with him to abide the event. The Thebans also, on account of the disaffection of their city to the Grecian cause, were detained, rather indeed as hostages than as auxiliaries.* Leonidas stationed his little band at the wall of Thermopylæ, where the pass was scarcely 50 feet wide; and all of them resolved to sell their lives to the enemy at the dearest rate. With the fury of men resolved to die, they rushed against the advance of the Persian army, and made a dreadful slaughter of the crowded and ill-disciplined multitude. Numbers of them were forced into the sea, and many of them expired under the pressure of their own people. Leonidas fell early in the fight, at the head of his troops; but the engagement was continued, with advantage on the side of the Greeks, till the Persian detachment came in sight of their rear. They then retreated to the narrowest part of the pass, where the Thebans began to sue for mercy, and were most of them taken prisoners. The surviving Lacedemonians and Thespians gained a little rising ground, where they fought in the midst of a surrounding host, till they were utterly cut to pieces. In the conduct of the Spartan prince, there was wisdom as well as magnanimity. His example checked the disposition which prevailed among the Greeks, to shrink from the Persian power; and gave a convincing proof to the invaders, at

* In the army at Thermopylæ there were originally 300 Lacedemonians, 700 Thespians, and 400 Thebans.

how vast a price of blood they would purchase their conquest. During their trancactions at Thermopylæ, the Grecian fleet gained several advantages over that of the Persians; and about two hundred galleys of the latter, attempting to take the Greeks in the rear by sailing round Eubœa, were totally lost in a storm. Having received intelligence of the fall of Leonidas, and the retreat of the rest of the army, the Grecian fleet retreated from Artemisium, and sought the interior seas of Greece. The Persian army experienced no opposition in their march through Doris and Bœotia, which, excepting the cities of Thespiæ and Platæa, had always been adverse to the confederacy of Greeks. Phocis alone, of all the provinces between Thessaly and the isthmus, remained faithful to the cause of the Grecian independence. Its territories, therefore, were ravaged without mercy by detachments of the enemy; while the main body advanced in a direct course to the devoted city of Athens. The Peloponnesian troops having resolved to confine their operations to the defence of the peninsula, Attica was completely abandoned to the whole weight of the invading host. Athens was filled with alarm, and all were convinced that their destruction was inevitable. The oracle at Delphi, however, having recently pronounced, that "the wooden wall" alone would afford an impregnable refuge to themselves and their children, Themistocles, who had probably himself suggested the response, persuaded his countrymen that they were thus directed to embark on board their fleet. Their families and effects were, in conformity to his advice, immediately transported to Salamis, Ægina, and Træzene; and all the males who were able to bear arms repaired to the ships. A few of the poorer citizens, who were unable to bear the expence of a removal, and some others, who conceived the answer of the oracle to point out their citadel, which was built of wood, as the place of safety, refused to abandon the city. The Persian army, advancing from Thebes, burned the forsaken cities of Thespiæ and Platæa; and experienced no resistance till they reached the citadel of Athens, which was immediately invested; and, being taken by assault, all within its gates were put to the sword. The commanders of the Grecian fleet, which was now assembled in the bay of Salamis, alarmed by the intelligence of the fall of Athens, had resolved in a council of war to retreat without delay, when Themistocles, addressing Eurybiades the Lacedemonian, who had the chief command, threatened, if such a resolution were adopted, to withdraw the whole of the Athenian ships, which composed nearly one-half of the allied fleet, and either to make peace with the enemy, or seek some distant settlement for his deserted people. His advice prevailed, and it was determined to await the approach of the enemy in the straits of Salamis. This Athenian chief, however, still fearful lest some of the squadrons should depart, is said to have accelerated the approach of the Persians, by causing their monarch to be privately informed, that the Greeks were planning a retreat, and that he would thus lose the most favourable opportunity of destroying their whole navy at one blow. His stratagem was attended with entire success. The Persian fleet hastened to make a general attack; while their army lined the adjacent shores, and their monarch himself was seated upon an eminence to view the approaching battle. His fleet amounted to 1200 galleys, and that of the confederated Greeks to 300; but the narrow strait prevented the numerous ships of the Persians from being regularly brought into action, and the crowded situation rendered it impossible for the Phenician squadron to avail themselves of the superior swiftness of their galleys, and skill of their seamen. The very zeal of the Persian commanders to distinguish themselves in the presence of their monarch, tended to increase the confusion. The resolute and persevering attacks of the Greeks, aided by the united talents of Themistocles and Aristides, allowed not a moment's respite to the enemy to restore order, or recover from alarm. The confusion soon became so general, that even flight was impracticable, and the sea itself (according to the description of the scene by the poet Æschylus, who fought on board the Athenian fleet) became scarcely visible from the quantity of wreck and corpses floating on its surface. Forty Grecian galleys are said to have been sunk or destroyed; but most of the crews saved themselves on board of the other ships, or on the neighbouring shore of Salamis. But the Persians had no refuge; and their defeat was attended with immense loss. Still the remains of their fleet were so large, that the principal port of Attica could not admit half its numbers; and the Greeks were expecting a renewal of the action on the following day. But the Persian commanders appear to have concerted no measures on the supposition of a retreat; and a hasty order during the night, directed the whole fleet to steer immediately for the Hellespont. The army, thus destitute of the supplies derived from the ships, and unprovided with sufficient magazines on land, fell back upon the friendly province of Bœotia, and speedily retreated into Thessaly. Three hundred thousand men were chosen to remain, under the command of Mardonius, to complete the conquest of Greece in the following summer. Of this number, 60,000 of the best troops were selected as a royal guard, to accompany their monarch as far as the Hellespont on his return to Persia. The rest of the immense multitude which he had led into Greece, left to their own resources, suffered beyond description, from the haste of their march, and the want of magazines. They subsisted by rapine from friends as well as foes; and were reduced at last to eat the very grass from the ground, and the bark from the trees. Disease destroyed whom famine had spared; and the towns of Thessaly, Macedonia, and Thrace, were crowded with the sick and the dying. Upon reaching the Hellespont, the bridges were found to have been destroyed by the violence of the current and the storms; but the fleet had arrived to transport the wretched remains of the Persian host; and its discomfited monarch proceeded to Sardis, not indeed entirely unattended, as some of the Greek historians relate, but with such a diminished retinue as might almost be called nothing, when compared with the incalculable numbers who formerly surrounded his person, and obeyed his command.

Early in the following spring, the Persian fleet assembled at Samos, and Mardonius, having attempted without success to detach the Athenians from the Grecian confederacy, compelled them again hastily to abandon their country; and, without opposition, regained possession of Athens. The Athenian people, under the protection of their fleet, withdrew to Salimas; and there, though deprived of their country, and disappointed of the timely assistance which they ought to have received from the Peloponnesian states, still rejected, with the most enthusiastic magnanimity, all the conciliatory proposals of Persia. The Lacedemonians, who were at the head of the allies, at length ashamed of their ungenerous and dastardly delays, dispatched an army of 5000 Spartans and 35,000 Helots, under the command of Pausanias. These were joined at the isthmus by the other Peloponnesian troops, and by the Athenian army under Aristides. Mardonius, secretly apprized of their march, gave up the city of Athens and its surrounding territories to be pillaged by his troops, and fell back upon his magazines in Bœotia, where he extended his camp along the course of the Asopus to the frontiers of Platæa. The confederated Greeks, animated by the propitious omens which had been indicated at their solemn sacrifices, advanced with confidence to meet the Persians, and pitched their camp at the foot of Mount Cithæron, on the opposite side of the river Asopus, composing a force of 110,000 men. Mardonius, who appears from the account given by Herodotus (the most impartial historian of the Persian invasion) to have been deficient neither in courage or policy, anxious to draw the Greeks from their advantageous position, harassed them greatly with incessant charges by his cavalry; and more than ten days were spent in various evolutions, on both sides, to gain the superiority of the ground, and to induce each other to commence the attack. In one of these movements, the greater part of the Grecian troops, excepting only the Tegeans, Lacedemonians, and Athenians, actually fled to the walls of Platæa; and the Persian commander, imagining the retreat to be general, hastily advanced with his infantry as to certain victory. A fierce engagement ensued, in which the Persian soldiers, though insufficiently armed for close fight, and unequal to the Greeks in the practice of war, discovered no inferiority in point of courage and enterprise; and were often seen, in their vigorous assaults, seizing and breaking with their hands the long spears of their opponents. Multitudes perished in these vain attempts to penetrate the Spartan phalanx. Their efforts, after repeated failures, began to relax. The Greeks advanced in their turn; and confusion soon became general among the Persian infantry. Their commander Mardonius, while leading on a chosen body of cavalry to support his broken troops, received a mortal wound; and his fall was the signal for flight to the whole Persian army. Artabazus, next in command, who is said to have dissented from his general in the conduct of the battle, as soon as he was assured of the rout of the main body, retreated with 40,000 men towards Phocis; but the Persian and Bœotian cavalry still kept the field, and afforded considerable protection to the flying infantry. The Lacedemonians and Athenians, however, having succeeded in carrying the Persian camp by assault, a dreadful slaughter ensued; and excepting the detachment which had escaped under Artabazus, only 3,000 finally survived of 260,000 Asiatics, who composed the rest of the army of Mardonius. In the mean time, the Grecian fleet, which had remained during the summer inactive at Delos, was encouraged, by a private assurance of the favourable disposition of the Ionians, to attack the Persian fleet at Samos. The Persian admiral, having suffered the Phenician squadron to depart, in the idea that the season was too far advanced for naval operations, as soon as he received intelligence of the approach of the Greeks, hastily sailed from Samos; and, passing to the opposite promontory of Mycale, drew his galleys upon the beach, and prepared to defend them on shore. The Greeks, resolving to attack the fortified camp, disembarked their forces in two divisions, one under the command of Xanthippus the Athenian, and the other led by Leotychides the Lacedemonian. The former arriving first at the Persian entrenchments, immediately commenced the assault; and, aided by the Greeks in the Persian service, had entered the rampart, before the Lacedemonians came up. The other Asiatics instantly fled from the Athenian assailants; but the native Persians resisted with the utmost bravery, till the arrival of the Lacedemonians, when they were completely overpowered, and almost entirely cut to pieces. The victorious Greeks, after carrying off the most valuable part of the spoil, set fire to the camp, and consumed the whole of the Persian fleet on the very same day that their army was annihilated at Platæa. This successful resistance of Greece to the Persian invasion holds out an encouraging example to all free states, to maintain their independency against any power, however formidable; and clearly shews, that an obstinate determination never to submit, accompanied with wise counsels and steady discipline, will rarely fail of ultimate success. The Persian war, indeed, was not yet terminated. The Greeks, in their turn, became the assailants and invaders. They prepared to protect the Ionians, who had thrown off the Persian yoke, and particularly to restore freedom to those Grecian cities in which the Persians had left garrisons. Under the Spartan general Pausanias, but especially under Cimon the Athenian, they carried their victorious arms to Byzantium, to the island of Cyprus, and even into Egypt. By a double victory gained on the river Eurymedon, under the last mentioned commander, both over the fleet and army of Persia on the same day, its naval strength was so broken, and its land forces so disheartened, that offensive operations against Greece were totally intermitted; and it became the boast of the Grecian states, that no armed ship of Persia was to be seen westward of the Chelidonian islands, or the entrance of the Euxine, and that no Persian troops dared to shew themselves within a day's journey of the Grecian seas. But the ambitious views and political jealousies which arose among the confederated states of Greece, during the prosecution of these successful operations, prepared greater evils for their country than all that they had endured, while struggling under the pressure of the Persian hosts. The Athenians, though apparently the greatest sufferers by the invasion, derived the greatest benefits from its effects. They found their country laid waste, and their city in ruins; but, in consequence chiefly of their naval superiority, and a succession of great commanders, they rapidly attained that supremacy in Greece, which the Lacedemonians had hitherto enjoyed; and by the able conduct of Cimon, the most distinguished of all their leaders, soon reached the summit of their political influence and military power. The Lacedemonians had not been inattentive observers or inactive opponents of the growing consequence of the rival state; but, usually slow in their counsels, (and weakened by an earthquake which laid their capital in ruins, and by a consequent insurrection of the Helots, which reduced them to the necessity of requiring aid from their neighbours,) had long evaded an open rupture with the Athenian republic. The latter people, however, accustomed to war, elated with success, swayed by a turbulent democracy, and unable longer to disguise their ambitious designs upon the liberties of Greece, not satisfied with repeated interferences and aggressions against the ancient allies of Lacedemon, proceeded at length to make a direct and unjustifiable attack upon its armies, while returning from the protection of Doris, against the inroads of the Phocians. Aided by the Argians and Thessalians, they met the Lacedemonians and their Peloponnesian allies at Tanagra in Bœotia. After a severe action of two days, and great slaughter on both sides, the Athenians were compelled to retreat, and the Spartans pursued their march without farther obstruction.

In the view, however, of raising a state without the peninsula, to balance the power and curb the ambition of Athens, they formed a close alliance with the Thebans, and willingly seconded their attempt to recover that supremacy in Bœotia, which they had been accustomed to claim before the event of the Persian war. But the Athenians under Myronides speedily regained the influence which they had lost by their defeat at Tanagra; and all Bœotia, with the exception of Thebes, was brought either into their alliance, or under their dominion. Burdened at length by the variety of their military operations, and even by the extent of their conquests, they were disposed to enter into negotiations with their Peloponnesian adversaries; and by the good offices of Cimon, whom they recalled from exile, and who had always been greatly esteemed at Lacedemon, a truce for five years was concluded between the rival powers. But after the death of that distinguished commander, who had uniformly exerted himself to divert the military spirit of the Greeks from internal wars, hostilities were again renewed. The Athenians, however, being hard pressed, and even invaded by the Peloponnesian confederates, as well as encumbered by the numerous islands and colonies subject to their empire, a second time sought an accommodation; and a truce was concluded for the space of thirty years, upon terms by no means advantageous to their influence. But the constitution of Greece, composed of so many small and independent states, was unfavourable to a long continuance of general tranquillity. Its governments were so distinct, that no common authority could prevent the occurrence of partial wars; and yet so connected, that war in any part always endangered the peace of the whole. This was more especially the consequence of a practice, which had become universal among the weaker states, to provide for their protection by courting the alliance, or rather acknowledging the dominion, of one of the two leading republics of Lacedemon or Athens. These two rival powers also differed considerably in the political principles which they respectively favoured, the former being generally the patroness of aristocracy, and the latter of democracy. Hence their influence was extended, according as one or other of these opposite factions prevailed in the different states; or rather, according as their arms were severally crowned with success, the party to which they were friendly gained the ascendency, and succeeded in bringing the state which it ruled to the side of Sparta or of Athens. This constant rivalship, never wholly dormant, and kept in continual excitement by the frequent quarrels of the minor commonwealths, at length gave rise to the long and bloody contest of the Peloponnesian war. The Athenians, having assisted the Corcyræans against the Corinthians, were formally accused by the latter people, joined by many other complainants, of having broken the truce, and insulted the Peloponnesian confederacy. An assembly of deputies from the different states, of which that confederacy was composed, having met at Sparta, a great majority decided for an immediate recourse to arms; and even the historian Thucydides admits, in the most explicit terms, that a general sentiment of indignation had been excited among a large portion of the Grecian people, by the arbitrary and oppressive sway of the Athenian republic. See Aristides, &c.

The two hostile confederacies, though very differently composed, divided between them very equally the force of the Greek nation. All the Peloponnesian states, except the Argians, who remained neutral, joined the Lacedemonians. In Northern Greece, the Megarians, Bœotians, Locrians, Phocians, &c. formed a part of the same alliance; and external assistance was expected from the king of Persia, and the Grecian colonies of Italy and Sicily. The Athenians had a few allies, and some of them not very zealously inclined to their cause. The principal were the Thessalians, and Acarnanians, and the islands of Corcyra, Zacinthus, Chios, and Lesbos. But all the other islands of the Ægean Sea, except Melos and Thera, and all the wealthy Grecian cities of Thrace, of the Hellespont, and of Asia Minor, were tributary subjects of Athens, and entirely subject to its controul. The Spartan king Archidamus, who had the chief command of the Peloponnesian forces, amounting to 60,000 men, advanced slowly to the invasion of Attica; but, before actually commencing hostilities, he once more proposed the terms of accommodation, which the Athenians had formerly rejected. The celebrated Pericles, who had long directed the councils of Athens, and who is supposed to have plunged his country into war, for the purpose of prolonging his personal influence in the state, easily induced his fellow citizens to refuse all farther negociation; but all his extraordinary talents were necessary to persuade the Athenian people to adopt measures of defence, to which they were reduced by the power of their enemies. Abandoning their country to the ravages of the hostile army, they were compelled to secure themselves and their effects within the walls of the metropolis, filling the temples, the turrets of the ramparts, the tombs even, and the lowest hovels, with their wives and children. Pericles, reproached and threatened as the principal author of their calamities, and vehemently urged to meet the invaders in the field, directed all his attention to the defence of the city and the preservation of good order. The Lacedemonians and their allies, having exhausted the means of subsistence, and loaded themselves with plunder, returned to Peloponnesus, and dispersed to their respective cities. The Athenian fleet, in the mean time, ravaged the coasts of Peloponnesus, taking, in its return, the island of Ægina; and, towards the end of autumn, Pericles, with the whole of the land forces, laid waste the neighbouring territory of Megara. At the commencement of the second summer, the confederates under Archidamus again entered and ravaged the country of Attica; while a more dreadful scourge, a pestilential fever, resembling the modern disease of the plague, raged in the crowded streets of the city. The war, however, was not arrested by this awful calamity; and, for several years, was regularly conducted in the same manner. The Peloponnesian states were so superior in land forces, that they annually invaded the territories of the Athenians, who could not risk a general action without exposing themselves to certain ruin; yet the confederates were, on the other hand, so ignorant of the art of attacking fortified places, that they could make no impression upon a city like Athens, defended by 30,000 men, and supplied by a powerful fleet. The war thus continued to rage, for many years, with nearly the same success, and equal losses on both sides. It consisted in a succession of partial engagements, hasty excursions, and distant sieges, which never affected the main object in view, or brought the contest one step nearer to a conclusion. Partaking also in a great degree of the nature of a civil war, it was carried on with a spirit of ferocity rarely exemplified among civilized nations; and, though the time of its continuance, the very age of Socrates himself, was an era, at least in the history of Athens, characterised by the high perfection to which arts and sciences, philosophy and refinement, had been brought; yet, in no period of Grecian history, were more atrocious barbarities committed. Every transaction has been minutely recorded by the Athenian historians, Thucydides and Xenophon, who were contemporary with most of the events which they describe; and our account must be greatly compressed, not from the scarcity, but from the abundance of materials. The league, headed by the Athenians, was almost entirely under their command; while that of Peloponnesus, being composed of independent states, was continually changing in its component parts, and liable every instant to be utterly dissolved. Had the Athenian people therefore steadily adhered to the plan of Pericles, and, renouncing every idea of conquest, confined themselves to a defensive war by land, and offensive operations by sea, they might ultimately have triumphed over their numerous opponents; and, at least, have inflicted more serious injuries than they could have received. From the excessive diversity and disproportion of the forces engaged in the contest, the one over-running the land, and the other scouring the seas and coasts, the war was inevitably spun out to an indefinite length; and often were both parties, wearied of their accumulated sufferings, desirous of peace; but proposals for negociation were as often prevented by the vain ambition of Cleon, who had succeeded, at the death of Pericles, to the direction of the Athenian councils, and by the warlike spirit of Brasidas, the bravest of the Spartan leaders. After their death, a truce was concluded for the space of fifty years; and every thing was restored to the same situation in which it had stood at the commencement of hostilities: but mutual hatred, and boundless ambition, had acquired such hold of the minds of the principal men on all sides, that the appearance of concord was of short duration. New leagues and dissensions arose, which led to reciprocal recriminations and partial hostilities; but it was not till the expiration of nearly seven years, that they again came to an open rupture. Athens was the aggressor, and the ambition of Alcibiades was the sole cause of the renewal of hostilities. This celebrated character, with all his accomplishments and talents, was guided by principles so inveterately vicious, that he alone may be charged with having accelerated the ruin of the Athenian state, and completed the corruption of its citizens. He persuaded the people, without any other reason, except that the city Egesta in Sicily had solicited the assistance of the Athenians to undertake the conquest of that island; but, scarcely had the expedition, in which he was appointed a commander, commenced its operations, when he was recalled to stand his trial upon a charge of impiety. Aware of the caprices of his countrymen, he took refuge in Peloponnesus; and, enraged by the sentences pronounced against him in his absence, he instigated the Lacedemonians to assist the Syracusans, and to attack the Athenians, while their army was engaged in the remote and romantic enterprize which himself had planned. The Sicilian expedition terminated in the most disastrous manner; and almost the whole of the Athenian army was destroyed or taken captive. The Lacedemonians, supported by a powerful confederacy, and assisted even by the Persian viceroys, invaded Attica, blockaded the city of Athens, and would speedily have terminated the war by its reduction. But Alcibiades, having been expelled from Sparta on account of his licentious practices, exerted himself to detach their Persian allies, and to retrieve the falling hopes of his country. Recalled by the army, and raised to the chief command by the unanimous acclamations of the people, he recovered many of the lost colonies, defeated the fleet of the confederates, and so alarmed the Lacedemonians, that they were ready to have treated for peace. But the Athenians, intoxicated with success, prolonged the war; and, insensible to their interest, again threw away the instrument of their victories. Their fleet having sustained a trifling loss while Alcibiades was absent, and employed in levying contributions in Ionia, for the support of his forces, he was instantly disgraced by the fickle voice of the populace; and the power of Peloponnesus again acquired the ascendancy. The confederates, taught by experience, had exerted themselves to increase the number of their ships, and had at length succeeded in attaining also a portion of that maritime skill, which had hitherto given to the Athenians so decided a superiority by sea. The Athenian navy, however, trusting to their long acknowledged eminence, and elated by a victory which they had gained over the Spartan fleet at Arginusa, near Lesbos, despised their enemies, and neglected all ordinary precautions, with unexampled imprudence. Lysander, the ablest of the Lacedemonian generals, having succeeded to the command of the allied fleet, and taken the city of Lampsacus upon the coast of the Hellespont, resolved to avail himself of that self-confidence which guided the councils of the Athenian captains. In order to increase their insolent security, he repeatedly declined battle, which they daily offered him, but kept his own crew prepared for action at a moment's warning. Having learned that they regularly drew their fleet ashore on the open beach at Aigospotami, on the opposite coast, not more than two miles from his own station, and then suffered the soldiers and crews to disperse over the adjoining country in quest of lodgings and provisions; he easily found means to surprise them in this unguarded condition, made himself master of their whole fleet except nine galleys, and took prisoners the greater part of their forces, by which it had been manned. A striking instance now occurred of that savage barbarity, with which the different powers in the Peloponnesian war were generally chargeable. The Athenians had resolved, in their assurance of victory, to cut off the right hand of every prisoner whom they should capture; and this intended cruelty, with many similar acts which they had perpetrated, was immediately requited by a general massacre of the captives at Aigospotami. Lysander, with his own hand, cut down their general Philocles, after reproaching him with having first set the example among the Greeks of such violations of the laws of war; and, upon this signal, about 3000 Athenian citizens were butchered in cold blood, by the allied troops. The Lacedemonian commander, now completely master of the seas, speedily reduced the principal colonies and dependencies of Athens; and then hastened, with a fleet of 200 galleys, to blockade the port of that devoted city, while the land forces of the confederates, at the same time, surrounded its walls. No assault was attempted, and its reduction was left entirely to the sure operation of famine. The haughty and turbulent citizens discovered not even the courage of despair in their defence; but were solely anxious to avert the sentence of utter extermination, with which they were threatened by some of the allied states. The Lacedemonians, however, probably as much from policy as generosity, secured for them more favourable terms, and saved their persons from servitude and slaughter. But it was determined, as a measure absolutely necessary to the safety and repose of Greece, that their tyrannical spirit should be effectually humbled, and their power as a state entirely broken. They were spared upon the following conditions; that all their ships of war should be surrendered, except 12; that the long walls and the fortifications of Peiræus should be destroyed; that all exiles and fugitives should be restored to the rights of the city; that the Athenians should hold always as friends or enemies those states, who were the allies or the adversaries of Lacedemon; and should be ready to attend the Spartan power, by sea or land, as they might receive orders. These terms being accepted, the Spartan fleet entered the Peiræus, and the army took possession of the walls. The fortifications, which had been condemned, were instantly thrown down, to the sound of military music, and their demolition celebrated with triumph as an æra of recovered freedom to Greece. The popular assembly was abolished; the government changed from democracy to oligarchy; and thirty magistrates were appointed to form the new administration of the commonwealth. Such was the termination of the Peloponnesian war, in its twenty-seventh year; and Lacedemon, now in alliance with Persia, having again become the leading power in Greece, the aristocratical interest reigned paramount in almost every Grecian state. See Alcibiades, &c.

Sparta, having recovered her influence in Greece, acted not less tyrannically than on former occasions; and, under the ambitious projects of Lysander, became daily more corrupted in her principles of policy. The thirty magistrates, who had been placed at the head of the Athenian state, were supported by assistance from Lacedemon in the most attrocious acts of cruelty and injustice; and the other Grecian cities were prohibited even to afford a refuge to the unhappy Athenians, who fled from their oppressors. Not contented with cutting off their political adversaries, the thirty tyrants, under the direction of Critias, proceeded to murder, upon frivolous pretences, all persons whose riches they wished to sieze; and the slightest murmur against their oppressions was punished with imprisonment, exile, or death. In the space of eight months, fifteen hundred citizens were sacrificed to their avarice or vengeance; and Xenophon goes so far as to affirm, that their short reign was more destructive to Athens, than the preceding war of thirty years. At length, however, Thrasybulus, at the head of his exiled countrymen, drove the tyrants from their seat of abused power, and restored the ancient democratical form of government at Athens. By his wise moderation the spirit of retaliation was restrained, a general amnesty proclaimed, and tranquillity restored to the Athenian state. But whatever was the form, tyranny was too generally the spirit of the Grecian governments, and especially of the pure democracy at Athens. Equally unjust and cruel as the most lawless despots, they were often much more inconsistent with themselves, and fickle in their proceedings. While they allowed their poets, for their amusement, to ridicule the gods upon the stage, they punished their sages, who endeavoured, for their instruction, to introduce worthier sentiments of religion. By their sentence, the celebrated Socrates, (whom even the thirty tyrants had spared, though he often opposed their measures,) was iniquitously put to death.

The Greeks were again involved in a contest with Persia, by the attempt of Cyrus the younger to dethrone his brother Artaxerxes. That ambitious prince being governor of Asia Minor, and friendly to the Spartans, persuaded them to join his standard with 13,000 Grecian troops; but, excepting their leader Clearchus, they are said to have been entirely ignorant of his views upon the Persian crown. The celebrated retreat of the remains of this army, after the death of Cyrus, generally called the retreat of the ten thousand, is considered as one of the most extraordinary exploits recorded in the annals of the military art; and, by proving the weakness of Persia, is supposed to have had considerable influence in promoting the Macedonian invasion, and conquest of that extensive but feeble empire. It had the more immediate effect of encouraging an expedition, under Agesilaus king of Sparta, to recover the liberty of the Grecian colonies in Asia. Assisted by 30 captains, with Lysander at their head, he filled all Asia with a dread of his arms; and was preparing to carry the war into the heart of the empire, when he was suddenly recalled for the protection of his own country. The Persian monarchs had discovered a more easy and effectual defence against Grecian valour, than their most numerous armies had been able to provide; and, by a seasonable distribution of bribes among the leading men of the different states, succeeded in turning the arms of these warlike republics against one another. The Thebans were first gained to their interests, who easily succeeded in persuading the Athenians. Even Argos and Corinth, two Peloponnesian states, joined the confederacy, to which were added Acarnania, Ambracia, Leucadia, Eubœa, part of Thessaly, and Chalcidice in Thrace. The haughty tyranny of Lacedemon furnished sufficiently ostensible reasons for the union; and Persian gold readily supplied the arguments which were wanting. The confederates sustained a severe check in the vicinity of Corinth, and were afterwards defeated by Agesilaus at Coroneia, with great loss on both sides; but Pharnabazus, assisted by the Athenian commander Conon, having defeated the Lacedemonian fleet, completely destroyed their influence in Asiatic Greece. They proceeded even to ravage the coasts of Laconia; and, assisting the Athenians to rebuild their long walls, which connected the Peiræus with the city, again laid the foundation of their naval power. After various vicissitudes and intrigues, all parties became tired of war, and disposed to peace. The Lacedemonians, though still superior in the field, yet destitute of the aid which they had formerly derived from the Persian treasury, were straitened in their pecuniary resources; and Pharnabazus, the friend of Athens, having been succeeded in Lydia by Teribazus, the new Satrap became favourable to the interests of Sparta. By the able negociations of Antalcidas the Lacedemonian, the Persian monarch was brought in as mediator, or rather dictator, for a general pacification among the states of Greece, of which the conditions were simply these; "that all cities on the continent of Asia, together with the islands of Clazomene and Cyprus, should belong to the Persian empire; and that all other Grecian cities, small and great, should be completely independent, except that the islands of Lemnos, Imbros, and Sciros, should remain as formerly under the dominion of Athens." Against all who should refuse these terms, the court of Persia declared itself ready to unite with those who accepted them, and to render every assistance, by land and sea, to reduce the refractory. The weaker states were well pleased to be secured in their independence. The Athenians were gratified by the exception in their favour. The Thebans, anxious to preserve their authority over the smaller towns of Bœotia, wished to stipulate for that superiority; but were compelled to concur in the terms. And the Lacedemonians, while they lost nothing by abandoning the Asiatic Greeks, whom they had already been obliged to desert, gained the great object of the war,—the separation of the states which had combined against them, and the emancipation, especially, of the Bœotians from the growing power of Thebes. They soon shewed that they accounted themselves to have established their supremacy; and were the first to disturb the general tranquillity. They demolished the fortifications of Mantinæa, as a punishment for the disaffection of its citizens to the Lacedemonian interests, during the preceding wars. They marched against Olynthus, a Grecian city of Thrace, because, by associating the smaller towns in its vicinity under one government, it was considered as infringing the conditions of the late treaty; though its only offence was the increase of its strength by a wise and liberal policy, which ought to have been emulated, rather than opposed by the other Greeks. They interfered also, in the most unjustifiable manner, in the political contests which agitated the Theban state; and, by this rash measure, gave rise to a long and complicated struggle, which ended only with the general overthrow of Grecian independence. Their general Phæbidas, returning from an expedition against the Olynthians, was persuaded to join the leader of the aristocratical party in Thebes, and to occupy the citadel with a Lacedemonian garrison. This unauthorised step, though at first disapproved by the government of Sparta, was finally sanctioned, by their retaining possession of the fortress thus treacherously seized, and by their bringing to trial and punishment the chief of the adverse faction, as if they had been the constituted judges of Thebes. For the space of four years, they succeeded in holding the Thebans under the most humiliating subjection; but suddenly the Theban exiles, with the assistance of the Athenians, by one of the boldest and best conducted exploits recorded in history, recovered possession of their power in the city, and compelled the Lacedemonians to evacuate the citadel. With difficulty the Thebans at first withstood the armies of Sparta, by acting on the defensive; but gradually improving in military skill, they learned to face in the field, and to combat, even with inferior numbers, the experienced troops of their powerful adversary. Under the able direction of Epaminondas and Pelopidas, they ventured, though then without an ally, to persevere in the unequal contest; and, in the famous battle of Leuctra, the bloodiest action hitherto known in Greece, these distinguished commanders, by their skilful dispositions, and the enthusiastic courage with which they inspired their troops, defeated an army nearly four times the number of their own. Never had the Lacedemonians, before that day, retreated from an inferior force, or lost in any one engagement so many of their citizens. Another of their boasts, "that never had the women of Sparta beheld the smoke of an enemy's camp," was now also done away.

The victorious Thebans, headed by Epaminondas, and joined by many of the Grecian states, ravaged the Lacedemonian territories to the very suburbs of the capital; and on their return reinstated the Messenians, whom the Spartans had driven from their country. The Lacedemonians, alarmed not merely for their supremacy but their safety, secured assistance from Athens, from Syracuse, and even from Persia, while the Thebans were hard pressed by a war in Thessaly, against Alexander, tyrant of Pheræ. Pelopidas, however, having been dispatched to the Persian court, succeeded in recommending himself to the esteem of the monarch, and in turning his friendship to a state which had never been at war with Persia. Thebes, intoxicated with her rising power, which she owed chiefly to the abilities of her leaders, obstinate in maintaining her authority over the cities of Bœotia, which was perhaps necessary for her resistance to Lacedemon, and aiming to become the arbitress of Greece, which her sudden elevation provoked many of the states to regard as unpardonable presumption, may be considered as at this period the cause of the continuation of hostilities among the Greeks. Sparta, however, was equally obstinate in refusing to acknowledge the independence of the Messenians, and war was prolonged for some time with little effect, chiefly between the confederates of the two principal powers. The Thebans, having at length terminated the war with Thessaly, with the loss of their able general Pelopidas, were at liberty to take part more effectually in the transactions of Peloponnesus. A civil war having broken out in Arcadia between the cities of Mantinæa and Tegea, the Thebans supported the cause of the latter, while the Athenians and Lacedemonians declared for the former. The very existence of Sparta was threatened by the bold and enterprising measures of Epaminondas, who had nearly taken the city by surprise; but, frustrated in his plan by the activity of Agesilaus, he returned and gave battle to the Lacedemonians and their allies at Mantinæa, where he was mortally wounded in the moment of victory, and where with him the power of the Theban state expired. A general pacification succeeded, upon the basis of the former treaties prescribed by Persia, that every city should be independent; but the Lacedemonians still persisting in their wish to reduce the emancipated Messenians, were excluded from the treaty, and remained nominally at war with the confederates of Thebes. Exasperated by the friendly dispositions which the Persian court had manifested to the Thebans, and perhaps expecting to acquire some pecuniary resources for the recovery of their power in Greece, they sent an army to aid the insurgents in Egypt. After the death of Agesilaus, on his return from Africa, little occurs in the history of Greece deserving of notice, till the appearance of Philip of Macedon. A great change had taken place in Grecian politics. There was now no leading state, either of the aristocratical or democratical interests; and, though every city exercised a jealous watchfulness to prevent any overbearing superiority in another, there were no extensive confederacies or hostilities; but lassitude, indecision, and divisions, pervaded the nation, and paved the way for the universal subjugation of their liberties by the Macedonian monarchy. See Agesilaus, Epaminondas, &c.

In consequence of the blow given to the Spartan power in the battle of Mantinæa, and the decline of Thebes after the loss of Epaminondas, Athens remained the most prominent and respected of the Grecian republics. In want, however, of any salutary check from a powerful rival, its government became extravagant and irregular in the most extraordinary degree; the inconsiderate voice of the multitude deciding every measure, frequently ratifying at night what they had rejected in the morning, and ready to follow every varying scheme of every flattering orator. The citizens also, sinking into unbounded luxury, declined all military service, and resorting to the aid of mercenaries, engaged in hostilities chiefly for the purpose of collecting plunder, or of extorting tribute. Every marauding expedition was approved, provided the leaders brought home a sufficiency of treasure to provide amusements for the people, and to bribe the orators to silence. The official men, in short, inadequately rewarded by their regular salaries, learned, as is almost uniformly the case, to recompense themselves; and the people, either become necessitous by their idle attendance on political matters, or injudiciously supported by the public funds as an encouragement to population, actually depended for their subsistence upon the sacrifices, feasts, and spoils, connected with their military expeditions. While Athens was in this situation, strangely feeble in the whole constitution of its government and population, yet by means of its naval force still the principal republic in Greece, a rival to its power arose in a quarter, which had hitherto attracted little attention, and had even been regarded by the Grecian states as undeserving of their notice. Though the kings of Macedonia pretended to be the descendants of Hercules, the Greeks considered them as no part of their nation, but always treated them as barbarians. This kingdom had existed more than four hundred years, but had generally stood in need of protection from Athens or from Sparta; and had never risen to a capacity of partaking in the eminence of these republics. But it now furnished an example, similar to that of Thebes, of the power of one distinguished individual to accomplish, in favourable circumstances, the most important revolutions. It was in Thebes, indeed, that the new leader of the Macedonians had received his best instructions in the arts of policy and war. Philip had been taken to that city as a hostage when he was only ten years of age, and had been carefully educated under the eye of Epaminondas, assisted by the celebrated Pythagorean philosopher Lysis. At twenty-four years of age he ascended the throne of Macedon, and gave early indication of his talents for government. At the period of his accession, he found himself at war with the Athenians, who supported one of his competitors for the kingdom. Having defeated his adversary, who was slain in the action, he instantly liberated, and loaded with favours, all the soldiers of Athens whom he had taken prisoners.

Having discovered, that the Athenians were intent upon the recovery of Amphipolis, which they claimed as one of their colonies, but which he had seized as the key of his dominions on that frontier, he was equally reluctant to put it in their power, or to come to a rupture for which he was not prepared. With his usual consummate policy, therefore, he declared it in the mean time a free city, and left the inhabitants to maintain their own independence. A peace and alliance were ratified between the Macedonian prince and the city of Athens; but their agreement was of short duration. A contest speedily commenced, which led to the subversion of Grecian freedom by the arts and arms of Philip; but which owed its origin as much to the unprincipled aggressions of the Athenian democracy, as to the ambitious views of the Macedonian monarch. While in full alliance and co-operation with Philip against the Olynthians, they suddenly indicated their hostility to his interests, by detaching the town of Pydna from his kingdom, and making a direct attempt to possess themselves of Amphipolis. Failing in their design, it was soon after occupied by Philip, and rendered a strong barrier between his dominions and those of the Grecian states. Before this time had commenced "the Sacred War," undertaken by the Bœotians, Locrians, Thessalians, &c. in order to punish the Phocians, who had ploughed a field sacred to Apollo at Delphos, and had refused to discharge the fine which the council of the Amphictyons had sentenced them to pay, as an atonement for the sacrilegious deed. They were supported by the Lacedemonians, Athenians, &c. and Philip, well pleased to leave the Grecian states to exhaust their strength against each other, had employed himself in the meantime in extending his power in Thrace, and in attaching Thessaly to his interests, by delivering its cities from the oppressive sway of the tyrants of Pheræ. Irritated, however, by the defection of Olynthus from the Macedonian to the Athenian alliance, he laid siege to that city; and, having gained possession of the place by bribing a party of its inhabitants, he razed its walls to the ground, and sold the people for slaves. The Sacred War, which was still carried on by both parties with the most sanguinary retaliations, next afforded him a fair opportunity of bringing his power into full contact with the Grecian states. Professing to adjust, as arbitrator, the matter in dispute, promising to the Phocians his protection against the fury of their enemies, and soothing the Athenians by the reports of his friends, that he was secretly intending to humble Thebes rather than Phocis, he marched an army into Greece; gained quiet possession of the Phocian cities; secured to that people, as he had promised, their personal safety; but procured, or at least sanctioned, a decree of the Amphictyonic Assembly, annihilating their political existence as a nation, and expelling them from the number of the Grecian states represented in the council. He was himself elected in their place as a member of the Assembly; invested with the double vote which they had enjoyed; and usually denominated in their future operations the Amphictyonic general. The Athenians refused to acknowledge his election; and manifested, in all their measures, an ambition even more unprincipled and indefensible than that of the Macedonian monarch. Guided rather by the inflammatory eloquence of Demosthenes, than by the pacific counsels of Phocion, they plunged at length into a destructive contest with their powerful rival and neighbour. A second sacred war again drew Philip into the midst of Greece. The Locrians of Amphissa having encroached upon the consecrated ground of Delphos, and having refused to obey the decrees of the Amphictyonic council, the Macedonian monarch was invited, as their general, to vindicate their authority by force of arms. Many of the Grecian states were now alarmed, and not without reason, by the forwardness of Philip to interfere in their politics, and by the reluctance which he shewed to withdraw his army, after the punishment of the Amphissians. Demosthenes hastened to Thebes, where he succeeded in rouzing the utmost enthusiasm for the liberties of Greece, and persuaded the Thebans to adopt the immediate resolution of uniting with the Athenians, to resist the dangerous progress of the Macedonian influence. In vain did Phocion recommend, and Philip request, the Athenians to lay aside their measures for instant hostilities. They excluded the former from the command of their army, and marched without delay to join their Theban allies against the enemy. The two armies, consisting of about 30,000 on each side, came to a general engagement at Cheronea. The battle was long doubtful. Alexander, who was only seventeen years of age, at the head of a chosen body of noble Macedonians, cut down the Sacred Band of Thebes; and the Athenians, for a time successful, but urging their advantage with imprudent impetuosity, were overwhelmed by the Macedonian phalanx under Philip. The vanquished were treated with a degree of clemency and generosity, of which there had been few examples in Grecian warfare. Philip hastened to stop the slaughter of the flying Greeks, and dismissed the Athenian prisoners without ransom, and voluntarily renewed his former treaty with that republic. To the Thebans he readily granted peace; but stationed a Macedonian garrison in their citadel. By this decisive victory, he secured the most entire ascendancy in Greece; and, on that side, there was little farther left for his ambition to desire.

Either, however, with a view to extend his conquests, or in order to unite the Greeks more firmly under his power, he planned the invasion of the Persian empire, and procured himself to be appointed generalissimo in the expedition. No measure could have been conceived more popular in Greece. A general council of the states was summoned, and the quota determined which each of them was to furnish. Philip exerted himself with extraordinary activity to complete his formidable preparations; and his whole army, in the most perfect state of military discipline and equipment, was in readiness to cross the Hellespont. But, in the midst of his greatest splendour, while solemnizing, before his departure, the nuptials of his daughter Cleopatra, surrounded by his guards and principal officers, and receiving, among the assembled states of Greece, little less than divine honours, he was stabbed to the heart by a desperate assassin. See DEMOSTHENES, and PHILIP.

Upon the accession of Alexander to the throne of Macedonia, when only twenty years of age, the different nations whom his father had brought under his dominion made an attempt to regain their independence; and Demosthenes exerted all his powers of persuasion to engage the Greeks to unite against the youthful successor of the formidable Philip. But Alexander, having punished the Thracians, Illyrians, and other barbarians, for their indiscretion, turned, with the utmost expedition, the whole weight of his arms upon Greece. The Thebans, who had massacred the Macedonian garrison, which Philip had placed in their citadel, having refused the offer of a free pardon made to them by Alexander, upon condition of their surrendering the principal leaders of the insurrection, were defeated with great slaughter, their city given up to be pillaged, and the inhabitants sold as slaves. These dreadful acts of severity filled the Athenians with alarm, and an embassy was instantly dispatched to implore the clemency of the Macedonian prince. Alexander at first insisted that ten of their principal orators should be delivered into his hands;

but was at length satisfied with the banishment of Charidemus, and expressed the highest regard for the republic of Athens. The other states hastened, in like manner, to make their submission; and, in one campaign, the whole nation of the Greeks acknowledged his supremacy. Having assembled their deputies at Corinth, and renewed the proposal of invading the Persian empire, he was appointed, as his father had been, to the chief command. His rapid conquest of Persia, which would form too extensive an episode in this brief sketch of Grecian history, and which must therefore be passed over without detail, produced one of the most extraordinary and important revolutions in the political aspect of the world. No national contest recorded in history was ever more interesting in its progress, or involved consequences of greater magnitude, than the struggle which had so long been maintained between Persia and Greece. Its object was to decide the great question, whether Europe or Asia should have the ascendancy; and at length, under the auspices of the Macedonian prince, the former gained a superiority, which it has preserved to the present day. During the progress of Alexander's conquests, various attempts were made by the Grecian states to shake off the yoke of Macedonia. The Spartans, especially, under the direction of their king Agis, excited a powerful insurrection in Peloponnesus; but Antipater, who had been left to govern in Macedonia, marching a powerful army into the peninsula, completely broke their spirit by a decisive defeat of their forces, and the death of Agis, who fell in the pursuit. Harpalus, one of the officers of Alexander, who had incurred the displeasure of that prince by his extortions, when governor of Babylon, took refuge in Athens; and, by means of his treasures, succeeded in attaching them to his cause; but, upon the report of a powerful army being dispatched by Alexander to punish their treachery, they expelled Harpalus from their city, and banished Demosthenes, who had been convicted of accepting his bribes. A new commotion also had been excited throughout all the states of Greece, by a proclamation of Alexander to restore the exiles to their respective countries and possessions; and, upon the event of his death being known, the revolt which had already commenced instantly became general. Demosthenes was recalled, and a powerful army of confederated Greeks, under the Athenian commander Leosthenes, marched against Antipater. Elated by the success which attended their first operations, they despised, as usual, the prudent warnings of Phocion, and began to calculate upon the return of their ancient greatness. But Antipater having been joined by Craterus with a part of the victorious army of Alexander, speedily reduced the insurgent states in succession; and, advancing towards Attica, as the great object of his vengeance, though in some measure softened by the intercession of the virtuous Phocion, he abolished the democracy of the Athenians, and established the aristocratical government, as it had existed in the days of Solon; obliged them to pay the expences of the war; and placed a Macedonian garrison in the port of Munychia. Similar changes were made in most of the other states; and, though the people loudly complained, in the first instance, of these infringements upon their liberties, they began at length to feel, that their freedom was in reality greater than it had hitherto been, and acknowledged their obligations to Antipater, by entitling him the Father and Protector of Greece. After the death of Antipater, the Grecian states largely shared in the revolutions and dissensions which agitated, for so many years, the empire of Alexander. Polysperchon, who had been associated with Cassander, the son of Antipater, in the regency of Macedonia, being engaged in a contest with his ambitious colleague, sought to attach the Greeks to his interests, by displacing the governors whom Antipater had placed over them, and by restoring the power of democracy. Several of the cities, particularly Megolopolis, resisted his decree, and drew upon their heads a bloody revenge. Athens, on the contrary, gladly hailed its recovered liberty; and proceeded, in its moments of renewed turbulence, to put to death the friends of Antipater. Among these perished the greatest ornament of their city, the incorruptible Phocion, who had served in the armies and councils of his country till he was above eighty years of age; and whose distinguished merit his fellow citizens soon after acknowledged, with their accustomed inconsistency, by erecting a statue to his memory, and inflicting punishment upon his accusers. But Cassander, by the aid of Antigonus, having recovered his influence in Greece, restored the aristocracy, replaced the Macedonian garrison, and appointed Demetrius Phalerius governor of the city, who conducted himself in his office with so much wisdom and moderation for ten years, that more than three hundred statues are said to have been erected in testimony of his benefits. The power of Cassander prevailed also in Peloponnesus; and, excepting a very few cities, Greece was again entirely subjected to the Macedonian dominion. See ALEXANDER.

During the revolutions which agitated Macedonia, after the death of Cassander, it was invaded and overrun by an immense body of Gauls, who pursued their course like a torrent, and poured upon the enfeebled states of Greece with the utmost fury. They were successfully resisted in the defiles of Thermopylæ, by the Grecian army under Calippus the Athenian; but, forcing their way by the path over mount Oeta, by which the Persians had penetrated under Xerxes, they directed their march to Delphos, with the design of plundering the temple of its accumulated treasures. But, meeting with a brave resistance from those who were assembled to protect the sacred spot, and, being thrown into confusion by a violent storm and earthquake, they fled in the utmost terror, and turned their arms upon one another, in the darkness of the night. They were keenly assailed by the Greeks in their flight, and the greater part of them cut to pieces. Scarcely recovering from the inroad of those barbarians, the states of Peloponnesus were involved in new calamities, by the ambitious arms of Pyrrhus king of Epire, who had reduced the greater part of Macedonia, and having been invited by Cleonymus, an exiled Spartan prince, to redress his grievances, led a powerful army to the gates of Sparta, while their king and the best of their troops were absent in Crete. But the inhabitants of the city, even the women, assisting in its defence, made so heroic a resistance, that time was allowed for the arrival of reinforcements; and Pyrrhus, being compelled to retreat, was slain in an attempt to enter the city of Argos. Antigonus, the son of Demetrius Poliorcetes, being again replaced on the throne of Macedonia, began to meditate the complete subjugation of Greece, and commenced his operations with the siege of Athens, which he speedily reduced, and garrisoned with Macedonian troops. Pursuing his schemes of conquest, he gained possession of Corinth by artifice, but was arrested in his ambitious career by the hand of death. His son Demetrius maintained a commanding influence in the different states of Greece, not by attempting to hold the sovereignty himself, but by supporting those who found means to usurp the supreme authority. His successor, Antigonus Doson, a prince distinguished by his justice and moderation, avoided all interference in the affairs of foreign states;

and the cities of Greece, imitating the example of the Achæan league, made one last attempt to recover their long lost independence.

During the distracted times of Macedonia, under Lysimachus and Ptolemy Ceraunus, the cities of Achaia gradually recovered their liberties, and renewed their ancient confederacy: (See ACHÆANS.) Aratus of Sicyon, having freed his native city from the government of Nicocles, joined the Achæan league, and was chosen prætor of the associated states. Intent upon delivering Peloponnesus from foreign dominion, and hoping to render the Achæan confederation a barrier against future invasion, he surprised the Macedonian garrison in Corinth, and attached the liberated city to the Achæans. He peruaded the governor of Megalopolis to abdicate his power, and follow the example of the Corinthians. Protected by the king of Egypt against the Macedonians, the Achæan confederacy was thus extended on all sides, and might soon have united all the peninsula as one nation, under one government, when its progress was interrupted by the hostility of Sparta. The ancient institutions of that distinguished city had fallen into total disuse, and the manners of its inhabitants had become entirely changed. Many of its kings had incurred deposition, exile, and death, by their attempts to resist the torrent of corruption; and Agis particularly, a young and virtuous prince, had fallen a sacrifice to his well-intended, but ill-executed scheme for restoring the laws of Lycurgus. Cleomenes, one of his successors, revived the prosecution of the plan, but pushed its accomplishment with the spirit of a tyrant, rather than of a reformer. Having massacred the Ephori, and banished the citizens who were unfriendly to his views, and rendered himself despotic at home; he turned his arms against the Achæans, either for the purpose of gratifying his ambition, by acquiring the direction of the confederacy, or, perhaps, only with a view of securing his usurped authority in Sparta, by having an army at his disposal. So strong was the antipathy of the Achæan republics to the prospect of Spartan domination, and so great at the same time their dread of its powerful tyrant, that Aratus was urged to the ruinous resource of calling in the aid of Antigonus Doson, king of Macedonia.* Cleomenes, defeated by Antigonus in the famous battle of Selasia, abandoned his ambitious projects, advised his subjects to submit to the conqueror, and sought a refuge for himself in Egypt. The Spartans were treated by Antigonus with the greatest moderation; but, from that period of its subjection to a foreign power, it sunk into insignificance, and the race of the Heraclidæ became extinct with the successor of Cleomenes. The Achæan league was still preserved entire and powerful, by the able conduct and prudent measures of Aratus; but having sought assistance from Philip of Macedonia, the son of Antigonus, against the Etolians, the inveterate enemies of Achaia, that ambitious ally, conceiving a design to subjugate the cities of Greece, and regarding the integrity of Aratus as an insurmountable obstacle in his way, caused the virtuous patriot to be secretly taken off by poison. The Romans, however, having formed an alliance with the Etolians, in order to occupy the arms of Philip, who had become the active ally of their formidable opponent Hannibal of Carthage, thus acquired a footing in Greece, which gradually led to its final subjugation, as a part of their empire. Philopœmen, the successor of Aratus, supported the cause of Philip as the professed protector of the liberties of Greece, and inspired the confederated states with an ardent love of independence, which long withstood the encroachments of the policy and power of Rome. The struggle maintained in Greece between the Macedonian and Roman interests, was languid and indecisive, while the latter were intent upon reducing the power of Carthage. But, after the conclusion of the second Punic war, more active measures were pursued against Philip. Titus Quintus Flaminius, the consul, partly by the vigour of his arms, but still more by his political dexterity, detached the Etolians, Achæans, and the most considerable of the other states, from all connection with Macedon; compelled the discomfited Philip to accept the most humiliating terms of peace; made a pompous proclamation, at the public games, of the freedom of Greece; withdrew, according to his promise, every Roman garrison from the different states; and left them in full possession of all that political independence which was compatible with the alliance of Rome. Antiochus, king of Syria, instigated by Hannibal, and aided by the Etolians attempting an invasion of Greece, recalled to that devoted country the armies of Rome, and afforded them an opportunity which they did not fail to embrace, of subjecting all that part of Europe to their growing dominion. After reducing and dismembering the kingdom of Macedonia, they were invited to assist the Spartans in a contest with the Achæan states: they soon succeeded in breaking the power of the confederacy, by seducing a part of the cities of which it was composed; and Philopœmen, generally designated the last of the Greeks, having fallen in an expedition against the revolted Messenians, it became no difficult task to accomplish the total overthrow of the confederacy, of which he had been so long the principal ornament and support. Above a thousand of the Achæan chiefs, accused of having acted in concert with Macedonia, were transported to Rome, to answer for their conduct at the tribunal of the senate. The Achæan constitution was, soon after, entirely dissolved; the whole of Greece reduced to the state of a Roman province, under the name of Achaia; and, from that period, its history comes properly to be included under that of Rome. See ACHÆANS, MACEDONIA, and ROME.

But Greece, though subject to the Roman arms, soon acquired, by her arts of peace, a silent superiority over her conquerors. The victors became the disciples of the vanquished; and the most distinguished Romans learned, in the Grecian schools of philosophy, to regard the country which they held in subjection, with the gratitude and respect due to a benefactor. These considerations probably contributed to secure to the inhabitants of Greece a milder exercise of authority, and more distinguished marks of favour, than were enjoyed by any other province under the yoke of Rome. Of these arts and attainments, to which this singular people were thus indebted for higher honours and advantages than all their military prowess had been able to command, we now proceed to offer an abridged view, as a suitable conclusion to the preceding sketch of their eventful history.

Of the state of society and knowledge among the earlier Greeks, particularly in what has been called the heroic age, as described in the writings of Homer, some account has already been given, when narrating the events of that period; and the remarks which follow apply chiefly to those times which were posterior to the first Persian war.

* The cities of Greece being so much decayed in strength, and unable to assume the attitude of independence, Aratus may be regarded as having adopted, if not the wisest, at least the only measure of security in his power. His object was to render the kings of Macedonia, the allies and protectors, in place of the masters and tyrants of the united commonwealths; and, by yielding so far to an influence which could not be withstood, to procure a free regulation of their internal concerns, and particularly an exemption from the odious and oppressive presence of foreign garrisons.

To agriculture, as an object of study, the Greeks paid little attention; and the care of its operations was almost entirely left to slaves. The Athenians considered themselves as having first received the common principles of the art from Egypt, and as having communicated the knowledge of it to the other countries of Greece. Attica itself, however, was adapted rather to the cultivation of fruits than of grain. Olives and barley formed its principal produce, and the citizens of Athens received their great supplies of wheat from the neighbouring states of Bœotia, or from their own colony of Byzantium. Their writers on the subject, among whom was Xenophon, have done little more than merely detail the common practices of their own times.

The inhabitants of Greece, though possessing a maritime country, surrounded with islands, and provided with excellent harbours, were extremely slow in availing themselves of these advantages; and made little progress in navigation and commerce, till after the expedition of Xerxes into Peloponnesus. After the example of Athens, especially in the course of the Peloponnesian war, the other states at length directed their attention to the maintenance of a navy; but chiefly for the purposes of warfare. The voyage of Alexander's fleet from Patala to Susa, after sailing down the Indus, was the first instance of Greeks navigating the ocean; and, previous to that expedition, they were entirely confined to the waters of the Mediterranean.

Excepting Corinth and Athens, it was principally in the smaller states, such as Megara, Sicyon, Cos, and Cnidus, (which possessed not sufficient political influence to interfere in the general affairs of Greece,) that the arts of commerce were most sedulously prosecuted. Athens, however, was the great seat of commercial views, where every circumstance favoured the acquisition, and encouraged the expenditure of wealth. Its port, Piræus, was then the centre of the traffic of those times, and there every commodity was to be found in abundance.

The fine arts appear to have attracted earlier attention in Greece, than the more useful occupations; and some of the ancient medals, long prior in date to the oldest historians, exhibit a chasteness and grandeur of design, both in architecture and sculpture, for which it is difficult to account.

The customs and circumstances of the Grecian states tended directly to encourage the progress of these arts. Three public buildings were indispensible in every city; a temple, a theatre, and a gymnasium, to which were afterwards added the baths, and portico or place of shelter for walking and conversing. In larger towns these edifices were soon multiplied, especially those for the service of religion; and every city almost forming a distinct community or nation, each required to possess these different buildings within its own walls, and strove to surpass its neighbours in the solidity and beauty of its public structures. The exertions of the Greek artists in this at once useful and ornamental study, are not therefore very wonderful; but, when it is considered, that its first architects derived their skill from those of Egypt and Persia, and that the Doric order, the foundation of all the rest, and the source of pure taste to all the architecture of Greece, was actually the most ancient, it is not easy to conceive by what accidental or intended principle of the art, a beautiful simplicity, so opposite to the enormous masses of the Egyptians, and cumbrous ornaments of the Asiatics, should have been so happily introduced; unless we ascribe it to the mere circumstance of necessity (the origin of so many human improvements) which obliged the early architects of that country to work with wooden materials: (See Civil Architecture.) But in whatever way we may account for the rise of Grecian architecture, its principles have received the approbation of every enlightened people in modern times; and its three orders, the Doric, Ionic, and Corinthian, still continue to form the invariable standard of good taste in the art.*

The same causes which rendered the skill of the architect so much in request, equally tended to encourage the labours of the painter and sculptor; and it is a remarkable circumstance, that, in the most turbulent periods of Grecian history, the fine arts received the most distinguished patronage, and made the most rapid progress. At Athens, particularly, the genius of Greece was nourished by Pisistratus, and brought to perfection by Pericles. The most eminent sculptors of those times were Phidias, Alcamenes, and Myron, of Athens; Polycletes and Lysippus, of Sicyon; Praxiteles and Scopas of Paros; and many of the ancient statues which have escaped the ravages of time, furnish ample testimony of the progress which had been made in the art. See Drawing and Sculpture.

Of the state of painting among the Greeks, many exaggerated and incredible accounts have been given by ancient authors. They used only four colours, black, white, red, and yellow; and knew nothing of painting in oil. They are considered also as having been very imperfectly acquainted with the effects of light and shade; and many pieces of ancient Mosaic, still preserved, are not much admired as performances in painting. Both in painting and statuary, the Greek artists produced representations of the human form, which could scarcely be called natural. By taking collective views of the species, and studying accurately the physical constitution of the body of man, they combined its various and scattered excellencies in one figure, and thus exhibited, what nature never does, a model of abstract and ideal perfection. Among the celebrated painters may be mentioned Polygnotus, who received the thanks of the Amphictyonic assembly for his painting of the Trojan war, placed in one of the porticos of Athens; Apollodorus, who is supposed to have invented the art of painting in clear-obscure; Zeuxis, who displayed himself at the Olympic games, dressed in purple and gold, and, having become wealthy, gave his works as presents, because he said they were above all price; Parrhasius, who insolently presented himself to public view with a crown of gold upon his head; Pamphilus, the first who applied the principles of science to his art; Timanthes, who produced the celebrated painting of the sacrifice of Iphigenia; Apelles, who exposed his works to public view, that he might derive improvement from the remarks of passengers; and Protogenes, the rival of Apelles, who censured the extreme minuteness of his contemporary, by saying, that "he knew not when to lay down his pencil."

Few things are more remarkable in the manners of the ancient Greeks, than the great importance which they attached to the musical art, which, in many of the states, was even regulated and recommended by the laws. It was considered as one of the most powerful means of influencing the sentiments of the people, and formed an essential part in the education of the youth. The ancient musicians are supposed to have been wholly ignorant of the art of performing pieces of music in different parts at the same time; and their compositions, especially the pathetic and warlike, are generally understood to have derived much of their effect from the poetry and sentiments with which they were combined.

* See an examination into the grounds of this preference in the Rev. Mr Alison's *Essay on Taste,* vol. ii. p. 156.

The honours and rewards lavished upon those who excelled in the fine arts, were doubtless one principal cause of the improvement which they reached; but often were they carried to a hurtful excess, exhausting the wealth which was wanted for the support of the state, and engrossing the rewards which were due to more essential services.

But the great occupation of the Greeks as a people, were war and politics. Leaving the ordinary labours of agriculture and the mechanical trades to the slaves, the citizens of the different states considered it as their peculiar privilege to share in the government of their country, and to fight in defence of its rights, or for the advancement of its power. Every citizen, therefore, being bound to serve in arms, was enrolled as a soldier at a certain age; and one of their regular employments was the exercise of the gymnasium, as a preparative for the toils of war. The armies were composed principally of heavy-armed infantry, attended by a number of slaves to carry the baggage, and serve in the camps, and sometimes to act as light armed troops. The arms of the infantry were a helmet, corselet, large brazen shield, leathern greaves or boots, long pike, and short sword. They were long accustomed to advance, in a compact body, to close fight; but Iphicrates, an Athenian general, introduced the employment of a greater proportion of light infantry, diminishing the weight and size of the buckler, exchanging the metal corselet for one of canvas, lengthening considerably the lance and sword, and accustoming the troops thus accoutred to the most active evolutions. That celebrated commander, describing an army as a human body, compared the general to the head, the heavy-armed infantry to the breast, the cavalry to the feet, and the light troops to the hands. Chariots were little used after the heroic age; and, for want of horses, cavalry were never numerous, generally consisting of the wealthier citizens, or of soldiers fitted out at their expence. Till the time of Philip of Macedon, the Greeks were little acquainted with the art of conducting sieges, but commonly limited their operations to a general assault, or inactive blockade. In long or distant wars, especially in the later ages of Greece, the citizens received pay, while serving in the field; but the constant object of every Grecian state was to support their troops at the expence of the enemy. Even in the most civilized periods, Grecian warfare was conducted with a spirit of rapine and barbarity, which seemed to increase, instead of diminishing, as knowledge and refinement spread among the people. Retaliation was considered as justifying the most atrocious measures, of which, in the course of the Peloponnesian war particularly, many instances occurred, in the proceedings of all parties. The Lacedemonians regularly massacred the crews of the Athenian merchant vessels, and even of neutrals, whenever they came in their way; and the Athenians deliberately decreed the extermination of the Æginetans and Scyonians, whom they put to death without distinction.

The Greeks distinguished six simple forms of government, namely, monarchy, hereditary or legally established, oligarchy, aristocracy, democracy, tyranny, and assumed oligarchy, of which the two last were considered as illegal and inadmissible. The title of King never implied among them the possession of absolute power, but only a legal and regulated superiority, particularly in directing the observances of religion, and the operations of war, and sometimes also in dispensing justice, but rarely in enacting laws. After the general abolition of monarchy in Greece, whenever a citizen of a commonwealth was raised by any means to monarchical authority, he was denominated Tyrant, not originally as a term of reproach, though in future times it came too justly to be applied in that sense. In Athens especially, as early as the days of Theseus, the nobly born formed a distinct class of the community, and were invested with great privileges; but hereditary nobility declined every where along with monarchy, and wealth became the principal cause of distinction among the citizens. Those who were able to serve in war on horseback at their own expence began to be regarded as a superior rank; and to the same circumstance may be traced the order of knighthood in most countries. Aristocracy, however, was less a regularly instituted form of government, than an assumed title adopted by the rich and the noble in those states where they held the chief power; but, as their administration was generally oppressive, oligarchy, or the government of a few, became a more frequent, though less honourable form of polity; and the term aristocracy was at length employed rather to signify those persons who, on account of distinguished merit, were elected by the people to undertake the management of public affairs. This last was commonly the mode adopted in the most democratical states; and pure democracy, in which all the freemen of the republic, in assembly, formed the supreme and absolute administration, was very rarely exemplified, and was usually denominated ochlogracy or mob-rule. Most of the Grecian governments contained a union of two or more of these forms; and, from these various mixtures, new distinctions and designations arose, which it would be tedious and unprofitable to trace. Of political economy the Greeks seem to have been extremely ignorant; and very little is known respecting their mode of managing the public finances. On the subject of population, it does not very clearly appear what was their regular system. They certainly employed many regulations for keeping up at least, if not for increasing, the number of their citizens; yet they shewed a decided aversion to any augmentation of their strength by the admission of foreigners to the privileges, or even to the protection of their state. They studied to preserve their townships completely insulated and distinct from all others; and prohibited intermarraige with the members of a different community, with all the jealousy of feudal clanship.

Amidst all the turbulence of the Grecian states, and the almost perpetual hostilities in which they were engaged, there were many circumstances favourable to the cultivation of literature and science. Few individuals possessed large properties, but many of them lived in great leisure, following no occupation themselves, and principally maintained by the labour of slaves. Assembled generally in towns, and having free intercourse with one another, polite manners were formed, and various opportunities were presented for the display of taste and genius. A lively imagination, and love of novelty, were general characteristics of the Greeks, and disposed them to welcome every ray of knowledge which beamed upon their limited society. Many, possessed of active and intelligent minds, yet less daring in their dispositions, or more scrupulous in their integrity, shunning the stormy paths of political ambition, sought employment and distinction by attainments in literature or science. Even those who aimed at the offices of statesmen, found a degree of general knowledge, especially in the pursuits of taste, and the arts of eloquence, highly advantageous to enable them to command attention in the public assemblies, and to assist them in swaying the minds of their fellow citizens. As knowledge increased among the members of a community, these qualifications became not merely useful, but essential to every political leader; and many, who were unable, or unwilling, to mingle in the struggle for public situations, found a less splendid, but often more gainful occupation, in communicating to others those literary acquisitions which had become so subservient to the success of public men. At length every city in Greece, but especially Athens, abounded with those persons, who, under the name of Sophists, undertook to teach every branch of science; and, at a time when books were few and expensive, the oral communication of knowledge was obviously a matter of the utmost importance.* These professors of wisdom studied the accomplishments of eloquence, to render their instructions more attractive; and frequenting all the places of public resort, strove to recommend themselves to notice by an ostentatious display of their abilities, especially by public disputations with one another, or with any who chose to converse with them amidst a circle of hearers. Grecian philosophy is generally admitted to have originated with Thales of Miletus, the contemporary of Solon, and the founder of the Ionian school. Soon after him arose Pythagoras, a native of Samos, who was compelled, by political troubles, to take refuge in Italy, and thus became the leader of what has been called the Italian school. Both these sages are understood to have acquired their learning in Egypt and Persia; but so much was it the practice of the Greeks to claim as their own, what they had merely purloined from the literary treasures of other nations, that it is impossible to ascertain what portion of their science was indigenous, and what of foreign growth. Both Thales and Pythagoras inculcated many valuable moral precepts, but they were not teachers of ethics as a system; and their countrymen of the Asiatic Greeks were more delighted with those metaphysical enquiries, respecting the nature of matter and spirit, the formation of the world, and laws of the heavenly bodies, which gratified their imagination, without proposing any restraint to their passions. It was during the administration of Periander at Corinth, and Pisistratus in Athens, that the love of these sciences was first kindled in Greece; but the growth of every liberal art was entirely checked by the violent political contests and revolutions which ensued, and particularly by the general alarm of the Persian invasion, which left no leisure for speculative pursuits. But when the commanding talents of Pericles had quieted the tumults of faction in Attica, the pursuits of science revived at Athens with new vigour; and, together with the fine arts, continued to receive improvement during all the turbulence which attended the progress and effects of the Peloponnesian war. During this period it was, that Anaxagoras of Clazomene introduced the best principles of the Ionian school, that Socrates dispensed his more practical instructions, that Plato wrote and taught his more refined speculations, that Lysias and Isocrates pleaded in the forum, and that Aristotle and Demosthenes studied in the schools of Athens. Anaxagoras first taught in Athens the existence of one eternal and supreme Being, or, as he is said to have expressed himself, "a perfect mind, independent of body," as the cause or creator of all things; and, by enabling his pupils to calculate eclipses of the sun and moon, proved these hitherto reputed divinities to be mere material substances. But his doctrine was so directly repugnant to the whole religious notions of the Grecian people, that he was accused of impiety, and obliged to withdraw from the Athenian territories. Socrates, early impressed by the sublime principles of theology taught by the exiled philosopher, yet, perceiving the inutility, or at least the unpopularity of such discussions respecting the nature of the Deity, applied himself rather to investigate the duty which man ought to render to such a Being, as Anaxagoras had described the great Creator. He seems to have settled it as a first principle, that, if the providence of God interfered in the government of the world, the duty of man to man must form a distinguished branch of the divine will. He therefore applied himself to examine and inculcate the social duties; and, possessing a most discriminating and ready eloquence, he rendered his conversation (the only mode of teaching which he employed) at once amusing and instructive. He was always to be found wherever there was the greatest resort of company, and was ready either to receive or to communicate information; but he would neither undertake the office of private instruction, nor accept a reward for his public labours. While he maintained the perfect wisdom and perfect goodness of the Supreme Being, and the constant superintendance of his providence over the affairs of men, he continued to observe and to recommend the various acts of religious worship which were practised in his native country. But all his caution and worth were unable to secure his protection against the jealous tyranny of Athenian democracy; and, either from an impression that he disapproved of their popular constitution, or from a dislike of his purer system of morals, he was rendered so obnoxious to his fellow citizens, that a decree was easily procured for his death. After the time of Socrates, the Greek philosophers were divided into two opposite sects, the Theists and Atheists. The latter, among whom were Leucippus, Democritus, Epicurus, &c. supported the opinion of Anaximander, that, without the aid of a supreme intelligence, all things were produced by a necessary action of matter, assuming all kinds of forms; and the former, among whom were Plato, Aristotle, Zeno, &c. adhered to the doctrine of Anaxagoras, respecting the existence of a Deity, while they held different notions as to his nature and attributes. Even those, however, who possessed the more correct ideas of the Supreme Being, almost without exception conceived the world to be governed by a number of inferior divinities, to whom different departments of the universe had been committed; and, as they readily conformed to the existing religious usages of their respective countries, their philosophical system and private example rather countenanced than counteracted the popular polytheism of antiquity. The origin and progress of the Grecian mythology, it is now impossible to trace with any probable degree of certainty. Whether it arose from the Chaldean hypothesis of the planets and elements being inferior divinities, and established mediators

* If an attempt were made to estimate the literary and scientific attainments of the ancient Greeks, the following would probably be found to be a few of the principal results; namely, that, in *literature*, it was rather in the entertaining than in the instructive branches that they made any extraordinary progress; and, even in history, produced merely exquisite narratives of events, without any exposition of their causes or relations;—that, in *moral science*, they excelled in acute disputations upon practical questions, and elegant manuals of useful precepts, but never ascended to any enquiry deserving the name of philosophy;—that, in *political science*, they described the most striking phenomena of government in the different states of their own country, or of the neighbouring nations, but made no researches into the principles, the ends, the safeguards of national constitutions;—that, in *physical science*, their progress was astonishing in the single branch of geometry, while they never thought of investigating the properties of physical bodies, or the order of physical events;—that, in *philosophy of mind*, the logic of Aristotle contains an ingenious but unsuccessful analysis of the process of general reasoning, while his metaphysics explains only the various uses which were made of general terms, and vainly attempts to penetrate the essences and causes of things, but nothing is done to arrange the phenomena of thought, or to ascertain the order of their succession; that "not one, in short, of the ancient philosophers had any conception of the real nature of general terms, or of the operation of mind which is called abstraction; and that it was chiefly by this radical defect, that they were perpetually perplexed, and led into all their trifling and absurdity."

between man and the one supreme God; or from the allegorical mode employed by the Egyptians of describing the attributes of the Deity; or from a poetical personification of the operations of nature; or from a fabulous embellishment of real events, in the first periods of Grecian history; or from mutilated traditions of the lives of the Hebrew patriarchs; or rather, which seems the most likely, from a mixture of all these, and perhaps other unknown sources;—one thing seems evident, that if it ever possessed the symmetry of a philosophical system, its unity was destroyed before it was described by any writer of antiquity whose works are now extant.

The theogony of Hesiod may be considered as the earliest and most entire account of the religious tenets of the Greeks; but it is affirmed by Herodotus, that, along with the divinities of the first inhabitants of Greece, the poet has mingled the gods of Libya and Egypt. The system, in short, admitted in some degree by the philosophers, assumed and altered by legislators, as best suited their purposes, embellished and expanded by the poets, as their imaginations pleased, became at length an inextricable mass of mysterious absurdities and ideal beings, of which we cannot attempt to furnish any consistent account. Neither can we afford space for enumerating the leading sects, and distinguishing tenets, and scientific attainments, of the different philosophers of Greece; but the most important and authentic information on these topics will be found under the articles devoted to their respective names. (See particularly Academics, Atomical Philosophy, Peripatetics, Stoics, Anaxagoras, Aristotle, Epicurus, Plato, Pythagoras, Socrates, Zeno.) It may be observed, in general, that the great defect of their physical science was, the want of experiment; and thus, having no fixed principles upon which to proceed, they had recourse to mere hypothesis and conjecture, amusing themselves with framing fanciful systems, while they should have been employed in actual observations. Hence a taste for sophistry and subtilty prevailed in every school of Grecian philosophy; and it became the boast of their teachers of wisdom to be able to support either side of a question, and to give plausibility to the most parodoxical opinions. This pernicious practice was soon transferred from the more abstruse speculations, to the more practical, political, and moral obligations. Its prevalence naturally gave rise to the sect of the Pyrrhonists or Sceptics, whose distinguishing principle was universal doubt, which they carried to such a degree of extravagance, as to pronounce every external object a mere illusion, and the life of man a perpetual dream. Neither the speculations of the philosophers, nor the fictions of the poets, were much calculated to favour the obligations of moral duty; and, even where their tendency was most unexceptionable, their influence was feeble.

At no period of Grecian history does their appear any thing deserving the name of evidence to prove the exitsence of that virtuous age, which more modern declaimers have delighted to describe rather in the spirit of poetical romance, than of historic accuracy. In the earlier ages, violence and rapine, except in as far as they were occasionally restrained by the solemn obligation of oaths, form the prevailing feature of the people and their leaders. In the more enlightened periods, in the times even of Plato and his disciples, the clearest principles, we do not say of moral purity, but even of moral integrity, were not better understood, and still less better observed, than in the days of Homer. Philosophy relaxed the hold of superstition upon the conscience, without substituting any efficacious restraint in its place; and "it is evident," to use the words of Mitford, "from the writings of Xenophon and Plato, that, in their age, the boundaries of right and wrong, justice and injustice, honesty and dishonesty, were little determined by any generally received principle." The philosophy of Epicurus had completely gained the ascendency in the age preceding the Christian era; and the greatest characters, and most learned scholars, wavered between the tenets of the theistical and atheistical systems. Corruption of manners, and the subtilties of scepticism, had reached a height of extravagance, which it seemed scarcely possible to exceed. Human reason had lost itself in the labyrinths of philosophical speculation; and human virtue had been abandoned to the wayward direction of the fancy or the passions. The history of the world had demonstrated (and it is the best lesson, which a review of its most interesting portions can teach) the necessity of some surer and more authoritative guide to man, than what the wisdom of the world had been able to afford him, either as a member of society, or a being formed for immortality. See *Ancient Universal History*; Millot's *Elements of General History*, vol. i.; Goldsmith's *History of Greece*; Rutherford's *View of Ancient History*; Gillies's *History of Greece*; Gillies's *History of the World*; Potter's *Antiquities of Greece*; Anacharsis's *Travels in Greece*; Leland's *History of Philip of Macedon*; Pausanias' *Description of Greece*; *Religion of the Ancient Greeks illustrated, by* M. Le Clerc; Newton's *Chronology*; Bossuet's *Universal History*; and particularly Mitford's *History of Greece*, a historical work, unequalled in modern times for extensive research, judicious conclusions, and well-arranged narrative. (*q*)

GREECE, Modern. See Turkey.

GREEK Music, *Ancient*. It appears from the writings of Aristoxenus, the earliest writer on the music of the Greeks whose works are extant, that before his time, their scale of music had been extended to two octaves, by the raising of a major tone, and then three succeeding minor fourths, upon the lowest of the notes of this double octave, and by the descending of two such succeeding minor fourths, from the upper note of this double octave: each of these fourths, or diatessara, being exactly of the same magnitude, and alike constituted, as to the situations of its two interior notes, throughout each of their several genera, and the colours or species of each.

The *fourth* being thus made the unvarying boundary of every one of the numerous Greek systems, as the *octave* is now with us, and as the major *sixth* was with Guido, in the formation of his scale: In the genus Diatonicum (which see) each fourth was made up of a semitone and two tones; in the genus Chromaticum, of two semitones and a minor third; and in the genus Enharmonicum (see Genera) of two quarter tones or diesis, and a major third; each of which semitones, tones, thirds, and diesis, were varied, or have different values assigned them, by almost every different writer, as references to our articles above mentioned will shew; but so as always to preserve the fourth entire and perfect: and it has been concluded, that every one of these writers intended five of the *fourths* which he has described to be disposed within two octaves, from A to A, as above mentioned; the third of these fourths, tuned from below, overlapping the second of those two tuned from above, by a grave or comma-deficient minor third, as will be best explained by giving an example of the *Diatonicum intensum* of Ptolemy, which can be done, with reference to the notes of Mr Liston's scale, (see Euharmonic *Organ*), using the artificial commas of Farey's *Notation* (which see.) for expressing the magnitudes of the several intervals; viz.

| Notes in Liston's Scale. | | Values of the Notes above A. | | Intervals of the several adjacent Notes. | |
|---|---|---|---|---|---|
| | | Σ | Σ | Σ | Σ |
| | A | | 1224 | | |
| | G | | 1131 | | 93 |
| | F | | 1027 | | 104 |
| | E | | 970 | | 57 |
| | D | | 877 | | 93 |
| D' | | 866 | | | 104 |
| C | C | 773 | 773 | 93 | |
| | B | | 716 | 104 | 57 |
| B♭ | | 669 | | | 104 |
| A | | 612 | 612 | 57 | |
| G | | 519 | | 93 | |
| F | | 415 | | 104 | |
| E | | 358 | | 57 | |
| D | | 265 | | 93 | |
| C | | 161 | | 104 | |
| B | | 104 | | 57 | |
| A | | 0 | | 104 | |

(Brackets in the table: values 612–1224 "Second Octave."; values 0–612 "First Octave."; intervals grouped as "1st 4th. 2d 4th.", "3d 4th.", "4th 4th.", "5th 4th.")

The first of the above three columns contains the notes of Mr Liston's scale, and opposite to each of these, its value in the artificial comma (Σ) is placed. In column three, intermediary to the lines of the first two columns, the difference of the adjacent numbers in column two are placed, by which it will appear that each of the five tetrachords or fourths, BE, EA, AD', and BE and EA, are exactly alike constituted, that is, rise each by the intervals 57, 104, and 93 artificial commas each, answering to the major semi-tone, the major and the minor tones respectively.

The interval AB, is in each case 104, or the major tone; and thus, exclusive of the notes B♭ and D', the system comprised in these two octaves may be more simply expressed thus, viz. T+4th +4th+ T + 4th+ 4th =2 VIII, forming thus far two similar octaves. The interval D'B or 866—716 = 150, is the comma-deficient minor third, by which interval the two series of fourths overcap each other.

It would be easy for the musical student to prepare a similar table to the above columns two and three, for each of the many Greek systems, whose fourths are given in Σ S, in our articles on the *Genera* above referred to, and to place Liston's corresponding notes against them, in column one, as far as is practicable, by reference to the values of his notes in the *Philosophical Magazine*, vol. xxxix. p. 419, whence the above numbers were derived, by adding 161 from C to C, and 773 from C to *a*; that is, by reducing Liston's series to A as a bass or key-note, instead of C. (*g*)

GREENHOUSE Plants. See Horticulture.

GREENSTONE. See Mineralogy.

GREEN, Matthew. Of this author of a popular poem, *The Spleen*, very few particulars are known. He was nephew to a Mr. Tanner, the clerk of Fish-mongers Hall, and belonged to a reputable family among the Dissenters. But though bred among the sectaries, he grew disgusted with their precision, and probably left them without being reconciled to the mother-church, as he is said to have thought freely on points of religion. He had a post at the custom-house, which he discharged with great fidelity, and died at a lodging in Nag's head Court, Grace-church street, at the age of forty-one, in 1737. Green's character is given by his intimates as that of an exceedingly honest man, witty and original in conversation, though slenderly educated; and agreeable in manners, though subject to the hip. Once when his friend Sylvanus Bevan, a Quaker, was complaining at Batson's coffee-house, that, while bathing in the river, he had been saluted by a water man with the usual cry of *Quaker Quirt*, and wondered how his profession could be known while he was without his clothes; Green replied, "by your swimming against the stream." A reform took place at the custom-house, while he belonged to it, by which, among other articles, a few pence, weekly allowed for milk to the cats, were taken away. On this occasion, Green wrote a petition from the cats, which prevented the regulation from taking place. The poem of the Spleen was never published in his lifetime, nor any of his fugitive pieces. Glover, his warm friend, presented it to the world after his death; and, it is much to be regretted, did not prefix any account of its interesting author. It was originally a very short copy of verses, and was gradually and piece-meal enlarged. Pope speedily noticed its merit; Mr Melmoth praised its strong originality, in Fitzosborne's Letters; and Gray duly commended it in his correspondence with Lord Oxford, when it appeared in Dodsley's Collection.

It would be as superfluous here to enter upon a serious defence of the poem of the Spleen, as it was absurd in the last editor of the British Poets to attack it upon the grounds of its author professing to offer no religious consolations for the cure of splenetic temperaments. Religion would have been quite as much misplaced amidst those light views of life which the author exhibits, as in a sentimental comedy. The views of life which he takes, are not indeed marked either by strong sensibility, or profound observation; but the *light* in which he arrays familiar scenes and situations, is peculiarly original. The matter of his precepts is common, while their manner of expression is happy, and all his own. The concluding allegory, for instance, in which life is compared to a sea voyage, is extremely hackneyed, yet nowhere has the allegory been renovated by so many, and by so fine picturesque circumstances. Reason at the helm; the Passions forming the crew; Philosophy putting forth the lights; Experience employing the glass and lead; the careening places of Bath and Tunbridge; and the dolphins sporting round; all compose a picture of animated and amusing effect. Many of his scattered thoughts and detached sentences, fairly rival the best in Butler; and upon the whole leave it much to be regretted, that so ingenious a mind should have been destined by a short life, and by the bondage of a confined vocation, to leave such scanty relics of its powers. (*n*)

GREENE (Nathaniel,) a major-general of the army of the United States, was born in Warwick, Rhode Island, about the year 1740. His parents were quakers. His father was an anchor-smith, who was concerned in some valuable iron works, and transacted much business. While he was a boy, he learned the Latin language chiefly by his own unassisted industry. Having procured a small library, his mind was much improved, though the perusal of military history occupied a considerable share of his attention. Such was the estimation in which his character was held, that he was at an early period of his life chosen a member of the assembly of Rhode Island. After the battle of Lexington had enkindled at once the spirit of Americans throughout the whole continent, Mr Greene, though educated in the peaceful principles of the friends, could not extinguish the martial ardour which had been excited in his own breast. Receiving the command of three regiments with the title of brigadier general, he led them to Cambridge; in consequence of which the quakers renounced all connexion with him as a member of their religious body. On the arrival of Washington at Cambridge, he was the first who expressed to the commander in chief his satisfaction in his appointment, and he soon gained his entire confidence. He was appointed by congress major general in August, 1776. In the battles of Trenton, on the 26th of December following, and of Princeton, on the 3d of January, 1777, he was much distinguished. He commanded the left wing of the American army at the battle of Germantown, on the 4th of October. In March, 1778, he was appointed quarter-master-general, which office he accepted on condition, that his rank in the army should not be affected, and that he should retain his command in the time of action. This right he exercised on the 28th of June, at the battle of Monmouth. His courage and skill were again displayed on the 29th of August in Rhode Island. He resigned in this year the office of quarter-master-general, and was succeeded by colonel Pickering. After the disasters which attended the American arms in South Carolina, he was appointed to supersede Gates, and he took the command in the southern department December 3, 1780. Having recruited the army, which had been exceedingly reduced by defeat and desertion, he sent out a detachment under the brave general Morgan, who gained the important victory at the Cowpens, January 17, 1781. Greene effected a junction with him on the seventh of February, but on account of the superior numbers of Cornwallis, he retreated with great skill to Virginia. Having received an accession to his forces, he returned to North Carolina, and in the battle of Guilford on the 15th of March was defeated. This victory, however, was dearly bought by the British, for their loss was greater than that of the Americans, and no advantages were derived from it. In a few days Cornwallis began to march towards Wilmington, leaving many of his wounded behind him, which had the appearance of a retreat, and Greene followed him for some time. But, altering his plan, he resolved to recommence offensive operations in South Carolina. He accordingly marched directly to Camden, where, on the 25th of April, he was engaged with lord Rawdon. Victory inclined for some time to the Americans, but the retreat of two companies occasioned the defeat of the whole army. Greene retreated in good order, and took such measures as effectually prevented lord Rawdon from improving his success, and obliged him in the beginning of May to retire beyond the Santee. While he was in the neighbourhood of Santee, Greene hung in one day eight soldiers, who had deserted from his army. For three months afterwards no instance of desertion took place. A number of forts and garrisons in South Carolina now fell into his hands. He commenced the siege of Ninety Six on the 22d of May, but he was obliged on the approach of lord Rawdon in June to raise the siege. The army, which had been highly encouraged by the late success, was now reduced to the melancholy necessity of retreating to the extremity of the state. The American commander was advised to retire to Virginia; but to suggestions of this kind he replied, "I will recover South Carolina, or die in the attempt." Waiting till the British forces were divided, he faced about, and lord Rawdon was pursued in his turn, and was offered battle after he reached his encampment at Orangeburgh, but he declined it. On the eighth of September, Greene covered himself with glory by the victory at the Eutaw springs, in which the British, who fought with the utmost bravery, lost eleven hundred men, and the Americans about half that number. For his good conduct in this action, congress presented him with a British standard and a golden medal. This engagement may be considered as closing the revolutionary war in South Carolina. During the remainder of his command he had to struggle with the greatest difficulties from the want of supplies for his troops. Strong symptoms of mutiny appeared, but his firmness and decision completely quelled it.

After the conclusion of the war he returned to Rhode Island, where the greatest dissenisons prevailed, and his endeavours to restore harmony were attended with success. In October 1785, he sailed to Georgia, where he had a considerable estate not far distant from Savannah. Here he passed his time as a private citizen, occupied by domestic concerns. While walking without an umbrella, the intense rays of the sun overpowered him, and occasioned an inflammation of the brain, of which he died June 19, 1786, in the forty-seventh year of his age. In August following, congress ordered a monument to be erected to his memory at the seat of the federal government.

General Greene possessed a humane and benevolent disposition, and abhorring the cruelties and excesses, of which partizans on both sides were guilty, he uniformly inculcated a spirit of moderation. Yet he was resolutely severe, when the preservation of discipline rendered severity necessary. In the campaign of 1781, he displayed the prudence, the military skill, the unshaken firmness, and the daring courage, which are seldom combined, and which place him in the first rank of American officers. His judgment was correct, and his self-possession never once forsook him. In one of his letters, he says, that he was seven months in the field without taking off his clothes for a single night. It is thought that he was the most endeared to the commander in chief of all his associates in arms. Washington often lamented his death with the keenest sorrow. *Hillhouse's oration on his death; American Museum*, ii. 337—343; iii. 23; vii. 39—41, 107—109, 210, 211; *Massa. Magazine*, iv. 616, 671; *Gordon*, ii. 65; iii. 473; iv. 168, 406; *Marshall*, iii. 219; iv. 263, 335, 540, 556; v. 116; *Ramsay's South Carolina*, ii. 190—193, 204—225, 245—251; *Hardie; Holmes' Annals*, ii. 440—449; *Stedman*, ii. 376; *Warren*, iii. 56—59.

# GREENLAND.*

Greenland is the most northern country of the western hemisphere of the globe. It reaches as far as the land is discovered, from Cape Farewell, in Latitude 59° 30′ to the 78th degree of North Latitude. Its eastern coast runs north-east towards Spitzbergen, and is bounded by the Atlantic Ocean. Its western coast has a northwest direction, and is bounded by Davis Straits and Baffin's Bay. Its southern coast is very narrow, not occupying one degree. The borders of its northern coast are entirely unknown. The eastern coast is commonly called East Greenland, and Osterbygd by the old Icelanders, and Norwegians; the western, West Greenland, and Westerbygd; *bygd* signifying, in the old Icelandic language, settlement. From the date of its recovery, the former is called Old Greenland, the latter New Greenland. The whale fishers, speaking of Greenland, include under this name the islands

* The Editor has been indebted for the following article on Greenland to the Chevalier Charles Louis Giesecke, Professor of Mineralogy to the Dublin Society, who resided many years in that country, for the express purpose of examining its mineralogy and natural history.

of Spitzbergen, so called from the many sharp-pointed mountains with which it abounds, and they call the whole west side Davis Strait. The Danes further divide the west coast into South Greenland, a distance from 59° 30′ to the 68th degree, and into North Greenland from the 68th degree to the most northern point. That Greenland joins the continent of America on the end of Baffin's Bay, is nearly ascertained.

The discovery of Greenland between the years 830 and 835, is mentioned in the chronicle of Snorre Sturleson, a learned Icelander, who wrote about the years 1212, or 1215. Another Danish writer, Claudius Christofferson, places the discovery in the year 770. An Icelander, Eric Raude, or Eric the Red, so called from his red hair, having killed another powerful chief of that land, was obliged to quit the country, and determined to make a voyage of discovery, a practice very common at that time. Soon after he set sail, he reached the point of a cape on the continent of Greenland, which cape he called Heriolfsnæs, in commemoration of one of his ancestors. Turning from this to the south-west, he entered a very large inlet, which he called Eric's Sound, probably the sound called by the natives Ikareseksoak, which separates Cape Farewell from the continent of Greenland; he then stopped and remained on an island in the vicinity of it. The following summer he explored the continent, and returned in the third year to Iceland, where he boasted very much of the fertility of the new country which he had discovered, to which he gave the name Greenland, hoping thereby to induce a great many people to follow him. Of 25 vessels which set out with him for Greenland, only fourteen arrived safe. These settlers were soon followed by others, both from Iceland and Norway, and their number in a very short time increased so much, that they occupied part of the east and west coast of Greenland. Eric Raude and his sons Leif and Thorstein afterwards made excursions from time to time to the opposite side of Davis Strait, or the North American coast, and founded colonies there, to which they gave the name of Winlandia. In the year 999, Leif made a voyage to Norway, and was persuaded by King Tryggegon to embrace the Christian religion; he took priests with him to Greenland, for the conversion of his countrymen; and his father, Eric Raude, with many of the people, went over to the Christian faith, and there was afterwards established a bishopric, and a great number of churches. The old Icelandic and Danish writers tell us, that there existed 12 parishes on the east coast of Greenland, containing 190 villages; and four parishes, containing 100 villages, on the western coast. The last bishop Andrew was sent there in 1408, and after that year Greenland was no more thought of for a very long time.

Amongst the foreign travellers who visited the coast of Greenland very early, about the years 1379 and 1380, were the Venetian noblemen Antonio and Nicolo Xeno, to whom we are indebted for the first map of Greenland, published, with a description of their voyage, by Francesco Marcolin, at Venice, in 1558. From the year 1408, all intercourse was cut off, and all knowledge of Greenland has been buried in oblivion. Previous to that time the Esquimaux, now called Greenlanders, began to shew themselves on the western coast. It cannot now be ascertained whether these Esquimaux, harassing incessantly the Icelandic and Norwegian settlers, have at length prevailed against them, and extirpated the whole race. Some suppose that the plague, called the black death, which devastated the north of Europe, from the year 1402 to 1404, reached this land, and carried off a great number of the settlers, so that, by their diminution, they were weakened to such a degree, that at last it became an easy matter for the Esquimaux, (called Skrællingers by the settlers) to make war upon them, and to extirpate them. In this forgotten and neglected state Greenland still remained, until the beginning of the 16th century, when a new spirit burst forth in Europe, to explore the unknown regions of the earth.

Martin Forbisher, or Frobisher, was, in the year 1576, the first that navigated this coast, and called it *Meta Incognita*. A sound which, according to him, divided that continent, was called Forbisher Strait. He was sent out again by Queen Elizabeth, in the year 1578; but he lost two of his vessels, and could find neither the sound nor the land. The Forbisher Strait is marked on all charts of Greenland, but it does not exist anywhere on the whole coast.

John Davis followed the same course, in the year 1585, and discovered that strait which now bears his name, viz. Davis Strait, which reaches to the 70th degree. Some public-spirited gentlemen sent out Robert Bylot as captain, and William Baffin as pilot, with the ship Discovery, in the year 1616: they reached Davis Strait, and advanced as far as the 77° 30′.

The Danish government, animated by these discoveries, began also to think of their lost Greenland, or the Osterbygd, (eastern settlements,) and during the reigns of seven kings, spent considerable sums upon it, but without success; the eastern coast having become inaccessible by the floating ice. Finally, in the reign of Frederic the Fourth, Hans Egede, a clergyman from Vogen, in the North of Norway, animated by a religious enthusiasm, offered himself for the conversion of the Greenlanders, and, accompanied by his wife and children, left his office, and his native country. He was furnished by the Danish government with two vessels; and, being provided with the necessary stores, he embarked on the 2d of May, in the year 1721, and, after struggling with many dangers, landed on the 3d of July, at Baal's river, in 64° 5′ of N. Lat. The Greenlanders did not like their new guests; but, by degrees, they were influenced, by friendly treatment and presents, to entertain those who visited them. The trade had a very poor appearance in the beginning, but all succeeded very well in the course of three years. From time to time, the establishments both for the mission and the trade were increased, and Mr Egede built the first European house in Baal's river, calling the settlement, metaphorically, Gotthaab (Good Hope.) The three first missionaries of the German *Unitas Fratrum*, or the Moravian Brethren, were sent out in the year 1733 They established their first settlement in the vicinity of that of Mr Egede, and gave to it the metaphorical name New Herrnhut, their first settlement in Germany being called Herrnhut, that is, protected by our Lord.

The Danish government were not discouraged by the unpromising appearance of the missions and the colonies, but made ample provision for upholding and extending them, and formed permanent settlements for the best possible cultivation of the land. Horses and soldiers were sent over to Greenland, that the settlers, by their aid, might travel over land to the east coast, or the lost Greenland; but the icy vallies, and glaciers crossing the interior of the country, were found impassable; the horses perished, and all those endeavours proved abortive. The only possible way to come there, would be with Greenlandish leather boats, which are easily transportable over the floating ice, travelling round Cape Farewell, and never losing sight of the coast. But the reports of the Greenlanders, who dwell in the most southern part of the country, give sufficient reason to suppose, that none of the old settlers will be found there; it being probable, that a coast incessantly surrounded by ice fields, which have lain there from time immemorial, and increase every year, as is ascertained by the whale-fishers, who go to Spitzbergen, will be now much colder than it was some centuries ago, when the sea was still open for sailing from Iceland and Norway, and free from floating ice during the whole summer.

The colonies and settlements existing at this time on the whole coast of West Greenland, in a line from south to north-west, are,

1. *Nennortelik*, or Bear-island, lying on the east of the promontory of Cape Farewell. The Greenlanders, who live on the remotest places in the south, come there, if the floating ice permits it, with their articles of trade, such as the skins of the blue and white fox, and of the white bear. The island is only inhabited by one Greenlandish family.

2. *Lichtenau*, the most southern establishment of the Moravian Brethren, lying in the Firth Agluitsok, in the 60° 34′ of latitude.

3. *Julianeshaab*, established in the Firth Kakortok, in the 60° 43′. In its vicinity are the ruins of an old Icelandic or Norwegian church.

4. *Fredrikshaab*, in the 62° 30′, is one of the oldest colonies, established in 1742.

5. *Fiskerness*, a Danish lodge, in the 63° 20′. Four leagues from this is,

6. *Lichtenfels*, a settlement of the Moravian Brethren, founded in the year 1754, on an island called Kikertarsoeitsiak.

7. *Godthaab*, in the 64° 5′, in Baal's river, the first settlement for the mission and trade, established in the year 1723, by Mr Hans Egede, the first missionary of Greenland. A dwelling-house of stone was built by him in the year 1726, the walls of which are three feet in thickness; it is 27 feet long, and 16 feet broad. Some hills, at the distance of one league, separate Godthaab from New Herrnhut, the first Moravian settlement in this country. The governor of South Greenland resides here.

8. *New Herrnhut*, which has also a very large dwelling-house, built of stone, by the Moravian Brethren.

9. *Zukkertoppen* (*Sugar-loaf*,) so called from a conical mountain in the vicinity of the settlement, established in 1755, in 65° 40′ North Lat.

10. *Holstein-burg*, established in 1770, in 67° 10′ North Lat. the last colony of South Greenland.

11. *Egedesminde* (that is, *Memory of Egede*) is established in honour of the first missionary, Hans Egede. It lies in 68° 40′ North Lat. on the most southern point of Disko Bay, generally called on the charts South East Bay, and Fish Bay, which is one of the most convenient places for the whale fishery.

12. *Christianshaab*; 13. *Clanshavn*; and, 14. *Jakobshavn*, in 68° 50′, are the settlements established round the continent of Disko Bay.

There are two other colonies, called, 15. *Kiokkerhuk*, and, 16. *Rittenbenk*, situated in 70° N. Lat. on islands in the Waygat, which is a sound that separates those islands from Disko island.

17. *Omenak*, another settlement, established 1768, in 70° North Lat. is situated on an island of the same name in James's Bay, which, in the English charts, is called Cornelius Bay. The most northern colony which existed, was,

18. *Upernavik*, on one of the Women Islands, 72° 32′ North Lat. although now abandoned by the settlers, for want of intercourse with, and support from, the other settlements. It is still inhabited by some Greenlanders, who have very little intercourse with the Europeans, and never venture farther to the north than to the 73d degree.

There is another settlement, *Godhavn*, on Disko island, where the governor of North Greenland resides, and two other at *Kronprinz island* and *Hund island*, called, on the charts, Whale Island. The English whale-fishers visit frequently those places. On the whole coast are five Protestant Lutheran Danish churches, where the gospel is preached both in Greenlandish and Danish; there are also three meeting-houses of the Moravian Brethren. The Lutheran churches are at Frederikshaab, Godthaab, Holsteinsburg, Jakobshavn, and Claushavn. The Moravian meeting-houses are at Lichtenau, Lichtenfels, and New Herrnhut. The Moravians have no mission farther to the north.

Greenland was always considered to be a property of the King of Denmark, the Danish flag having been hoisted there so early as in the 13th century. The trade with the Greenlanders was several times interrupted, as already mentioned, the inhabitants wishing to avoid all intercourse with foreign countries. The religious zeal of the venerable Lutheran clergyman, Hans Egede, by degrees attached the Greenlanders to the Danes: the uninterrupted communication with the Greenlanders made the Danes acquainted with the language of the country; and as the natives began to feel the want of some European articles, a commercial intercourse was established. The trade was always a monopoly, undertaken at first by a company of merchants, and afterwards conducted on account of the government. Each settlement is managed by a trader and his assistant, both of whom are paid by the government. These officers and their workmen are subjected, besides the Danish law-book, to another regulation of trade, called Instruction. The general inspection of the trade, and the administration of the laws, is placed by the king under the care of two governors, or general inspectors, one of whom resides at Godthaab in South Greenland, the other at Godhavn (Good Harbour) on Disko island. Their power is very extensive, but is restricted to the settlements; the natives being without laws, except such individuals as are in the pay of the Danish government. The trade and the navigation to the colonies is governed by the royal direction of the Greenland trade at Copenhagen. The Danish missionaries, their installations, functions, and residences, are settled by the royal Danish college for converting the heathens. The Moravian Brethren there are under the immediate direction of the *Unitas Fratrum* of Herrnhut in Germany.

The exports from Greenland are, feathers and eider-down, horns of the sea-unicorns (*Monodon Monoceros*,) skins of seals, of the blue and white foxes, white bears, white hares, and rein-deers, whale-bone and blubber, or oil of every kind.

The imports directly from Copenhagen to Greenland are, guns, powder and shot, all kinds of iron-mongery, particularly knives, files, axes, needles, nails, arrow-heads, linen and hosiery; articles of luxury for the women, such as cottons, ribbons, gloves, looking-glasses, snuff-boxes; tobacco is an article in great demand everywhere. They are also anxious to obtain rye-bread, barley, tea, coffee, beer, and brandy. The latter article, however, is strictly prohibited from being sold, or even given to any Greenlander. Every spring, in the beginning of May, five or six vessels go out from Copenhagen to Greenland with the articles of trade for the natives, and the necessaries and comforts of life for the Europeans. The cargoes of these vessels may be calculated at 65,000 rix-dollars (13,000*l.* sterling.) The value of the productions carried to Copenhagen may amount, on an average, to 85,000 rixdollars (17,000*l.* sterling.) But the communication between Greenland and Copenhagen was entirely suspended for five years, in consequence of the war between Great Britain and Denmark. The buildings and stores of the Greenland company have suffered very much, from not having been repaired, in consequence of the want of timber and other materials; and it is now supposed that the establishments will be reduced to a smaller scale.

The natives inhabiting the western coast of Greenland, from the 59th degree to the highest north, belong to the Mongolic race of mankind. They are called Skrællingar by the old Icelanders and Norwegians, on account of their little stature; but they call themselves, in their own language, Innuit, that is, men or human beings, in opposition to other creatures, and this not from presumption. They are called Esquimaux, or Eskimos, by some authors. They speak the same language as the inhabitants of Labrador and part of Hudson's Bay, and their mode of living is very similar. They are probably spread over Behring's Strait, and part of Nootka and William's Sound, as it appears from the maps of the late Captain Cook, where some islands are marked with names used by the Greenlanders in Davis Strait. They resemble one another in their stature, their complexion, and their customs. Living under a rigorous climate, which presents very few productions, the size of their bodies is reduced by the nature and scarcity of their food, and the extreme cold. Although the stature of the Greenlanders is in general below the common standard, their persons are not proportionably slender, being usually pretty plump, but very seldom muscular. Their face is large and broad, the nose not very flat, but small and short; the nostrils somewhat wide, the cheek bones high, the cheeks round and plump. The face frequently appears fallen in quite across between the temples. The forehead is low, the eyes little and black, dull and drooping, but having the power to distinguish accurately at a very great distance. The eyelids are drawn towards the temple; the mouth is generally little, and round; the teeth very regular, and beautifully white; the lips thick, and turned outwards; the under lip somewhat thicker than the upper. The beards and eyebrows are thin, but they have abundance of hair on their head, which is black, long, coarse, and straight. Their necks are short, their legs thin, but their feet and hands are small and very well formed; their heads are uncommonly large. The shape of the women is very similar to that of the men, and they resemble them so nearly, that one cannot at first distinguish the sexes, their dresses being nearly the same. The appearance of the women is by no means feminine; they have high breasts and broad shoulders, being accustomed, when very young, to labour hard, and carry great burdens. The Greenlanders are of a yellowish grey colour, which approaches somewhat to olive green; but this may be attributed not only to the climate, but to their dirty habits, and to the great quantity of smoke and soot which their houses contain; for their children are born as white as any European child.

The oily nature of their food contributes probably somewhat to deepen their colour; their blood becoming so dark, dense, warm, and oily, that their skin has the smell of oil, and their hands and feet are as clammy as bacon. Their bodies being very fleshy and fat, and coated as it were with a varnish of oil and dirt, they can bear the cold better than an European. They sit commonly naked in their houses; and the effluvia from their bodies is such, that an European who sits by them can scarcely endure it. Their children are in general very healthy; and one rarely sees among them a human being mis-shapen from its birth. They consider themselves to be very well educated and informed; and when they meet together, nothing is so customary among them as to ridicule the Europeans and their manners. The women, in particular, understand that sort of humour extremely well. They use a mode of very expressive mimicry, consisting of certain grimaces, by means of which they can make themselves understood from one corner of the house to the other; and a European coming to their country will instantly be characterised by a nickname, expressive of his manners, or behaviour, or personal defects. They reckon themselves the most modest people in the world: and seeing a modest foreigner, they say, *innucksisimavok*, or *innungorpok*, that is, "he is as modest as a Greenlander." Although there may be some presumption in this, yet it cannot be denied, that they are modest, friendly, and not litigious: generally compliant; but, when exasperated, they are so desperate, that no danger deters them from their revenge. Although very ignorant, they are by no means stupid. They learn easily to read and to write their language, not only the children, but also men advanced to twenty and thirty years of age. Some of them, besides their maternal tongue, speak Danish very well, and they have a great inclination to mechanics. As their supply of food is but precarious, their patience in hunger is astonishing. Their strength, in proportion to the size of their bodies, is not less wonderful. Pinched with hunger for some days, the man is nevertheless able to row out, and to manage his kajak in the most boisterous sea.

Their manner of clothing is quite correspondent to the climate. Men, women, and children, from the time they are three years old, are cloathed nearly in the same manner. Their ordinary dress is a sort of close frock, or rather robe, which reaches to the knees. It has at the upper part a round hole, sufficient to put the head through, and not large enough to admit the cold. The sleeves are rather wide on the shoulders, becoming narrower as they reach the wrists. A hood similar in shape to the cowl used by monks, is attached to the back of the frock. This is drawn over the head in winter or bad weather. In warm weather they generally walk bareheaded. Some of them now use the round hats of the Europeans. Their breeches are nearly like those of Europeans. Their stockings are in summer of seal-skin, in winter of dog or rein-deer skin; and those of the women are of fowl-skin. Their boots are made in a very neat and ingenious manner; sometimes of seal skin, sometimes of rein-deer skin. The frocks are also made of seal or rein-deer skin. At the seams, where the different skins are sewed together, they are usually adorned with narrow thongs of differeut skin, sometimes coloured red; they are worn with the hairy side outwards. In cold weather they use under the frock a shirt made of fowl-skin, of the *Alca pica*, or *Anas mollissima* or *Pelicanus carbo*.

When at sea in their small canoes (called *kajak*), they use a sort of frock impenetrable to water, with the hair taken away, called *Erysak*. The bottom part is fastened round a ring or hoop made of bone; and this hoop is joined to the hole in which the Greenlander sits, so that no water can penetrate it. They have also another frock made very ingeniously from the intestines of whales, dolphins, or seals, prepared with such skill as to resemble, in a great measure, our goldbeater's leaf. The clothes of the women differ very little from those of the men. The sleeves are very high and wide on the shoulder, and reach only to the elbow. They are cut out downwards from the top of the thigh, and form a long tongue-formed flap both behind and before, the end of which reaches to the knee. It is very carefully sewed, and bordered round the body with narrow thongs of white or coloured leather, sometimes of red cloth. They wear breeches, with very short drawers underneath. Their common boots are made of black or brown seal-skin, their dress boots of white or red coloured seal-skin, reaching over the knees. Shoes are rarely used either by the men or women.

They live in winter in houses, and in summer in tents. When the summer is over, which is generally at the end of August, the women belonging to the family or to the house are very busy in repairing an old or in building a new house. It is done in a very few days; and this labour resembles the liveliness of an ant-hill. Some carry stones, others bring sod; several turf, timber, shrubs, or earth. The walls are made of water-worn stones, put together with turf or sod instead of mortar; and the roof is formed of pieces of floating timber. It is flat, and is covered with shrubs, turf or sod, and earth. The stones are taken from the shores, as they never build a house at a greater distance from the sea than 20 or 30 paces; the timbers are picked up from the sea during the summer. Their houses are sometimes regular, sometimes oblong squares; being from 12 to 18 feet in length, and from 10 to 12 feet in breadth. The height is generally six feet. The walls are at their base two feet, and on the top one foot thick. The entrance is usually under the earth, two feet high, two feet broad, and from 12 to 15 feet long. It is in the centre of the house, and generally faces the south. The house has no door, and one must always creep in on hands and feet. Above the entrance is one, and sometimes two windows, which are made of the intestines of whales, or dolphins, or seals, sewed together. The house consists of only one room, at the back of which there is a kind of stage, raised from one foot to one and a half from the ground, and extending the whole length of the house. It is covered with seal-skin, and is used as bench, chair, table, and bed-stead. Being divided in the front by perpendicular standing timbers, it has the appearance of low cow-sheds or stables, separated by skins. Each family occupies such a division. They sit on this bench the whole day, the men with their legs hanging down, the women generally cross-legged. Each family has at least one burning lamp, made by the Greenlanders themselves of pot-stone. All round the margin of the vessel oiled moss is placed, which serves instead of a wick; and the vessel contains about a quart of oil. The lamp serves them as candle, chimney, and cooking fire; and is attended by the women. On the roof of the house, over the lamps, are racks for the purpose of drying clothes, boots, gloves, &c. The extremities of the large bench on both sides of the house are considered to be the best places, being most removed from the entrance, and therefore given to the first women of the house, or to travellers of distinction. A narrow bench runs along on both sides, and under the windows of the house; and in this place strangers of less consideration sit and sleep. The houses are very well heated, and the heat is increased by the uncommon evaporation of the natives. A European is obliged to go out occasionally, to get fresh air. The interior of their houses looks very well at the beginning of the winter, as long as any degree of order exists in them. But this is over in a very short time; and even this irregularity and confusion is exceeded by their nastiness and stench. They not only keep a number of dead seals, fowls, &c. in their warm houses, but they also gut them there. This, together with the bones, and rotten or half eaten fragments of boiled and raw flesh, occasions several heaps of filth, which are never removed, till, from their bulk, it becomes troublesome to pass over them. Every thing about the house smells of train oil and smoke; and every part of it is as filthy as can be imagined. It is revolting to Europeans to see their dirty hands and faces, almost always dripping oil; their meat dressed and eaten in such a disgusting manner; and their nasty clothes, literally alive with vermin. They are also very dirty in cooking their meat; they seldom wash a vessel; the colour and the odour of the last dish must remove that of a former one. They lay their boiled meat in wooden dishes of fir wood, made by themselves, which are never cleaned; and first drink the soup, or eat it with spoons made of bones or wood. Their undressed meat lies on the bare ground, or on an old seal-skin. They have no determined time for dinner or supper; but when the men of the house return with the game, which generally happens in the evening, part of the day's spoil is immediately boiled, and all the people who live in the neighbourhood are invited.

The men get their meal first, sitting upon the ground, round a large wooden dish, and taking the meat with their fingers. When this is over, the women begin in the same stile, but at the opposite end of the house. If there be a European guest, or any other stranger, the woman of the house takes a piece from the kettle, licks it clean from blood and scum, and presents it to him with her own hands. It would be considered a high degree of impoliteness to decline it.

Their time of removing from their houses to their tents is not exactly fixed. It takes place generally at the end of April, or in the middle of May, as the snow melts sooner or later; and it frequently happens that part of the badly supported roof of the house gives way and falls down, an accident which forces them to remove to the summer place. The tents are larger and smaller, in proportion to the size of the family and its fortune, but rarely exceeding the length of 12 feet, and the breadth of 10 feet. A wall one foot high is first made of stones and sods, on which they rest the poles, which form an acute angled triangle with the ground. The poles are then covered with seal-skin; and a curtain is placed before the entrance, made from the intestines of the whale, dolphin, or seal. The bed-places are similar to those in their houses. The tents are, like the houses, near the shore, as the sea supplies them with all their wants, and the seal provides them with all the necessaries of life. The instruments to procure their food are very simple, but they are admirably adapted to their purpose. The principal of them is the harpoon, called *erneinek*, and *unnereek*, which is the largest of them all, being two yards and a half in length. The second is the lance, called *angoviak;* the third a smaller lance, is called *kapput:* these three are generally used for seal-game, the first to attack, the two others to kill the animal. The first was also formerly used to attack the whale; but now the Greenlanders do it in the European manner, with large harpoons. A fourth instrument, called *akligak*, is a kind of javelin with a head of iron, barbed, to prevent its becoming disengaged from the animal. It is generally used when they pursue their game in company. For catching birds, they use the *nugit*, or fowling-pike, headed with iron like the last, and furnished, towards the middle of the shaft, with three notched forks made of bone, that one of these may reach the bird, if he escapes the apex, which is of iron. For land-game they formerly used the common Indian bow, with its arrows made of fir, and stiffened with sinews of animals, with a string likewise made of sinews; but the use of it was nearly abolished on their being provided with guns by the Europeans: although they were obliged, during the time of the late war, to resort to their old method of shooting, which succeeded very badly, from the want of that dexterity which they formerly possessed. The Greenlanders being a very pacific people, none of the dreadful instruments of war used by other Indians are found among them. They use for fishing the same apparatus as other nations, the lines being generally made of very thinly shaved thongs of whalebone.

Their canoes are of two different sorts; the one large and open, the other small and covered. The framing of both consists of slender pieces of wood, covered on the outside with skins of seal sewed together. The wooden framing is joined by thongs, cut from seal-skins, or by thinly shaved whalebone. This manner of putting them together, gives to the canoes so great a degree of flexibility, or rather elasticity, that they very seldom can go to pieces even in the most boisterous sea. The large canoe, called umiak, or the canoe for women, is generally twenty-four or thirty feet long, four or five feet wide, and two or three feet deep, terminating acutely at both ends. The bottom is flat. It is used in summer to transport the whole family, and its utensils and tent, from one place to another; and is in the evening always taken up on land, in order to be dried, repaired, and varnished on the outside with old thick rancid oil, called Minnek, to prevent the water from penetrating the seams.

The other small canoe is called kajak, and is only used by the men; it is sharp at both ends, and its entire shape and appearance is not unlike a weaver's shuttle. It is from four to five yards in length from one extremity to the other, about a foot and a half wide in the middle, and scarcely one foot in depth. In its centre is a round hole, with a prominent ring of bone or wood, in which the man seats himself, and fastens the under part of his frock round that ring, forming thus one body with his canoe. Upon his kajak he has his instruments, striking the sea alternately on both sides with a paddle called pautik, four fingers broad at each end. He can row in a very boisterous sea, and if overturned by the billows, he is able to raise himself again. All their sea game is procured in these small boats. The boy is employed by his father in his earliest age, that is, in his sixth or seventh year, to prepare himself to perform the business of a man. The first sea-fowl caught by a boy gives occasion to a great festival, and dinner of the family, for the purpose of doing homage to the rising master of the house. Another kind of sea-amusement, or rather ice-amusement, is used in winter, in the north of Greenland, from the 70th degree to the highest northern latitude, by means of sledges drawn by 6 to 12 dogs. The Greenlanders drive them over the frozen sea, a distance of 50 and sometimes more miles from the lands, to the rifts and clifts of the ice, and catch there the dolphins, sea-unicorns, and seals, which come there in great numbers to take air. The spoil is carried home by the assistance of the sledges. The velocity of the dogs is astonishing; they may be driven 100 miles in 9 or 10 hours.

The men take no charge of any of the domestic operations. The women must make clothes, boots, canoes, and tents, dress leather, clean and dry clothes and boots, gut and dismember the spoil, cook the meat, cut the pot-stone-lamps, prepare oil and wicks, and build houses and tents. The girls are employed to this business from the time they are twelve years old. The boys are, from their first childhood, regarded as the future masters of the house. The Greenlanders never strike their children, who are very untractable until their sixth and seventh year; afterwards they follow their parents very willingly, and shew with their increasing age a still more respectful behaviour towards them.

The men seldom marry before the twentieth year of their age; and the women in their seventeenth or eighteenth year. The bridegroom never concerns himself about marriage-dowry; he is well satisfied if his bride understands housewifery; that is, all the business which we have already mentioned as belonging to the female. The parents never interfere, but they always wish that their son-in-law should be a good hunter; and on the other hand, that the wife should understand housewifery. The girl always makes great difficulties, runs to the mountains, or cries *pro forma*, and the bridegroom generally takes her by force from the house of her parents, and puts her, supported by some old women, in his umiak, which is lying on shore. He brings her to his house, and they are considered as married. They never marry their relations. Polygamy is not very common among the unconverted, and is strongly prohibited among the baptized. It occurs, however, though very rarely, that a heathen has three or four wives. The most respected of them is she who is so fortunate as to have boys. They are not very prolific, the number of children seldom exceeding five or six. If a wife has no children, she herself often requests the man to take a second wife, it being thought ignominious among them not to have a family. The second and third wife is always inferior in rank to the first. Their marriages are not indissoluble; the man sometimes puts his wife away, and the wife also occasionally elopes, and generally retires to her parents, if she is not satisfied with the man, or with his conduct. The women bring forth their children very easily, and perform their usual business in the house to the last moment, and go out again the day after the delivery; they are assisted in the delivery by some old women, as many as there are in the neighbourhood; they rarely bring forth a child before the proper time; the birth of a child is always followed by a dinner. As the people are not very prolific, the coast is very thinly inhabited; the population of which was stated to have been about 20,000 souls, on the arrival of the first missionary, Mr Hans Egede. The small-pox, carried hither from Europe in the year 1733, swept away more than 3000 souls. Other diseases diminished the number of the natives from time to time very much, which, according to the latest accounts given by the governors and missionaries, does not surpass the number of 7000 on the whole coast, from the 60° to the 73° of Latitude. Venereal diseases are unknown. It is a curious circumstance, that the fruitfulness of the native women increases, when they are married to Europeans. This is still perceptible at this day in Greenlandish families, mixed with Europeans at the time of the first mission (1721), the European features being still visible.

The Greenlanders are very sociable; although they do not live in towns or villages, they like to visit and to be visited. A man or woman never pays a visit to a person residing at a distance, without making some present at the house she visits, either a skin or fowl, or some sinew. They are very fond of making bargains, and often part with their most useful utensils in exchange for trifles, particularly to satisfy the capricious frivolity of their wives. No one desires to usurp any authority over another, to make regulations for him, or to call him to account for his actions; for, as they have no riches, one individual supports another; the helpless finds refuge in the house of the more fortunate, without being related to him, and each Greenlander has his landed property where he resides. They may therefore change their residences as often as they like. Whatever the sea drives on shore, particularly floating timber, is the property of him who has taken it up, and brought it on shore. Notwithstanding, however, their honesty towards each other, they are not scrupulous in stealing from Europeans.

It is very singlar, that the heathens inhabiting this country, have no worship. It was believed by some navigators, who saw the Greenlanders observing the rising sun in the morning, that this people worshipped the sun. They were confirmed in their opinion by the squares of stones, which they saw erected for the purpose of their tents, and supposed that they were places of worship; but they have no religion at all, although they are not without some notion of a Divine Being, and of a future state.

They frequently speak of a supreme Being, called by them Tornarsuk, a compound of bad and good, probably a remnant of the religion of the old Norwegians. He is the oracle of the Angekut, or Greenlandish philosophers, (if this word may be so improperly used,) who are alone admitted to have intercourse with that great spirit. Besides Tornarsuk, they speak of many inferior beings or spirits residing in every corner of their country. Each Greenlander may become an angekok or sorcerer, if he will submit to certain trials and ceremonies; but the angekok never enjoys any peculiar veneration from the Greenlanders. He profits by the superstitious credulity of his countrymen, pretending to cure the sick with magic art, and presenting amulets of seals, rein-deers, &c. as a preservative to those in health. The angekut have their peculiar kind of language, a kirendum or jargon, understood only by themselves.

The Greenland language might with more propriety be called the language of the Esquimaux, as it is spoken by the Esquimaux in Labrador, on the shores of Hudson's Bay, and in various other places of that coast, the Greenlanders being only part of that nation. It probably also extends to Behring's Strait, Nootka Sound, and William's Sound, and has no affinity to any of the other north Indian languages, as far as they are known. There is but little variation in the dialect on the coast of Greenland, but in the south it is spoken in a more singing tone. The letters *b*, *d*, *g*, *h*, *l*, *v*, are never used in the beginning of a word; the letters *c*, *f*, *q*, *x*, and *z*, are not used in their language. It abounds with double consonants, particularly *k*, and *r*, and is very guttural. The language is made extremely difficult, in consequence of the great number of polysyllables, by the use of which a whole sentence is put together in an elliptical manner. They have very few adjectives, and use the participles of the verb to supply their place. In the language are a great number of *affixa verbalia*, by the use of which an astonishing variety is produced in the signification of their verbs. Thus from the radical verb, *innuvok*, "he lives, is a man," is derived *innugikpok*, "he is a handsome man;" *innurdlukpok*, "he is a mis-shapen man;" *innukulukpok*, "he is an unfortunate man;" *innuksiorpok*, "he is a good man;" *innukpilukpok*, "he is a bad man;" *innuksisimavok*, "he is a man as a Greenlander, (a modest man;") *innungorpok*, "he begins to be a Greenlander." The third person *singularis præsentis* is its radix. Every verb has its corresponding negative, formed by the addition *ngilak* to the radix, thus: *pekkarpok*, "he has," *pekkangilak*, "he has not." Each flexible word has its dual, ending with the letter *k*; the plural ends with *t*; thus, *nuna*, "land, country;" *nunæk*, "two countries;" *nunæt*, "countries." The articles, pronouns, and prepositions, are formed by suffixes, changing the termination of the noun thus: *nalegak*, "master, lord; *nalegama*, "my lord;" *arnak*, "mother;" *arnamut*, "to the mother." A great number of augmentatives and diminutives are also formed, by varying and adding to the termination; and this circumstance contributes to make the language agreeable and expressive. Thus, *kikertak*, "island;" *kikertangoak*, "a small island;" *kikertarsoak*, "a large island;" *kikerteitsiak*, "a fine island;" *kertarsoeitsiak*, "a large fine island." Their numerals are limited to five. They express numbers from six to twenty, with the help of addition. Thus; five and one, five and two: twenty is expressed by *innùk*, man; that is, 10 fingers and 10 toes; numbers exceeding 20 are generally called innumerable.

They have no traditions from their ancestors, except an incongruous account of their battles with the old Norwegians; the history of the Greenlanders is therefore buried in impenetrable darkness. They have no chronology, no one can tell his age; but they are well acquainted with the north star. The angekut call the ursa minor *asellut* in the south, and *kuttak* in north Greenland, the ursa major *tukto*, or *rein-deer*. They divide the day according to the tide, and reckon their years by winters. The distance of 32 miles, from one place to another, is called one day's voyage, (made with a canoe.) The different seasons are marked by the migration of birds, fishes, and other animals which regularly visit their coast.

The angekut are somewhat acquainted with physics, particularly meteorology; they observe the weather with great attention, and from the state of the atmosphere they make very accurate conclusions respecting its changes, even at a distance of three or four days; and as the natives procure their food from the sea, this habit is of great importance to them. The angekut are also the physicians of their countrymen, and prescribe generally a certain diet, as most of the diseases result from their very irregular mode of living. If diet is ineffectual, amulets are applied, presented in bones of different animals, particularly of rein-deers and seals. The most common diseases are eruptions of the skin; one is a sort of small pimple, which in a very short time covers the whole body; the best remedy is to drink a decoction of *ledum groenlandicum*. The other is a kind of leprosy, which infects their whole body with cancerous boils and scurf. Those who are afflicted with it, are abandoned by their relations, and die in the greatest misery. The smallpox and measles were formerly unknown to them, but were conveyed from time to time by European vessels to these poor people, and committed dreadful devastations. These diseases are mortal to the Greenlanders, their skins being so dirty and oily as to prevent the eruption. In the year 1733, the first year of the mission, 3000 people died of the smallpox. But vaccination is now employed by the Danish government with great success. All the other diseases which arise, where the air is condensed by cold, and perspiration is obstructed, are very common in Greenland. A wounded or fractured limb is cured very quickly by themselves, but they have no remedies for internal diseases, such as consumption, blood-spitting, pleurisy and diarrhœa. Scurvy is not very common amongst them, as they do not use salt meat or fish. The want of food, to which they frequently are exposed in winter, produces very serious complaints, which are particularly perceptible in the following spring. It frequently happens in winter, when the frozen sea refuses the necessary supply to the wretched family, when the last thong of leather is swallowed up, and when there is no longer oil to burn in their lamps, that the hunter returns with an animal, and some of these poor creatures devour the raw or half-boiled meat, and falling victims to the indulgence of their appetite, instantly die of indigestion.

They bury their dead generally on a small hill, in a sitting posture, dressed in their best clothes, and covered with seal-skin. The land being a mass of rocks, the inhabitants are obliged to build graves of stone, which are covered with plates of mica slate, or clay slate, to prevent carnivorous animals from destroying the bodies. Their kajaks (canoes), instruments, and utensils, are placed by the side of the grave. They return from the burial-place to the house of the deceased, to continue the lamentation, which consists of a dreadful monotonous howling, supported by all the attendants, who sit with their faces turned to the ground. When this is over, some refreshment is taken, and each returns to his own house.

The whole coast of Greenland, receiving the beams of the sun in a very oblique direction, is deprived of that general comfort which other parts of the earth enjoy. The soil being shallow, is frozen during the greater part of the year; and the ice having taken possession of all the vallies of this barren and rocky land, the winds which blow over these are, even in summer, extremely cold. The prevailing winds are those from the east and north-east, north-west and north. The cold which the north-eastern wind brings in winter is almost insupportable; and the thermometer is very often at —35° or 36° of Reaumur (—48° of Fahrenheit). The winds which blow directly from the sea (Davis Strait), are moist and generally attended with rains, in winter with snow and sleet; and are more boisterous in spring and autumn than in other seasons. Winds reflected from the mountains, and striking through the vallies with great violence, are extremely dangerous to vessels sailing near the coast. Strong stormy winds from the W. or S.W. always break the sea-ice even in the middle of winter. The cold sets in with the month of January, accompanied with but little snow, which generally falls either before or after that time. More snow falls in the south than in the north. The sea does not freeze before the beginning of January, forming thus on its surface clammy spherical concretions, which increase rapidly, and as they join together, present a crust of the thickness of an inch in a very few hours. This coagulation only takes place when the sea is calm. Previous to that operation of nature, the sea smokes, like burning turf-land; and a fog or mist arises, called *frost-smoke*. This cutting mist frequently raises blisters on the face and hands, and is very pernicious to the health. It appears to consist of small particles of ice, and produces the sensation of needles pricking the skin. The same icy particles carried up by the wind, cause probably another phenomenon which is frequently seen in winter round the moon, a ring of light, or halo, called by the Greenlanders *Illuparosek*; this ring appears at a great distance from the moon, and has a fine pearly lustre. It is seen at a time when the horizon is quite clear, and every star may be distinguished. Mock suns are also very frequently seen in this country, but only in winter. In January 1809, six were observed at the same time, all of a pale yellow colour. The remotest was paler than the others.—See Halo.

Of all the phenomena peculiar to this country, the aurora borealis is the most beautiful. It streams here with peculiar lustre, and with a variety of colours, which having great brilliancy, sometimes dart their sportive fire, and fill the whole horizon with the most beautiful tints of the rainbow. They are very rarely observed in the north of the horizon, commonly in the east and in the zenith. They appear sometimes to stand very low, and then they are much agitated, and a crashing and crackling sound is heard like that of an electric spark, or of the falling hail. They are more frequent and more powerful from the 60th to the 67th degree than in higher latitudes. The Greenlanders believe, that they are the souls of the deceased fighting together in the air.

Another very curious optical phenomenon presents itself, partly in clear, partly in thin foggy weather. The islands lying at a distance from the continent appear to approach to the spectator, and to increase in size. They form to the eye various and peculiar groups, very different from their proper shape. At other moments they appear to hang in the air. If this phenomenon appears with respect to the islands which lie in the south, southerly winds will follow; if the object be in the west, westerly winds may be expected. The winds decrease generally after sunset.

Fire-balls are rarely seen in this country, although one was observed in the year 1808, taking a direction from north-west to south-east. The comet of 1807 was first observed on the 4th of October, in the north-west; and that of 1811 on the 4th of September, in the north, and disappeared the 14th January. Thunder is very seldom heard, but sometimes flashes of lightning are seen. The air is extremely pure and light; the rains are not of long continuance; and the heat, particularly in the inlets, is astonishing, being caused principally by the reflection of the solar beams from the mountains. The saline particles of the sea-water are frequently found crystallised on the shores. In the month of July, the thermometer of Reaumur rises in the shade to 24 degrees, (86° of Fahrenheit). The moskitos (*culex pipiens*) are at that time as painful and troublesome as in a southern climate.

The ice, which embarrasses the polar regions, and disturbs the navigation, is of different kinds, some of it being of fresh water, some of salt water. The former is clear, very hard, brittle, having an appearance entirely glassy, and presenting sometimes colours of the finest pale emerald green, or the brightest sky-blue; when cut in pieces, the fragments are as sharp edged as those of rock crystal. The ice of salt water has the appearance of frozen snow, is greyish white, not transparent, and has generally a clammy coherency; when very thin, it is flexible to a certain degree, under the step of a man. It coagulates in small spheroidal particles; whereas that of fresh water presents rather acicular and prismatic forms. The fresh-water ice forms tremendous masses and mountains of different magnitudes, and wonderful shapes, sometimes rising more than 500 feet over the surface of the water. The salt ice occurs always in flakes, called by the mariners ice fields, sometimes of many thousand fathoms in length and breadth, divided by fissures, but following close to each other. These flakes of driving ice are not found so large in Davis Straits, as between the east coast of Greenland and Spitzbergen. The surface of the salt ice is generally covered with a crystalline crust, deposited by hoar frost or snow; it has a mealy or sandy surface, and becomes brackish by the tides. The salt ice never forms large mountains. On the shores, however, where the sea freezes, the mass becomes enlarged by the effect of the tides, and by stormy weather, which breaks the ice, and heaps it up.

Ice mountains are formed, during a series of years, in the inlets and bays, in valleys, or on precipitous rocks reaching to the sea. As they melt in summer at the base, where they are in contact with the rock, they get rift; and at last, losing their points of support, they plunge into the sea with a thundering noise; an awful and imposing spectacle, which may be seen in the Ice Bay, near Disko island, particularly at the time of the tides. These mountains very often enclose vegetable substances, earth, and stones; and are sometimes so large as to reach to the bottom of the sea, a depth of more than 300 fathoms, until they lose somewhat of their mass, and roll over. Immense masses of ice are driven out from the Ice Bay in the tides, at the time of high water, covering the sea of Disko Bay, to a distance of many miles.

The driving ice which comes from Spitzbergen, is generally seen at Cape Farewell in the month of May, setting over to the eastern coast of Davis Straits; but it returns again with south-west and west winds, filling all the bays and inlets of the south of Greenland, and is again thrown out from the land by the easterly winds. This ice is always followed by impenetrable fogs; a circumstance, which makes it much more dangerous to navigators. The specific gravity of the ice depends upon its density or porosity.

The floating timber, mostly pine, which comes with the ice round Cape Farewell, affords great relief both to the poor Greenlanders and the European settlers. It furnishes materials to the natives to roof their houses, to support their tents, to strengthen their canoes, to shaft their instruments, and to prepare their utensils. It supplies the Europeans with building materials and fuel. It is very difficult to say from what country these timbers come; undoubtedly from a very remote land, washed away from shores covered with forests. The timber is always much injured, generally without bark or roots, and great part of it is worm-eaten by the *Pholas teredo*, (*Teredo navalis*, Lin.) It is mostly found in the small bays of those islands which are nearest to the open sea.

The continent of Greenland is surrounded by many thousand islands of different sizes, upon which the Greenlanders generally reside, on account of their good situation for sea-game. The continent of Greenland itself is intersected by innumerable bays, inlets, and firths, many of them 100 miles in length. Their direction is generally from south-west to north-east; and some reach as far as the tremendous glacier which covers uninterruptedly the middle of the continent, and separates the east coast from the west. The connection of these firths with the large continental ice causes the numerous ice-mountains which plunge down in the summer, and are driven by the currents into the open sea. The most remarkable of the firths are, 1. *Tunugliarbik*, and 2. *Ikareseksoak*, both in the 60th degree of latitude; these reach to the glacier, and are generally full of floating ice. 3. *Sermiliarsuk*, the same firth or bay which is marked on the charts with the name Forbisher or Frobisher Strait, but falsely, as this bay extends to the great continental glacier, which surrounds it. 4. *Baal's River*, one of the largest firths, is divided into several branches by large islands. 5 *Nerusutok*, remarkable for its violent currents. 6. *Sermilik* or *Icefiord*, a firth, which presents the largest ice mountains on the whole coast. It is supposed to have been formerly a sound, which divided the continent, but is now shut up by ice. 7. *Omenaks Bay*, called *St. James Bay* and *Cornelius Bay* on the English and Dutch charts, which is the most extensive firth on the whole coast, and contains more than twenty islands. It is situated in the 71° of latitude, and in all its different branches is connected with the large glacier. 8. *Kangerdluarsursoak*, in Baffin's Bay, called *Horn's Sound* on the charts, in the 74° of latitude, is likewise a most dreadful firth, on account of its monstrous masses of ice. In the months of May and June, the Greenlanders visit the firths, to provide themselves with a kind of small fish, the *salmo arcticus*, Fabricii, (*clupea villosa*, Mulleri,) which visits the firths in millions at that season. They are dried in the sun on the rocks, and used instead of bread. They are the principal food of the seal in summer, and followed by them in great numbers. Seals are also caught here.

The *rivers* are neither numerous nor large. They can have but a small supply in that desolate region, where the valleys are covered with eternal ice, which does not melt frequently, and then only on the surface. In the vallies between precipitous mountains, there are occasionally very large lakes, which have their origin from the melting of the ice and snow on the mountains, and are confined by the rocky bottom of the valley. The springs and rivulets which come from the mountains, rapid as they are in the spring, generally dry up in summer. The inundation of these rivers in the spring, makes the soil marshy, and produces good vegetation on the shores of the firths. The old Norwegians and Icelanders formerly made all their settlements in such situations.

What are called *springs* by the Greenlanders, frequently consist only of ice-water, forced out of its accustomed channels by the power of the waterfalls running through the ruins of destroyed rocks. There are, however, some spring wells, one of which is very remarkable, from its rising and falling with the tide, although it is situated more than 36 feet above the level of the sea. Its water is not brackish, perhaps from the circumstance of its being filtered in passing through a bed of very fine sand. The most interesting is a warm spring on the island Ounartok, which has a temperature of 32° of Reaumur (104° Fahrenheit) at all seasons. It is situated on the south-east of the coast, in the 60°.

*The streams or currents of the sea* have an easterly direction, and are in some places very rapid and dangerous, particularly during high tides. It is supposed that these currents are produced partly by the unevenness of the bottom of the sea, and partly by the numerous islands, which increase the rapidity of the currents by diminishing their channels. The obstacles, which rise from the bottom of the sea, may assist in producing back currents and whirlpools. One of the most dangerous whirlpools exists at the mouth of a Firth, (called by the natives Puiosortok,) in the south-east of Greenland.

*The water of the sea* near the shores, is less salt than that at some distance from them, the former being always in contact and communication with the ice-water. *The rising of the tides* is very unequal, in consequence of the number of islands through which the tide passes. They rise in the south (from 60° to 64° of N. Lat.) to eleven feet, and decrease gradually in the north of Davis Strait (74°,) where they do not rise more than four and six feet. The highest flood is the third day after new moon, and the third day after full moon. The Icefiord, or Sermilik, in Disko Bay, has flood, but no ebb. Greenland, from its most southern point to its most northern extremity, consists of insulated rocky mountains and sharp acuminated cliffs, separated by narrow valleys, which are rendered inaccessible by the glaciers. These places never enjoy the rays of the sun, and are mostly intersected by rapid torrents, which precipitate themselves from the mural cliffs of the mountains. Ice and snow accumulate here in dreadful masses, and fill the spaces with increasing devastation. Even the Greenlanders, so accustomed to the horrors of nature, call some of these spots places of desolation. The water, converted into ice, splits the rocks with mighty force, which are precipitated from the summits with thundering noise in the summer, threatening death to the wanderer. The mountains themselves are covered with a mourning veil of black lichens, variegated here and there with spots of crumbling snow, which, being dissolved by sun and rain, run in small torrents along the precipice. The view of the valleys watered by the inlets and firths is more agreeable, and presents the entire vegetation of that deserted country.

*The small islands* which surround the continent, are generally of a different character, forming small roundish elevations or hills, the base of which is inhabited by innumerable sea fowls, which breed there at the return of spring. The large islands are similar to the continent, and consist of barren insurmountable rocks, the valleys of which are filled with eternal ice. Amongst the largest are particularly remarkable: 1st, Cape Farewell, called by the Greenlanders Kangekkyadlek, that is, the cape running towards the west. The entire island, which turns from west to east and south-east, has the name Sermesok, or Iceland, its narrow and dreadful valleys being always covered with ice. It has very little low land, and is therefore very seldom visited in summer by the natives. No family lives there in winter; but the ruins of old houses on the west side, shew that it was formerly inhabited. The most eastern islands nearest to Sermesok, or Cape Farewell, are Omenak and Cangersoak: The latter is called Statenhuk by the navigators, and both are uninhabited. In the east of Kangersoak, or Statenhuk, are more than 100 small islands called Kittiksorsoit. The Greenlanders of the neighbourhood visit these islands in the beginning of spring, to procure seal game, which is there very plentiful. The large islands, which form the promontory of the southern coast, extend 1½° from the west to the south, and are separated from the continent of Greenland by a sound of five English miles in breadth, called Ikareseksoak, through which runs a very rapid current. The sound is generally filled with immense flat masses of floating ice, and innumerable ice mountains, which are driven out from the inlets and firths of that continent. Many vessels have been beset in this floating ice by currents from north-east, and have been lost on the coast. From this, a series of small islands border the continent as far as the 61° 21′, where the eye is terrified by another island, barren, precipitous, and of considerable extent. It presents so dreadful a view, that the older navigators, although accustomed to dangers and terrors, called it the *Cape of Desolation*. This cape, which reaches far to the open sea of Davis Strait, is always intrenched by floating ice to a great distance. The island is called by the natives *Nunarsoit*, that is, a great land, and is separated from the continent by a narrow sound called *Torsukatek*. It is uninhabited, and even the Greenlanders but seldom visit it. There is no island of importance between this place and the 64°, where Baal's river falls into the ocean. This river, or rather this firth, is one of the largest on the whole coast. It extends 64 English miles to the interior of the continent, and then divides into two arms, one of which runs towards the north-east, the other towards the south-east. Both arms are bounded by the glacier. In this firth are three large islands, *Sermitsiak*, *Kikertarsoak*, and *Karosut*, the first of which consists of one large and high mountain, called Saddle by the Danes, from its saddle-shaped top. It is seen at a distance of thirty leagues from the coast. Another large island (called *Omenak* by the Greenlanders, and *Kin of Saal*, or *Zaal*, on the charts) is situated in the 65°, and being easily distinguished by its conical form, which resembles a sugar-loaf, it serves as a landmark to navigators. No large island occurs until the 69° 14′, where the *Island Disko* is situated. It is the largest on the whole coast, its length from the north to the south occupying one degree of latitude. It forms (with the continent) Disko Bay, called Fish Bay on the charts, and is separated from Greenland by a narrow strait called Waygat. It is uninhabited, except by the Danish settlement called Godhavn, which is established in Love Bay, or Liefde Bay, for the purpose of whale fishing. To the north of Disko is an island, which deserves to be noticed, called by some navigators *Hare*, or *Hazen Island*, by others *Waygat Island*; and in the mouth of Cornelius Bay is situated another called *Unknown Island*. These places are visited by the whale fishers in the month of May. All the islands from the 71° northwards are small, and generally marked on the charts with the name *Vrowen*, or *Women Islands*. The height of the mountains decreases gradually towards the north.

Mineralogy.—The accumulation of the ice having rendered the interior of Greenland totally inaccessible, it can only be examined on different parts of the coast; and the promontory Cape Farewell, which is its most southern point, presents to the eye immense groups of precipitous mountain masses, insulated, barren and naked, sharp-pointed at the top, greatly decomposed at the surface, and cleft by the action of the snows and the ice. These rocks are intersected by narrow valleys, where immense broken and scattered masses are borne along by irresistible currents, and carried immediately to the shores, where there is no low land to intercept their course. The Granite of this island is fine granular, consisting of pearl white felspar, greyish black mica, and very little quartz of an ash grey colour. The whole rock is very much ironshot, and disintegrated. At the foot of the granite rocks occur beds of common quartz of a milk white colour, (not milk quartz,) and flesh red felspar, with small crystals of moroxite, (foliated or common apatite.) In another place are found flesh red felspar, with little quartz, common horn-blende, magnetic iron-stone, and gadolinite, crystallized in longish four-sided pyramids. A bed on the east side of this promontory, contains garnets in a fine granular greyish white rock, very much resembling the rock of Namiest in Moravia, called by Werner weiss-stein, (white stone;) but the crystals of garnet here are larger, and perfect dodecahedrons. The granite extends from Cape Farewell to the east and south-east of the coast, viz. over the islands of Staaten-huck and Kakasoeitsiak, Alluck, and Cape Discord, to a distance of more than 400 miles. Gneiss and mica slate lie upon it at Kippingajak, both rocks containing garnets. Talc slate forms a large bed in it at Akajarosanik, along with actynolite, which occurs in large masses. Near the coast of Akajarosanik, is the small island called Kakasoeitsiak. It consists of one hill, formed of a granitic rock, mixed with some horn-blende, slender crystals of zirkon, and the new mineral called *Allanite*. (See *Edin. Trans.* vol. vi. p. 371.) The rock here assumes the character of the Norwegian zirkon-syenite: but its constituent parts are of a finer grain. All the granitic mountains of the islands of Staaten-huck and Cape Farewell, are surrounded by numerous very small islands, presenting round-backed or flat conical low hills of primitive syenite. To the west of Cape Farewell, at a place called Niakornak, is a very extensive bed of yellowish white felspar, crystallized in large flat six-sided prisms, the crystals being only separated by black mica, which gives to the rock a porphyritic appearance. The place is very difficultly accessible, it being harassed perpetually by the most boisterous sea, and washed by the tide at high water. Not far from this, at an elevation of about 1000 feet, the granite is divided into immense columnar or quadrangular pieces, which, seen from a distance, present an appearance similar to the ruins of a town. The Greenlanders state, that the masses were carried thither by some giants, who inhabited the country in the oldest times, and, having been sorcerers, disappeared from the earth.

As granite is the principal rock which constitutes the mountains of this vast coast, to enumerate all the places where it is found, would exceed the limits of such an article as the present. Its most common colour is greyish white, flesh-red, and tile-red; the latter colours are characteristic of the coarse granular felspar. Magnetic iron ore is generally found either disseminated or imbedded in the red variety. In some places, molybdena occurs, and in others graphite imbedded in the rock. At Baal's river and at Disko island, iron pyrites is found; but excepting there, the rock is not very metalliferous. Precious garnet occurs very frequently; also common schorl, tourmaline, common horn-blende, jade, rock crystal, moroxite, calcareous spar, fluor spar, and the above mentioned substances. Rock crystal is only found in veins traversing the red coarse granular variety, and appears to be contemporaneous, the vein being intimately mingled with the rock, and presenting no walls. Beds of horn-blende, slate, mica slate, felspar, and quartz rest upon it; and on the red coarse granular granite at Kogneckpamiedluœk, there is an extensive bed of red ironstone mingled with massive iron-flint (eisenkiesel of Werner.) At the end of the north-eastern arm of Baal's river, in the vicinity of the great continental ice, the traveller, ascending from a narrow cliff, suddenly beholds a dreadful chaos of immense columnar granitic blocks detached from each other, and heaped together in the most fantastic groups, the planes of fracture being so fresh, that the points from which they are broken are distinctly observable. Places of desolation and devastation of this kind are very frequently met with in the mountains of Greenland. Most of the granitic rocks affect the needle.

2. The next rock, which forms numerous mountains in this country, is Gneiss. It occurs very often alternating with granite, sometimes with mica slate. Its character or texture may be ascertained partly in the cliffs and on the shores, partly by the forms of the mountains. The granitic mountains are always more decomposed, and therefore more precipitous, presenting very sharp-edged summits; the summits of the gneiss are more flat and round-backed. The texture of the gneiss is thick and thin slaty; its felspar generally pearl-grey and pearl-white, seldom flesh-red, fine granular: its mica grey, pinchbeck-brown, and blackish-brown: it contains but little ash-grey quartz. The valleys and clefts round the mountains are filled with rhomboidal fragments, many of them of immense size. The smaller fragments were used by the old Norwegians, with mica slate, hornblende-slate, and slaty claystone, to build their houses; the walls of which, although not cemented, after a lapse of several centuries, still brave the power of this destructive climate.

Gneiss constitutes one of the most elevated points of this extensive coast, viz. the mountain *Kingiktorsoak*, situated in the 62d degree of latitude. It is covered with mica slate from the shore to a height of about 1000 feet above the level of the sea, where the gneiss again becomes visible, and continues to a height of nearly 3000 feet. The top of this mountain is similar in shape to the roof of a house, where the ridge is not much elevated. It is entirely free from snow in summer, except a few small spots, where it rests in the hollows of its summit.

The mica slate resting upon the gneiss presents a variety of beds of hornblende slate, whitestone, (weiss-stein) with small garnets, talc-slate, with common and indurated talc, potstone, actynolite, and precious splintery serpentine. The gneiss is traversed with numerous veins of greenstone, varying in thickness from one inch to six feet. The greenstone which occurs in the veins resembles basalt; but it is more crystalline in its texture, lighter in its colour, and not quite so hard. Common schorl, tourmaline, and precious garnet, occur imbedded in gneiss. It contains veins of tinstone, accompanied by arsenical pyrites, wolfram, flour, and quartz, in a firth, called Arksut, situated about thirty leagues from the colony of Juliana-Hope, towards north-east. The same place is remarkable for two thin layers of cryolite resting upon gneiss; and it is the only place where this mineral has hitherto been found. One of these layers contains the snow white and greyish white variety, unmixed with any other mineral. Its thickness varies from one foot to two feet and a half, and it is divided from the underlying gneiss by a thin layer of mica, always in a state of disintegration. The other variety is of a yellowish brown colour passing into tile-red. It occurs along with iron pyrites, liver-brown sparry iron ore crystallised in rhombs, earthy cryolite, quartz, compact and foliated fluor, earthy fluor, and galena. It is remarkable, that the galena is sometimes coated with a greyish white sulphureous crust, which burns in the flame of a candle with a bluish colour, emitting a sulphureous smell.

These layers of cryolite are situated very near each other, only separated by a small ridge of gneiss, of a thickness of 27 feet: both are washed at high water by the tide, and for the most part exposed, the superincumbent gneiss having been removed. The white cryolite, seen at a distance, presents the appearance of a small layer of ice; small detached fragments have acquired, from decomposition, the shape of cubes. This mineral is called by the Greenlanders *orsuksiksæt*, from the word *orksuk*, blubber, to which it bears some resemblance. The same name is also given by the natives to white calcareous spar.

3. Mica Slate is likewise one of the most common rocks in Greenland, and an inseparable companion of gneiss: There are very few instances where they are not found in the vicinity of each other, and frequently in contact. Mica slate forms in this country a very extensive series of insulated mountains, which never rise to a considerable height, and appear generally to rest upon gneiss. Mica slate is frequently visible on the shores, and the gneiss itself forms also very extensive beds in it at Disko bay, where the whitestone also occurs in beds. The Greenlandish mica slate abounds in mica; it is generally thin-slaty, and only thick-slaty when the quartz prevails. Sometimes it has an undulating aspect; but when this is the case, it passes into primitive clay slate. The mica of this mica slate is mostly greyish-black and pinchbeck-brown, passing into brownish black, seldom silver-white. Its quartz is pearl-grey. It is sometimes mingled with nodules of pearl-grey felspar, from the size of a pea to that of an orange, and this gives it the appearance of gneiss; but they may be easily and accurately distinguished, as the mica-slate presents a surface perfectly continuous, and easily separable in the direction of the plates of the mica. The strata dip towards north-west. Mica slate also occurs in beds in various parts of this country. One of the most remarkable, most interesting, and most extensive, is that in the firth Kangerdluarsuk, in the 61st degree of latitude, in the district of Juliana-Hope. It extends about five miles in length, and four miles in breadth; its thickness varies from six to twelve feet; and it contains, besides felspar, which is its principal constituent part, hornblende, augite, actinolite, sahlite, garnet, and that new mineral which has been analysed by Dr Thomson and professor Eckeberg, called *Sodalite*. It is of pale and apple-green, leek-green, greenish white, and pearl-grey colour, partly massive, partly crystallised. Another mineral, which has not yet been analysed, occurs also with the sodalite: it is of a peach blossom red and purple-red colour. On the shore, the underlying gneiss is visible in several places. In the superincumbent mica slate, granite is found of very fine texture, partly in veins, partly imbedded. Calcareous spar and fluor occur in veins, both of which are sometimes coated with a thin crust of chalcedony, also galena in small veins. Blue phosphate of iron in detached pieces is found on the shores. The mica slate is generally decomposed and iron-shot, where the graphite is imbedded. In the firth of Arksut, a bed of very fine granular limestone is found in mica slate, which resembles the Carrara marble. The beds which occur in this rock on the mountain Kingilktorsoak have been already mentioned. Hornblende slate, forming beds in mica slate, is found in many places.

In the 64th degree of latitude, in a firth called Ameraglik, in the south of the Danish colony Godthaab, (Good-hope,) a variety of mica slate is found, which passes into talc slate, forming a very small layer in coarse granular granite. It is very remarkable, on account of the large groups of tourmaline which occur, imbedded or rather involved in talcose mica; and which are the largest crystals of this fine mineral that have been met with. At the end of the same firth, Auaitsirksarbick, in the neighbourhood of the great continental glacier, the finest garnets are found. They are of a lamellar texture, and surpass the oriental specimens in colour, lustre and hardness. At the same place, dichroite and hyperstene of a beautiful blue colour occur, along with precious garnet, in decomposed mica slate.

All the lower mountains from the 66th to the 71st degree of north latitude, and particularly all the mountains of the continent forming Disko bay, with the greatest part of the adjacent islands, are composed of mica slate. There is scarcely a square mile where the rock is entirely free from garnets. A large mountain in Omenaks firth, called Sedliarusæt, presents on its surface only the powder of mica slate, and fragments of precious garnet. From the appearance of this powder, it is probable that the rock formerly contained great masses of imbedded iron pyrites. No snow rests on the surface of this mountain in the coldest winter. The fragments of precious garnet which are found here, when clear, are the most highly prized of any on the coast. Other minerals which are found in mica-slate in Greenland, are, emery, on the island Kikertarsoeitsiak, in South Greenland; granatite, on the island Manetsok; moroxite, in very large six-sided prisms, at Sungangarsok, in North Greenland; and dichroite, in six-sided prisms, on the island Ujordlersoak, in the 76th degree of North latitude. Except iron pyrites, copper pyrites and galena, no metal occurs in this rock.

*White-stone*, (Weiss-stein,) which has lately been determined by Werner, appears to belong to this rock. It presents a white and greyish-white granular appearance, which was formerly supposed to be compact or granular felspar. It is in this country characterised by very small and minute crystals of garnet disseminated through the whole mass. Here it is found in layers of inconsiderable extent, resting on mica slate, very seldom on gneiss. It is also found in detached pieces.

4. Clay Slate is very seldom met with on this coast, and consequently the different beds which are characteristic of this rock, viz. flint-slate, lydian-stone, alum-slate, but rarely occur. Nevertheless, at the mouth of the firth Arksut, it forms two islands of some importance, called Arksut and Ujorbik. The colour of the slate is ash-grey and bluish grey; its fragments present a double cleavage, and it is traversed in all directions by numerous veins of massive and crystallized quartz, massive hornstone, and sparry iron ore of an isabella yellow colour. An extensive bed of flinty-slate and lydian-stone rests upon it on the east side of the island Ujorbik. In Ameraglikfiord, in the 65° 4′, there is a small island, where the clay-slate forms small layers in fine-grained granite, fine cubes of iron pyrites, with various truncations, occur in this slate, which is greatly decomposed. Some small islands in the south-east of Disko bay consist of clay-slate, with a variety of small beds and layers, viz. very ironshot hornblende-slate, with small garnets, whet-slate, granular hornblende and greenstone. This clay-slate may perhaps belong to the class denominated transition rocks.

5. Porphyry is very common on the south of Greenland, from Cape Farewell to the 64th degree of latitude; but it is generally found towards the interior of the continent, forming insulated rocks. In the interior of the firth Igalikko, at Akulliarascksoak, hornstone porphyry is found, very distinctly stratified, and resting upon fine-grained granite, containing large crystals of reddish white, flesh-red, and tile-red felspar, and another mineral of a talcose appearance, crystallised in six-sided prisms, and hitherto unknown. The mass of the porphyry is brownish-red, and passes in some places into clay-stone, forming claystone porphyry, the crystals then becoming less distinct. Hornstone porphyry, with a few very small crystals of felspar, occurs also in an adjacent firth called Tunugliarbik. This rock rests upon old red sand stone. The porphyry is very much decomposed. It is of a brown-red colour, and called by the natives *aukpadlrtok*, that is, blood-red rock. It contains small layers of a kind of brown-red iron ochre, which the Greenlanders use as a dyeing material, to embellish their utensils, and the interior of their houses; a species of luxury they have learned from the Europeans.

6. Syenite, and all the porphyritic rocks belonging to the primitive and transition trap-formation, are found in great abundance in this country. Hornblende is a mineral which occurs almost every where. A kind of coarse granular syenite, composed of coarse granular Labrador-felspar, and crystallized common hornblende, rests upon fine grained granite at the mountain Illejutit, or Redekammen, in the 61st degree of latitude, in the neighbourhood of that extensive bed of sodalite, sahlite, and hornblende, which has been already mentioned before. This Labrador-syenite occurs also at the mountain Kognek, in the 62d degree, upon granite of a coarser grain. In the vicinity of the mountain Kogneck, is a group of more than 50 islands, lying in a western direction, in Davis Strait, and called by the natives Kittiksut, from kitta, *west*. These islands form round-backed low hills, and consist of common felspar, of yellowish-brown and leek-green colours, and common hornblende of raven-black, and sometimes velvet-black, colour, accompanied by small four-sided prismatic crystals of zirkon of red-brown, and purple-red colour, with fine-grained common magnetic ironstone interspersed, and very little black mica. In some parts of the rock allanite occurs, of a pitch black colour. The rocks are somewhat ironshot, and disintegrated on their surface. Titanium iron ore is found in small layers, and fine granular chromate of iron. The rock itself has a striking resemblance to the zirkon-syenite, found at Friedrichswærn and other places in Norway, and described by Von Buch, Esmark, and Hausmann. The neighbouring mountains have no trace of that rock. At Narksak in the vicinity of Baal's river, brown titanite, or brunon, is found disseminated in syenite.

Granular porphyritic syenite is found at Nunarsoit, (Cape of Desolation.) Its stratification is not very distinct. It contains very extensive beds of coarse grained, tile-red felspar, and common magnetic iron-stone.

7. Primitive Trap. (*Greenstone.*) The islands which lie between the 62° and 63° of latitude present a very complete series of the rocks that belong to the primitive trap formation. The greenstone first appears at Sakkak and Ujorbik in the mouth of Arksuts-fiord, where clay-slate predominates, and extends from those islands towards the east, that is, to the continent of Greenland, alternating with greenstone of a porphyritic structure, (*porphyrartiger grunstein* of Werner,) and green porphyry. or *verde antico*. Another rock of slaty texture, consisting of compact felspar and hornblende, appears to be intermediate between hornblende slate and greenstone slate; it is here the only rock which presents very distinct stratification. The greenstone slate covers uninterruptedly both the greenstone and the green porphyry, and appears to belong to the transition greenstone formation; and perhaps the whole formation should be referred to it. It probably extends farther to the interior of the continent, as the fragments which are thrown out from the continental ice have an appearance exactly similar. Variolite is found there in small roundish rolled pieces. The greenstone, alternating with syenite, is found upon gneiss and mica slate, on the large island Nunarsoit.

8. Primitive Limestone, of fine granular texture, is

found only in beds and rolled pieces, and occurs very seldom in Greenland. Its beds are confined to gneiss and mica slate, and it is mingled with minute leaves of silver-white mica, seldom with grains of quartz. It is generally accompanied by tremolite, asbestos, actynolite, sahlite, and seldom with rock-cork. Thus situated, it occurs at the island Akudlek, at the island Manetsok, at Kakarsoit and Kaugerluluk, mountains in the vicinity of Jakobs-havn and Christians-haab, in Disko bay. It is very surprising, that no vestige of flœtz-limestone is found on this vast coast, nor does any petrifaction occur there. Very distinct impressions of the *salmo arcticus*, with its bones very little altered, occur in detached pieces on the alluvial land, which are forming daily. In the uppermost sandstone, which belongs to the brown coal of the flœtz trap formation, fragments of *pecten Islandicus* are found, which have undergone but little alteration.

The flœtz trap formation of Greenland, is perhaps the most extensive that has yet been discovered. It begins at the 69° 14′ of latitude, occupies the large island Disko, and the eastern coast of the Waygat, from Niakornak, on the northern cape of Arve-prinz island, round the Cape Noursoak, as far as the end of the southern coast of Cornelius Bay, where it reaches the great continental glacier. Hare island in the north of Disko island, Unknown island in the mouth of Cornelius bay, the islands Kakiliseit in the north of the latter, and many other northern islands, consist entirely of flœtz trap. From thence it extends over a part of the continental coast of Greenland, viz. London-coast, Svartenhuk, Ekallnit, Kangersoeitsiak, Karsorsoak, and disappears in the 76th degree under the most northern continental ice, or glacier, which precludes all further investigation.

The whole flœtz trap formation of Greenland, as far as it has been examined, rests on gneiss or on mica slate, these rocks alternating continually. The underlying primitive rocks, as well as the superincumbent flœtz trap, are always somewhat decomposed, where they come in contact. Trap-tuff generally rests immediately upon the primitive rock; it consists of balls and nodules of basalt and wacke, joined together by a cement of the same substance; the centre of the balls and nodules is very often filled with mesotype, blended with massive or crystallized apophyllite, the crystals of which are sometimes penetrated by acicular mesotype. This trap-tuff scarcely presents another mineral, and the apophyllite, or ichthyophthalmite, does not occur there in any other rock. The underlying primitive rock is very variable in its elevations, sometimes it does not surpass the level of the sea, sometimes, (for instance, at Godhavn,) it reaches a height of from 500 to 600 feet, which can be observed very exactly in the cliffs there. Columnar basalt lies upon trap-tuff; it presents four, five, and seven-sided columnar distinct concretions; the columns very seldom exceed a foot in diameter. This basalt does not include any mineral, except sometimes very minute spots of greyish white glassy felspar. Wacke generally rests upon it, forming an amygdaloid with different minerals, viz. chabasite, stilbite, analcime, chalcedony, opal, heliotrope, quartz, zeolite, miemite, and basillar arragonite. At Hare island the chalcedony is found crystallized in cubes. At Kannioak, in Omenaks-fiord, miemite occurs in kidneys, along with chalcedony, opal, wavellite, arragonite, and some quartz in grey decomposed wacke. The wacke of the flœtz trap formation of this country is generally intersected by small veins of iron-clay and bole. Lithomarge and green earth occur in nodules Olivine and augite are but seldom met with in the flœtz trap of Greenland. Laumonite, in a friable state, is found in very small veins, traversing wacke at Sergvarsoit, on the northern coast of Disko island. Most of the Greenlandish basalt affects the needle very powerfully. There are generally two, and sometimes three strata of columnar basalt, and one of them forms the summit, except at Hare island, where the summit consists of porphyry slate resting upon wacke. The shape of the mountains is very various, some of them present pyramidal, some conical forms, and some are entirely flat: Their stratification is very nearly horizontal, and the valleys between the mountains are generally narrow. There is no doubt that some of the mountains have been separated by very recent eruptions of rapid torrents.

On some parts of Disko island beds of brown coal occur in flœtz trap: they rest upon yellowish-white coarse-grained sandstone, which is very friable;—large balls of iron pyrites are imbedded in it. The beds of coal are generally divided from each other by strata of fine-grained sandstone, and are of very unequal thickness. In some places of the east coast of Disko island, in the Waygat, the sandstone becomes harder, and carbonized impressions of leaves are found in it, which are similar to those of sorbus and angelica.

The coal of Disko island is common brown coal, of slaty texture: it burns very easily, but it leaves a great residuum in the form of white ashes, which have a slaty texture, and somewhat resemble the polishing slate from Bilin in Bohemia. A very remarkable variety of brown coal, passing into bituminous wood, occurs in a small bed at Hare island. It is of slaty texture; and honey-yellow amber, in numerous grains of various sizes, is disseminated parallel to the cleavage of the coal. It rests upon ash-grey coarse-grained sandstone, is covered with grey common clay, and belongs, undoubtedly, to the newest brown coal formation. At Koome, in Omenaks-fiord, native capillary and fibrous sulphate of iron, of a beautiful green colour, is found in the cliffs of the brown coal. All the Greenland coal is subordinate to flœtz trap.

*Alluvial land* has been formed at the end of every bay and firth of the coast, and, in addition to grey and greyish-white sandy clay, it contains fragments of the neighbouring mountains. This formation is daily increasing, and contains no metallic substance, except magnetic iron sand, with which it generally abounds.

Botany.—Although Greenland affords a great variety of objects to the mineralogist, yet it offers but few to the botanist, when compared with other countries, the first efforts towards vegetation being repressed by the barrenness of the soil, and the want of the sun's genial influence. Those shrubs and trees, therefore, which in milder climates afford a comfortable shade to the wanderer, creep in this forlorn land under scattered rocks, to find shelter from their destroying enemies,—storm, snow, and ice. This land, however, presents a series of plants, which probably could not subsist in a milder climate; and in the interior of the inlets and firths may be found many species hitherto unknown in other countries. Some of the new species are published in the last number of the *Flora Danica*. There are also other spots which boast the most luxuriant verdure, but they are only places in the neighbourhood of the Greenland houses, which have been improved for many years by the blood and fat of seals and other animals. There are also small hills on the uninhabited islands, where the birds build their nests, and manuring the decomposed rocks, extort vegetation to their abode from the unfertile soil. These places, however, are but of rare occurrence, in proportion to the immense extent of the country. Innumerable cryptogamic plants, growing with great rapidity under snow and ice, supply the want of flourishing vegetation on the rocks and cliffs.

The vegetation commences very late, not till the end of May or June, in proportion to the different latitudes, and is over by the end of August or September. The bottom of the sea in these climates appears to be better suited to vegetation than the surface of the land; there is a great variety of fuci, ulvæ, and confervæ. The plants which have been hitherto found are,—

I. Monandria.

Hippuris vulgaris. Lin. Very seldom; only in the 60°.

II. Diandria.

Veronica alpina. L.
saxatilis. L.
Pinguicula vulgaris. L.
Anthoxanthum odoratum. L.

III. Triandria.

Scirpus cæspitosus. L.
Eriophorum vaginatum. L.
capitatum.
angustifolium.
latifolium.
polystachium. L.
Phleum arcticum. Vahlii.
Alopecurus antarcticus.
Agrostis arundinacea. L.
Aira subspicata.
Festuca ovina. L.
rubra. L.
Arundo stricta. Timmii.
Elymus arenarius. L.
Koenigia islandica.

IV. Tetrandria.

Alchemilla montana.
alpina.
Plantago. (*Nova Species.*) Only in the 60°.

V. Pentandria.

Pulmonaria maritima. L.
Diapensia lapponica. L.
Primula farinosa. L. (Varietas.)
Menyanthes trifoliata. L.
Azalea procumbens. L.
lapponica. L.
Campanula rotundifolia. L.
uniflora.
Gentiana lutea. L.
Angelica archangelica. L. Eaten raw by the Greenlanders, and as pickle with oil.
Ligusticum Scoticum. Only found to the 67°.
Alsine media. L.
Statice armeria. L.
Sibbaldia procumbens. L.

VI. Hexandria.

Juncus arcticus. Wildenow.
campestris. Wahlenberg.
pallescens. Wahlenberg.
parviflorus. L.
pilosus. Wahlenberg.
spicatus. L.
trifidus. L.
Tofieldia borealis. Wahlenberg. (Anthericum caliculatum. L.)
Tofieldia alpina.
Rumex acetosa. L.
Rumex acetosella. L.
Rumex digynus. L. Rheum digynum. Wahlenberg.
An Uvularia amplexifolia, seu Streptopus?

VII. Heptandria.

VIII. Octandria.

Epilobium angustifolium. L.
latifolium. L.
alpinum.
fontanum. Wahlenberg.
Vaccinium vitis idæa. L.
uliginosum. L.
pubescens.
Erica vulgaris. L.
If it flourishes plentifully, the Greenlanders suppose that the following winter will be very severe.
Erica cœrulea. Wildenow.
Polygonum aviculare. L.
latifolium.
viviparum. L.
The root is eaten raw by the natives.

IX. Enneandria.

Rheum digynum. Wahlenberg. (Vide Rumex digynus.) L.

X. Decandria.

Ledum palustre. L.
groenlandicum. Retzii?
latifolium. Aiton.
Andromeda hypnoides. L.
cœrulea. L. (v. Erica cœrulea and Menziesia cœrulea.)
tetragona. L.
polyfolia. L.
Pyrola rotundifolia. L.
uniflora.
secunda. The leaves are eaten by the natives, and also used as tea.
Saxifraga cotyledon. L.
stellaris.
nivalis. Smith.
palmata. Smith.
oppositifolia.
bulbifera. L.
cernua. L.
rivularis. L.
cæspitosa. L.
groenlandica.
hypnoides.
tricuspidata. L.—It grows to the height of one foot; and the leaves are used as tea by the natives.
petræa.
Silene acaulis. L.—Eaten, mixed with oil, by the Greenlanders.
Stellaria groenlandica. Vahlii.
glauca. Wither.
humifusa. Rotboll.
cerastoides. L.
Arenaria peploides. L.
peploides (varietas) trinervia.
Sedum annuum. L.
Oxalis acetosella. L.
Lychnis alpina. L.
varietas flore albo.
Cerastium alpinum. L.
hirsutum. Vahlii.
viscosum. L.
latifolium. L.

XI. Dodecandria.

XII. Icosandria.

Sorbus aucuparia. L. This tree is only found in the form of small shrubs, to the 61°, in the interior of some firths, and was probably brought to Greenland by the old Norwegians or Icelanders.
Rubus chamæmorus. L.
Potentilla aurea. L.
hirsuta. Vahlii.
nivea. L.
retusa.
Dryas octopetala.
integrifolia.
Comarum palustre. L.

XIII. Polyandria.

Papaver nudicaule. L.
radicatum. Rotboll.
Thalictrum alpinum. L.
Ranunculus acris. L.
hederaceo proximus.
nivalis.
sulphureus. Wahlenberg.
pygmæus. Wahlenberg.
Anemone pratensis. L. Rarely in the 60°.
Helleborus trifoliatus. L.
Anemone groenlandica.

XIV. Didynamia.

Ajuga pyramidalis. Only in the 60th degree.
Thymus serpyllum. L. Only to the 66° of latitude; it is used as tea by the natives.
Bartsia alpina. L.
Rhinanthus crista galli. L.
Euphrasia officinalis. L. Very small.
Pedicularis groenlandica.
flammea.
hirsuta.
lapponica.
*Nova Species* (*Flora Danica.*)

XV. Tetradynamia.

Draba alpina. L.
hirta. L.
androsacea. Wildenow.
alpicola. Wahlenberg.
incana. L.
muricella. Wahlenberg.
*Nova Species.* Now published in the *Flora Danica.*

Erysimum officinale. L.
Arabis alpina. L.

XVI. Monadelphia.

XVII. Diadelphia.

Lathyrus pratensis. Only about the firths of 60°.
Vicia cracca. Only in the vicinity of Cape Farewell.

XVIII. Polyadelphia.

XIX. Syngenesia.

Leontodon taraxacum. L. The young roots are eaten by the natives raw, and the young leaves as sallad with train oil.
Hieracium alpinum. L.
murorum. L.
Artemisia. *Nova species.*
An engraving of this species will soon be published in the *Flora Danica.*
Gnaphalium alpinum. L.
sylvaticum, fuscatum. Wahlenberg.
Erigeron uniflorum. L.
Pyrethrum inodorum. Wildenow.
Arnica alpina. L.
angustifolia. Vahlii.
Achillea millefolium. L. Used by the Greenlanders as a remedy for old sores.
Viola canina. L.
palustris. L. } Both of these are found only about the firths of 60° and 61°

XX. Gynandria.

Orchis albida. Swartz.
groenlandica. *Species Nova.* (Vide *Flora Danica.*)

XXI. Monœcia.

Carex dioica. L.
atrata.
bracteata.
cæspitosa.
stricta.
Xanthium strumarium. L. Only found in the garden of the Moravian Brethren at Lichtenau, in the firth Agluitsok, near Cape Farewell, in the 60°, probably sent from Europe amongst other seeds.
Betula alba. L.
nana.
alnus pumila.

XXII. Diœcia.

Salix myrsinites. L.
glauca. B. Lapponum. L.
herbacea. L.
reticulata. L.
lanata. L.
lapponica. L.
livida. Wahlenberg.
affinis versifoliæ, Wahlenberg.
Empetrum nigrum. The fruit eagerly eaten by the natives.
Rhodiola rosea. L. It only reaches the 65° of latitude. Both the root and the leaves are eaten by the natives, the former raw, the latter with train oil.
Juniperus communis. L. It only reaches the 66° of latitude.

XXIII. Polygamia.

Holcus alpinus. Wahlenberg.

XXIV. Cryptogamia.

1. *Filices.* (Ferns.)

Equisetum arvense. L.
sylvaticum. L.
reptans. Wahlenberg.
*Nova Species.* (*Flora Danica.*)
Osmunda lunaria. L.
spicant. L.
Aspidium filix mas. L.
filix femina. L.
dilatatum.
fragile. Swartz.
varietas fragilis. Swartz.
spinulosum. Wildenow.
lonchitis. L.
Cyathea dentata. Smith.
Woodsia Brownii, (vid. *Linn. Trans.*)
groenlandica. (*Nova Species.*)
Asplenium septentrionale.
Lycopodium selago. L.
selaginoides.
alpinum. L.
annotinum. L.
Polypodium vulgare. L.
ilvense. Swartz.
phegopteris.
lonchitis. L.

2. *Musci.*

*a. Frondosi.*

Sphagnum squarrosum.
obtusifolium.
Gymnostomum æstivum.
truncatulum.
Dicranum purpureum.
scoparium.
flexuosum.
undulatum.
tenue. (*Nova Species* examined by Dr. Taylor, at Dublin.)
groenlandicum. (*Nova Species* examined by Dr. Taylor, at Dublin.)
Didymodon capillaceum.
Grimmia maritima. (Very common on the whole coast.)
Grimmia apocarpo.
Trichostomum canescens.
lanuginosum.
Splachnum urceolatum.
rubrum.
vasculosum.
mnioides.
Syntrichia ruralis.
subulata.
Polytrichum piliforme.
juniperinum.
alpinum.
septentrionale.
subrotundum.
Orthotrichum striatum.
anomalum.
Mnium turgidum. Vulgatissimum, locis paludosis.
Bryum nutans.
pseudotriquetrum.
crudum.
cæspititium.
argenteum.
turbinatum.
Bryum? straminifolium. *fructus decrat.* T.
Bryum? epidendrum. *fructus deerat.* T.
Leskea incurvata.
Hypnum nitens.
aduncum.
uncinatum.
rutabulum.
rugosum.
schreberi.
cupressiforme.
fluitans.
stramineum.
molle.
loreum.
splendens.
cuspidatum.
filicinum.
cordifolium.
scorpioides.
palustre.
Hypnum? cochlearifolium. T.
Bartramia fontana.
ithyphylla.
Fontinalis squamosa.
Funaria hygrometrica.
Buxbaumia foliosa

*b. Musci Hepatici.*

Jungermannia pulcherrima.
excisa.
dilatata.
tamarisci.
ciliaris.
pinguis.
Marchantia hemispherica.
Blasia pusilla.

3. *Lichenes.*

Lecidea sanguinaria.
fusco-lutea.
pustulata.
Lepraria botryoides.
jolithus.
Gyrophora hyperborea. (Lichen proboscideus. L.)

Gyrophora erosa.
cylindrica.
hirsuta.
Endocarpon tephroides.
Isidium defraudans.
Urceolaria calcarea.
Parmelia tartarea.
candelaria.
brunnea.
subfusca.
gelida.
stellaris.
saxatilis.
omphalodes.
parietina.
fraxinea.
farinacea.
jubata.
capillaris.
nigrescens.
ciliaris.
ochroleuca.
Peltidia horizontalis.
venosa.
resupinata.
canina.
saccata.
crocea.
Cetraria islandica.
groenlandica nigra.
groenlandica viridis.
nivalis.
pulmonaria.
juniperina.
Cornicularia lanata.
tristis.
pubescens.
Stereocaulon paschale.
globulare.
Bœomices cocciferus.
pyxidatus.
cornucopioides.
fimbriatus.
gracilis.
digitatus.
radiatus.
cristatus.
foliaceus.
rangiferinus.
uncialis.
Bœomices subulatus.
radiatus.
fragilis. Coralloid. fragil. Hoffm.

4. *Fuci.*

*Algæ aquaticæ.*

Fucus vesiculosus.
divaricatus.
inflatus.
ceranoides.
spiralis.
canaliculatus.
serratus. Eaten by the natives.
soboliferus.
coccineus.
plumosus.
lycopodioides.
confervoides.
nodosus.
siliquosus. (Angustifolius.) *Alga marina. Seba.*
loreus.
aculeatus.
clathrus.
laceratus.
laciniatus.
flagelliformis. (Fucus filum.)
palmatus. Eaten by the Greenlanders.
edulis. Editur ab Groenlandis fame coactis.
cordatus. Lubentissime editur, aukpadlartok dictus.
esculentus. Fimbriatus. Sutluitsok Greenlandis, delicatula illis esca incocta.
cartilagineus. Urgente hyeme cocta editur, haud lubenter.
ramentaceus. Ulva sobolifera.
saccharinus. Suavis esca nativis.
alatus.
bulbosus.
digitatus. Fucus hyperboreus.
giganticus.
plicatus.
albus.
corneus.
fungosus.
clavellosus.
Fucus vittatus.
viridis.
coronopifolius.
norvegicus.
perforatus. *Nova Species. Ulva.*
Ulva umbilicalis.
plicata.
intestinalis.
spongiformis.
incrassata.
clavata.
latissima.
lanceolata.
flavescens.
compressa.

*Tremellæ.*

Tremella granulata.
verrucosa.
hemispherica.
nostoc.
agaricoides.
rubra.
adnata.
pituitosa.

*Confervæ.*

Conferva rivularis.
fontinalis.
dichotoma.
canalicularis.
distorta.
reticulata.
linum.
nitida.
pennatula.
rupestris.
floccosa.
diaphana.

5. *Fungi.*

Agaricus campanulatus.
fimetarius. D. ædib. Groenland.
Boletus luteus.
Helvella atra.
Peziza scutellata.
zonalis.
Clavaria muscoides. Rarissime.
Lycoperdon bovista. Vulneribus applicatur a Groenlandis sanguinis flux. imped. causa.
Mucor mucedo.

Zoology.—The character of the man who inhabits these latitudes, is given in a former part of the article: it will therefore only be necessary to enumerate the animals which can bear the hardships of this climate.

*Mammalia.*—There are only four different land quadrupeds, which are found in every season on the coast of Greenland, viz. the dog, the isatis, the arctic hare, and the reindeer. The arctic, or white bear, is a migrating animal: It comes from the eastern and north-eastern polar regions, in the beginning of the winter, with the floating ice, to the western coast of Greenland, and leaves it again about the end of June.

The *dog* is the faithful companion of man in this as in every other country, and would undoubtedly be so in a higher degree, if the Greenlanders treated this poor animal in a more humane manner. The dogs are in general large, and have the size and appearance of wolves. Their colour is very various, generally greyish brown, greyish white, mixed with yellow and black: they bark very seldom, but set up a dreadful howl. They sleep on the roofs of the houses of their masters, or lodge themselves in the snow, lying with only their noses out. They swim very well. The Greenlanders use them in place of horses: they harness them to their sledges, side by side, by means of thongs cut out of the *Phoca barbata*, or great seal: These thongs are ten yards long, the common distance between the dogs and the sledge; and in this manner they visit their friends in winter, or draw home the seals which they have killed over the ice of the frozen sea. They will travel sixty English miles in a day with sledges or sliders of whalebone, loaded with their two masters and five or six seals, and 100 miles if they have no load. In the most northern parts they use the dogs also in the chase of the white bear. The Greenlandish dogs are very ferocious, and often fight among themselves till one of them is killed. Canine madness is unknown in Greenland. These dogs are very prolific, having frequently nine and ten whelps twice in a year: some of the bitches eat their whelps. The Greenlanders put their dogs generally on uninhabited islands during the summer, the season in which they are useless, where these poor animals are obliged to provide for themselves, and very often perish by famine. The Greenlanders use the skins for shirts, stockings, and gloves: they make strings of the guts: they are very fond of their flesh as food, and reckon a very fat dog a great delicacy. The dog skins having a very unpleasant smell, do not form an article of trade.

The *isatis* (*canis lagopus*) generally called the arctic fox, or blue and white fox, is only found in the arctic regions, a few degrees within and without the polar circle. It inhabits the whole coast of Greenland, but lives always in the neighbourhood of the sea, in cliffs and cavities, or holes formed accidentally from fragments of rocks, and having many outlets. Their food is small birds and their eggs, eggs of sea fowls, shell-fish, and, when compelled by want, they eat grass, and all that the sea throws up. The arctic fox is of a bluish grey colour: one variety is entirely snow white, both in summer and winter. The hair is very thick, thicker in winter than in summer; and very soft and silky. The blue variety changes its colour in summer, and acquires a spotted skin of grey, blue, and white. The isatis is undoubtedly the hardiest of quadrupeds. It sets out for prey to the houses of the Greenlanders, during the severity of winter. It couples twice a year, like the dog, and, when with young, the female retires to her kennel. It swims uncommonly well from one island to another, to the distance of four and five miles, in search of prey. It is very harmless, and, when young, is very easily tamed. Its skin is highly prized, and very much thought of in China. It is generally caught by the natives in traps made of stones, like small huts, with a broad flat stone of hornblende slate, or mica slate, hanging perpendicularly by way of a door, which falls down by means of a string baited on the inside with the *salmo arcticus*, a small fish, which the isatis is very fond of. It is also taken by the European settlers in pitfalls, and in springes of iron. The flesh is not eaten by the Greenlanders, unless when they are in the greatest want of food.

The *white hare*, *arctic hare*, or *varying hare*, is in Greenland of a snow white colour, both in summer and winter, and lives in great numbers amidst the snowy mountains. It is usually fat, and feeds in summer on grass, and in winter on cryptogamic plants, particularly on lichen islandicus and nivalis (*Cetraria islandica* and *nivalis*.) Its hair is very thick and soft, but very loose. The Greenlanders are not very fond of its flesh, but they like very much to eat the raw contents of the intestines, together with the stomach. They make use of the skins, which are not an article of trade, to clothe their children.

The *rein-deer*, (*Cervus tarandus*), though very useful to the Laplanders, is only considered as an object of chase by the Greenlanders, and of no utility until deprived of life. They kill every summer more in the interior than they can carry to the shores, and their number is rapidly diminishing every year. Besides this, these thoughtless people neglect the time of their best fish and seal game for this sport. They eat the flesh, which is tender and well-tasted, raw, boiled, and dried. The hunters drink the warm blood, dressed with some berries; the contents of the stomach, called *nerrikak*, is a delicate dish. They are also very fond of the fat of the animal. The skin forms a part of their clothing, particularly of that of the women; and the inhabitant of this dreadful climate is obliged to procure a couple of fine reindeer skins during the summer, if he wishes to be agreeable to his wife. The sinews, when split, are very good threads, with which the women sew their clothes. The horns are employed for utensils and instruments. The greatest number of rein-deers is found in the vicinity of Baal's river, near to the continental ice, from the 63d to the 66th degree. They occur very seldom in more southern or more northern latitudes.

The *white bear*, *polar bear*, *or arctic bear*, (*Ursus maritimus*, or *Ursus arcticus*), is a migrating animal. It is never seen after the large or black whale (*Balæna mysticetus*) leaves the coast of West Greenland. Their size is stated by some authors to be from 13 to 23 feet, but this is probably too much exaggerated. The largest white bear which was met with on the west coast of Greenland, measured 9 feet and 4 inches from the snout to the tail, the skull of which is now in the museum of the Dublin Society. Another, caught by the celebrated navigator, Captain Phipps, (Lord Mulgrave) at Spitzbergen, measured 7 feet from the snout to the tail. The white bear seems the only animal, that, by being placed in the coldest climate, grows larger than those that live in the temperate zones. Its flesh is not so good as that of the other kinds of bear; it has an oily taste, and a fishy flavour; the liver is very unwholesome, and causes vomiting. The usual food of this animal is fish, seals, and the carcases of whales. On land, which it seldom approaches, it preys on rein-deer, hares, foxes, and birds. It lies in ambush on the flakes of the floating ice, and lurks there after seals and other marine animals; it also attacks the morse, or walrus, with which it is in constant enmity. The walrus, by reason of its large teeth, has generally the superiority, but frequently both the combatants perish in the conflict. In winter, when hungry, it sometimes attempts to break into the houses of the Greenlanders, allured by the scent of the flesh of seals, but it is very easily driven away with fire-arms and dogs. The female has only one young one, and lodges it in the snow of the floating ice, or on the shores. The affection between the parents and their young is so great, that they will sooner die than desert one another. The Greenlanders kill them with fire-arms, generally assisted by dogs; and both the man and dog feed on the flesh and fat. The skin is used for boots, and some other domestic purposes; it is also a valuable article of trade, a good skin being generally sold for three or four pounds.

The pinnated quadrupeds, or quadrupeds with fin-like feet, are, the *morse*, or *walrus*, (*Trichechus rosmarus*). It is sometimes found of the length of 18 feet, and the circumference in the thickest part is ten or twelve feet. Its weight is from 600 to 1500 pounds. It has very short legs, and five toes on each foot, joined together by webs, with a small roundish blunt nail to each. Its skin is generally an inch thick, thicker on the neck, and very much wrinkled about the joints; it is very thinly beset with grey and reddish grey hair, sometimes mouse-coloured. It has two large teeth or tusks in the upper-jaw, from a foot to two feet long, and four grinders, flat at the top, above and below, the surfaces of them generally being very much worn. It is found of the largest size in the Icy Sea. The animals feed both upon seagrass and small marine animals, viz. shells and small fishes. It sleeps upon the floating flat ice, or on the surface of the sea, and when attacked by men, will endeavour to overset the boat, or to make holes in it with their teeth; but it is very clumsy when out of the water upon the ice, where it may be killed with little difficulty. When a walrus or morse is struck with the harpoon, the Greenlanders let it run till it is wearied, and then draw in the line to kill it with the lances. The Greenlanders very seldom kill them in their small canoes; but if they do, they are always in company with three or four men. They are no more seen in large flocks on the coast of West Greenland as formerly, having been diminished by the whale fishers, who killed a great number of them. A flat island on the southern coast of Disko island, called Saitok, situated in the mouth of Disko firth, consists of alluvial land, which is covered with numberless bones and skulls of the walrus. The Greenlanders feed on their flesh, which is of a dark red colour; they use the oil in their houses, cut thongs out of the skin, and employ the tusks for their utensils and instruments.

*Trichechus manatus*, which is called *auvekæjak* by the Greenlanders, is very seldom seen on the coast, according to their own accounts; and it appears more towards Behring Straits, and the sea in the vicinity of Kamtschatka.

The *seals* may be called the flocks of the Greenlanders. They supply them with flesh, the most desirable food of this nation. The blubber furnishes them with oil for their lamps, and for their chamber and kitchen fire; the fibres of the sinews of the seal furnish thread for their clothes; of the skins of the intestines they make their windows, and their curtains for the tents; the stomach is used as a train oil vessel, and the bladder is employed for the javelins. The blood, mixed with flesh, is eaten as soup. But the most valuable thing is the skin: it covers their boats and their tents; it furnishes clothes, boots, stockings, gloves, and coverings for their bedsteads.

There are different species of seals, partly migrating, partly living on the coast of Greenland. One of the most remarkable is,

The *hooded seal*, *Klappmutze* of the Germans, *Klapmyds* of the Danes, *Neitsersoak* of the Greenlanders, *Phoca cristata* of Gmelin. It is so called from a thick folded skin on the forehead of the male, which it can draw over the eyes like a cap, to defend them against its enemies. Its hair is of a double kind, the longest silver white, the shortest black and woolly, which gives it a very beautiful appearance. It grows to the length of ten and twelve feet. The Greenlanders value the skin of the young ones very high. It is uncommonly fierce when wounded, and often attacks the canoe. These seals fight very stoutly among themselves, from jealousy, as the natives suppose. They live in flocks; are found in great numbers round Cape Farewell, and go very seldom to the northern parts of the coast. It is falsely called *Phoca leonina* by some zoologists, this being a very different animal.

The *common seal*, called *Spragled Sael* by the Danes, *Kobbe* by the Norwegians, *Meerkalb* by the Germans, and *Kassigiak* by the Greenlanders, (*Phoca vitulina* of Gmelin) is found sometimes in very large flocks on the coast of Greenland. It is one of the smaller animals of the family, but its skin is the finest of them all, and is of great value among the Greenlanders. It is principally employed for female dresses. The common seal is very cautious, and therefore caught with difficulty.

The *harp seal*, or *half-moon*, (*Phoca groenlandica*,) called *Swartside* by the Danes, *Robbe* by the Germans, and *Atarsoak* by the natives. It is nine feet long when full grown, and gives the best blubber. Its skin is of a yellowish-white and greyish-white colour, with two large black spots on the opposite sides of its body, in the form of two half-moons, the horns of which are turned in an uniform direction towards one another, and therefore called Half-moon. It becomes like the black spots in its fourth year when full grown. Its skin is the most durable, and therefore used to cover the canoes and the tents. It is incautious, and very easily taken. It never ascends the fixed ice. It is a migrating animal; comes with its young from Spitzbergen to Davis Strait about the end of March, returns in May to Spitzbergen, and comes back again in July. Three or four of them afford a barrel of blubber. It comes in great flocks, and visits the firths of Davis Strait.

The *rough seal*, (*Phoca hispida* and *Phoca fœtida*,) called *Neitsek* by the Greenlanders, is the smallest of the generally known species, very seldom exceeding four feet in length. It never frequents the high seas, but keeps always in the vicinity of the fixed ice, generally in high latitudes, and is very seldom seen southward from Disko Bay. Many thousand are killed every winter in Omenak's firth or Cornelius bay, in the 72° of latitude. The male emits an insupportable smell in its coupling time, nevertheless it is eaten with great avidity by the northern Greenlanders.

The *great seal*, (*Phoca barbata*,) called by the Greenlanders *Urksuk*, is of the largest kind, but is very seldom met with on the coast of West Greenland. It measures sometimes ten feet in length, has a thick skin, with very thin brown hairs; and on its upper lip very long white pellucid whiskers, which are curled at their points. Its flesh is white and very good. The Greenlanders cut out of the skin thongs and lines for their seal game, whips, and other domestic articles.

The Greenlanders mention some other species of seals, which very seldom occur, viz.

*Siguktok*, having a very long snout; in its body it is similar to the *Phoca groenlandica*. Perhaps it is the *Phoca ursina*.

*Imab-ukallia*, of a snow-white colour, the eye presenting a fire-red iris, probably the *Phoca leporina*.

*Atarpiak* or *atarpek*, the smallest species of seal, not exceeding the size of the hand, of a whitish colour, with a black spot of the form of a half-moon on each side of the body.

*Kongeseteriak* has, according to the description given by the natives, some resemblance to the sea-ape, which is described by Mr Heller.

The *Sea-unicorn* or *narwhal*, (*Monodon monoceros*,) called *Kernertak* by the Greenlanders, is a migrating animal. It is generally from seventeen to twenty feet long, has a smooth black skin, and a small mouth in proportion to its body. It has no teeth, but a horn, wreathed or twisted on its surface, and from eight to ten feet long, runs from the left point or end of the upper jaw. It is white, has the solidity of the hardest bone, and far surpasses ivory in all its qualities. The animal uses the horn to get at its food the sea-grass, and also as a weapon against its enemies. It has two nostrils in the skull, but they emerge in one aperture through the skin. It swims with wonderful velocity, and can only be killed when there is a great number of them together. They are always seen in flocks, in the severest winter, amidst the fissures of the fixed ice, in the bays from 70° of N. Lat. to the most northern regions. They never occur in more southern latitudes. The Greenlanders drive with their sledges to the fissures of the ice, where the animals generally come up to take air, and kill them there with their harpoons, or with guns. They eat both their flesh and skin, raw, dried, or boiled; use the blubber for their lamps; and the horns, which are highly valued as an article of trade. Most of them are killed in Disko bay, in the 70°; in Omenak's firth, or Cornelius bay, in the 72°; and at Upernavik, in the 73°.

The *white-fish*, *beluga* of the Russians, and *kelleluak* of the Greenlanders, is likewise a migrating animal, and visits the coast of West Greenland regularly every year about the end of November. It is, next to the seal, the most useful animal to the Greenlanders, and it comes at a season, when their provisions fall very short. It arrives in flocks, in very stormy weather, when the wind blows from the south-west. It has a short, roundish, very fleshy head, but the skull is longish and flat; the eyes and the mouth are small; in each jaw of each side are nine teeth; the pectoral fins are nearly of an oval form; and beneath their skin may be felt the bones of five fingers, which terminate in five very distinct projections. The body is round, oblong, and well proportioned; and its tail is divided into two lobes, which lie horizontally. Its length is from twelve to seventeen feet. In swimming it makes great use of the lobes of its tail, bending them under the body, and working it with such force as to dart along with the velocity of an arrow. One of the large size yields five barrels of good blubber. Its flesh is somewhat similar to that of beef, though oily; its skin is eaten raw, dried, and boiled. Its oil is of the best, whitest, and finest quality. The intestines are used for windows, and the curtains of tents. The sinews, when split, give the best sort of strong thread. The female white-fish has two nipples, and yields a yellowish-white milk, but it produces only a single young one, which is of a fine pearl-grey colour, but it afterwards grows white. The pearl-grey young is called *utak* by the natives. The full grown are the most beautiful animals; they are not shy, and sometimes follow, tumbling themselves round the boats. They are killed with harpoons, and also caught in large strong nets, which are set in narrow sounds between the islands.

The *porpoise*, or *Delphinus delphis*; the *nise*, or *Delphinus phocæna*; and *the sword-fish*, or *Delphinus orca*, are frequently seen on the coast, but very rarely caught.

Whales.—There are different species of whales which visit the coast of West Greenland, viz. *Balæna physalus*, or fin-fish, called *tunnolik* by the Greenlanders; *Balæna musculus*, or *northcaper*, (Green. *kepokarnak*); *Balæna rostrata*, (Green. *tigagulik*); *Balæna boops*, (Green. *keporkak*), and *Balæna mysticetus*, or the Greenland whale, called *arbek* by the natives. The *Balæna boops* or *butskopf*, comes regularly to the coast in the neighbourhood of Fredrikshaab about the end of July, when the Greenlanders, both men and women, go out in their canoes. The men in their small canoes follow the whale, and continue to throw a great number of harpoons and lances into the animal, until it dies from loss of blood. They afterwards join their canoes, fasten their spoil to them, and carry the booty to their houses, where it is divided.

The *Balæna boops* is a smaller kind of whale, its length being from twenty to twenty-five feet. It has a fin on its back, and also a protuberance which grows towards the tail. It has long rugged wrinkles under its neck, that are white inside, and greyish-black on their elevation. A great number of the shells called *Lepas balænaris*, or *Lepas diadema*, are found near its fins. Its body is longer, and sharper behind and before, than that of the other whales. Its back is of a black, and its belly of a greyish-white colour; the whalebones of this species rarely exceed the length of one foot. Its blubber is thin, and not very oily. This whale follows always along the coast farther to the north, and it is also caught by the Greenlanders in Disko Bay.

*Balæna mysticetus*, the great or Greenland whale, is the most valuable and lucrative species of this genus, on account of its bigness, and the great quantity of fat, which affords much oil; it is also the most tame, and the easiest to be caught, on account of its unwieldy size. It has no back-fin. The head of it forms one-third part of the whole body. Its eyes are very small in proportion, not much bigger than those of an ox, and black, with a white iris; they lie deep, and are placed above the junction of both lips. Instead of ears, a hole appears on each side of its head, so small that it is scarcely discernible, not admitting any thing thicker than a goose-quill; but within the flesh there is a larger orifice, formed like an ear, which enables it, as has been noticed, to hear very distinctly. The two holes, or pipes, on the top of its head, are crooked, and very similar to the holes in the belly of a violin. They are for receiving air, as well as for discharging the water which it swallows by its mouth. This is forced upwards through these holes in very large quantities, and to a considerable height, (of some fathoms) with such a noise, that it roars like a hollow wind, and may be heard at three miles distance. When wounded, it blows more fiercely than ever, the water frequently being mixed with blood. Its throat is uncommonly narrow, not exceeding the width of one inch and a half. Its tongue is eighteen feet long, when the animal measures fifty-six or sixty feet; it is then ten feet broad, is very fibrous, floats on the water, and affords four to six barrels of oil; its weight is to 600 or 800 pounds. The tongue is inclosed in long pieces of a corneous substance, generally called whalebones; and these are covered on their interior side with a kind of fibre, or straight hair of the same substance, similar to coarse horse hair. On each side of the tongue are commonly found 250 of different lengths; the longest are about the middle, and decrease towards the snout and the throat; they are attached to the upper jaw. The under jaw forms with the jaw bones an oblong triangular deep bason, of a tendinous and cartilaginous substance, which is as deep as to cover the longest whalebones in their perpendicular shape when the mouth is closed; this receptacle is, of course, deepest towards its middle part. The broad ends of the whalebones, where they are joined to the palate, are generally one foot broad; they terminate very pointed, and have the form of a curved sword; they would wound the tongue, which is very delicate, if they were not covered with hair on their inside. There are no other teeth in the mouth. This whale is very thick from the head to the middle, but thinner and sharper towards the tail; its fins and its tail stand horizontally.

In the spring of 1813, a whale was killed at Godhavn, of the length of 67 feet. The dimensions of a whale, killed in the year 1811 at Godhavn, was, from the centre of the mouth to the point of the tail, 56 feet. From the point of the under lip to the root of the fins 23½ feet. From the fins to the point between the two lobes or wings of the tail 33 feet. The length of the head was 18 feet. From the middle point of the upper lip to the blow-holes 16½ feet. The length of one of the fins 8 feet 4 inches. The thickness of a fin, on its thickest part, 1 foot 9 inches. The breadth of the tail from one extremity of its wings to the other, 22 feet 7 inches. The length of one of the blow-holes 11 inches. There were 13 ribs on each side, and in all 26 ribs. The animal was a female. The fins serve this large animal for rudders, to turn in the water, and to give a direction to the velocity impressed by the tail. The tail serves for an oar, to advance itself in the water; wherewith it swims with incredible force and celerity. When swimming a little under the surface of the water it leaves a track in the sea like a great ship, and this is called its wake, by which it often is followed. The female makes use also of the fins, when pursued, to bear the young one, placing it on its back, and supporting it by the fins on each side, from falling. They are also seen sometimes having their young upon the tail.

The skin of the whale is of a different nature. The epidermis resting upon the skin is not thicker than parchment; but when this is removed, the real skin appears, which is about an inch thick, of a bluish-black colour, fibrous and spongy; it is called by the Greenlanders *maktak*; it is very much wrinkled in the old whales, and smooth in the young ones. Beneath the skin (*maktak*) lies a yellowish white, very tenacious, reticulated fibrous substance, which affords more fritters than oil; it is called *maksak* by the natives: with this substance the real blubber is immediately connected. The blubber is of very unequal thickness, from 10 inches to one foot thick upon the back, and on the under lips two feet thick; but the latter is very cartilaginous, and intermixed with coarse nerves. The head and the back of the whale is bluish-black, the under jaw is white, and sprinkled or spotted with bluish-black, and the tail is greyish-black. The skin of the suckers is greyish-blue. The Greenlanders state, that the old animals become more and more of a greyish-white colour. The blubber of young whales is reddish-white and rose-red, that of the old is yellowish-white; the flesh of the young is dark blood-red, that of the old is dark red-brown. The bones of the whales are very porous, and afford, when sawed in pieces, the finest oil. The female whale has two breasts, with teats like a cow, and has one young one, very seldom two. When it suckles the young it lies on its side, on the surface of the sea, and the young one attaches itself to the teat. The food of the whales is the *clio arctica*, the *argonauta arctica*, *cancer pedatus*, and *cancer oculatus*, none of them exceeding the size of a common wasp. Sometimes also *oniscus pulex*, and other species of oniscus, are found in its stomach. It takes its food under water; these small insects become entangled by the hair of the whalebones, and the water is emitted partly on the sides of the mouth, partly through the blow-holes. The whale cannot remain longer than from 15 to 20 minutes under water. It sleeps on the surface of the sea, and is often caught asleep.

The settlements or colonies, which are established and supported by the Danish government on the coast of West Greenland, for the purpose of the whale-fishery, are Holsteinsburg in 67° 10′, Egedesminde and Wester-island on the southern point of Disko bay, Hunde Island, and Crown-prince-island in Disko bay, Christianshaab, Claushavn and Jacobshavn on the continent of Disko bay, Godhavn on Disko island, and Klokkerhuck on Arve-Prince-Island, situated on the entrance of the Waygat. The fishery is carried on in boats, by natives and settlers, on the account of the Danish government. The fishery was not very successful during the last ten years. The English and Scotch whale-fishers visit Disko bay every year, about the end of April, and leave it again in June. The Dutch whale-fishers, who formerly also came there every year, were prevented from fishing at all during the late war. It is only the balæna mysticetus, which is caught there at that season. It comes to the coast about the end of December, and leaves it again in June.

The spermaceti whale, or cachalot, (*Physeter macrocephalus*) the enemy of the balæna mysticetus, is seldom seen on the coast of West Greenland.

Birds.—West Greenland presents very few land birds. The largest of them is the *vultur albicilla*, the cinereous eagle, called *nektoralik* by the natives; it feeds on seals, fishes, and all kinds of birds; is of a greyish brown colour, and inhabits Greenland the whole year, sitting on the rocks with flagging wings, and flies slowly. It is eaten by the Greenlanders, and the skin employed for clothing.

The *falco rusticatus*, the *falco islandus*, and the *falco fuscus*, or Greenland falcon, called by the natives *Kirksoviarsuk kernertok*, inhabit the most remote parts of the friths; they feed on birds. The latter is of a very fine appearance. Its colour is marbled of white grey and brown. It is only eaten by the natives when compelled by hunger. All falcons inhabit Greenland the whole year.

The *beautiful snowy owl*, or *stryx nyctea*, called *orpik* by the Greenlanders, is found in the interior of the continent, in the vicinity of the glaciers. It preys on every kind of bird day and night.

The *raven*, (*Corvus corax*,) (Green. *Tulugak*,) occurs in great number, and frequents the huts of the natives, who abhor its flesh.

The *white partridge*, (*Tetrao lagopus*), called in North Greenland *ageiksek*, and in South Greenland, *kauio*, inhabits in summer the mountains for the sake of crowberries, (*Empetrum nigrum*). In winter it descends to the valleys near the shores. It is brownish in summer, and changes its colour in winter into a snow white. The Greenlanders like very much to eat its intestines raw.

Of small land birds, which all leave this country in the beginning of winter, are only seen the *fringilla lapponica*, (Green. *Narksamiutak*), the *fringilla linaria*, (Green. *Orpingmiutak*), the *motacilla oenanthe*, (Green. *Kussektak*), and the *emberiza nivalis*, (Green. *Kopanauarsuk*). The arrival of the latter about the end of May announces the approach of spring. In autumn, in the beginning of September, it collects again in great flocks, in order to migrate.

Of water birds, there occur on the coast,—

1. *Anas bernicla*, bernacle. Green. *Nerdlek*.
2. *Anas clangula*, golden-eye. Green. *Kærtlutorpiarsuk*.
3. *Anas histrionica*, harlequin. Green. *Tornaviarsuk*.
4. *Anas boschas*, mallard. Green. *Kertluctok*.
5. *Anas glacialis seu hyemalis*, long tailed duck. Green. *Aglek*.
6. *Anas spectabilis*, king-duck. Green. *Siorakitsok*.
7. *Anas mollissima*, eider-duck. Green. *Mitek*.

The *Anas molissima*, or eider-duck, visits the coast as soon as the grass begins to grow, and plucks the finest down from its breast to form its nest. The down taken from the nest is the finest and most elastic. It is customary to take away the first eggs, which occasions a second laying, and a second deplumation. They lay their eggs on uninhabited islands among the grass growing near the shores. They brave the severest winter of the arctic regions, and their breeding-places are the most northern. They come constantly every spring to the same spot again, if not disturbed. The Greenlanders kill them with darts and guns, watching their course (when they dive) by the air-bubbles, and strike them when they ascend. The flesh is valued as food. The skin of this duck is the most valuable of all as a garment placed next to the skin. The down forms a very considerable article of trade. The colony Egedesminde produced in the year 1808, 1000 pounds weight of that article. One pound sterling is paid for one pound weight of the best sort of down.

Of *Merganseres* occur,—1. *Mergus serrator*. Green. *Paik*.

2. *Mergus merganser*, goosander. Green. *Pararsuk*.

Of *Auks*.—1. *Alca impennis*, great auk. Green. *Isarokitsok*.

2. *Alca torda*, razor-bill. Green. *Akpardluk*.
3. *Alca pica*, black-billed auk. Green, *Akpa*.
4. *Alca arctica*, puffin. Green. *Killangak*.
5. *Alca alle*, little auk. Green. *Akpalliarsuk*.

The *alca pica* vies with the eider duck in point of utility to the Greenlanders. The skins are used for clothing, and the flesh is eaten. They only approach the coast when the cold becomes very severe, and breed in summer in the clefts of the remotest rocks. They are killed in canoes with darts, and give food to the Greenlanders in the months of February and March, when they want every other supply from the sea. It appears that the words *alca*, *auk*, and *akpa*, are formed from the note or sound which the bird emits when flying or swimming in large flocks.

Of *Petrels*, or *Procellariæ*, are seen,—

1. The *Procellaria glacialis* fulmar. Green. *Kakordluk*; and,
2. The *Procellaria puffinus*, shear-water. Green. *Kakordlungoak*.

The prey of these birds being the blubber of the whale, they are only found in the vicinity of the whale-fisheries. They are, from the nature of their food, extremely fetid; and so stupid and voracious, as to be killed with rods in their attempt to obtain prey. They are rarely eaten.

Of *Guillemots*.—1. *Colymbus Grylle*, black guillemot. Greek. *Sergvak*.

2. *Colymbus glacialis*, northern guillemot. Green. *Tudlik*.

3. *Colymbus septentrionalis*, red-throated guillemot. Green. *Karkfak*.

Their skins are very excellent for clothing, in consequence of their durability.

Of *Terns*.—*Sterna hirundo*, great tern. Green. *Imerkoteilak*.

Their eggs are the most delicate of all water-birds. They come latest in summer, that is, in the beginning of June, and leave the coast earliest, that is, in the beginning of September, under great noise.

Of *Gulls*.—1. *Larus marinus*, black-backed gull. Green. *Nayardluk*.

2. *Larus trydactylus*, kittiwake. Green. *Tattarak*.

3. *Larus candidus*, ivory gull. Green. *Nayauarsuk*.

4. *Larus arcticus*, *cataracta parasitica*, arctic gull. Green. *Meriarsairsok*.

5. *Larus glaucus*, glaucous gull. Green. *Naya*.

Of *Pelicans*.—1. *Pelicanus carbo*, corvorant. Green. *Okaitsok*.

2. *Pelicanus cristatus*, crested corvorant. Green. *Tingmik*.

3. *Pelicanus bassanus*, gannet. Green. *Kuksuk*.

All these birds are used as food; their skins for clothing.

Of *Scolopax*.—1. *Scolopax gallinago*, common snipe. Green. *Sigrektok*.

2. *Scolopax jardreka*, jardreka. Green. *Sargvarsursoak*.

Of *Tringa*.—1. *Tringa striata*, striated sandpiper. Green. *Sirksariarsungoak*.

2. *Tringa interpres*, Hebridal sandpiper. Green. *Telligvak*.

3. *Tringa lobata*. Green. *Nelloumirsortok*.

4. *Tringa fulicaria*. Green. *Kajok*.

5. *Tringa alpina*, dunlin. Green. *Tojuk*.

Of *Charadrius*, or *plover*—1. *Charadrius apricarius*, alvargrim. Green. *Najoirovek*.

2. *Charadrius stiaticula*, ringed plover. Green. *Tukagvajok*.

Fishes.—Greenland cannot boast of valuable fisheries. The natives attend only to their seal-game, and neglect entirely every other branch of industry. The few Europeans residing there are occupied with trade. There can be no doubt, however, that such an extensive coast would afford numerous and profitable banks. Some have already been discovered at Tunugliarbik, Guannersoak, Fredericksbaab, Fishfiord, Sukkertop, Amertlok, where *different species of cod-fish* are caught; for instance, *Gadus æglefinus*, (Green. *Misokarnak*;) *gadus callarias*, (Green. *Sarolik*;) *gadus morrhua*, (Green. *Saraudlirsoak*;) and *gadus barbatus*, (Green. *Ogak*.) In the north of Greenland, in the 70, 72, and 73d degrees, were discovered very extensive *flounder banks*. The *pleuronectes hippoglossus*, holibut, Green. *Netarnak*, sometimes of a weight of more than 100 pounds, is found in abundance in the neighbourhood of the colonies of Godthaab and Sukkertop. Extensive banks of the *pleuronectes cynoglossus*, (Green. *Kaleraglick*,) were lately discovered at Jacobs havn in Disko bay, and at Omenak in Cornelius bay. Different species of *salmo*, viz. the *salmo carpio*, (Green. *Ekalluk*,) the *salmo alpinus*, (Green. *Iviksarsok*,) and the *salmo rivalis*, visit every year the friths and inlets of the continent. But the most remarkable of all the fishes is the *salmo arcticus*, called *Angmarsæt*, the Greenlanders deriving their daily food from them. It forms their bread, and makes also a sort of dessert after their most delicate repasts. The *Angmarsæt* live at sea most part of the year; but, at the end of May, they come in immense numbers into the bays and friths. They are taken in nets in all kinds of vessels, and even with the hands, in great multitudes. The whole bottom of the sea seems covered with them. They are dried on the rocks, put into sacks, and preserved for the winter under heaps of stones. They are generally eaten dried instead of bread, but many are dressed fresh as soon as they are taken. They seldom exceed seven inches in length. They have a very strong sharp smell when they are dry; and are, on the whole coast of Norway, in bad credit, as a very noxious fish, a calumny which they do not deserve. The impression of this fish occurs frequently in an indurated gray sandy marl on the end of the bays. Next to *angmarsæt*, the Greenlanders eat most of the *ulkes*, a kind of *cottus*, particularly *cottus scorpius*. They eat the fishes dried, or boiled in sea water, but the heads of *pleuronectes* are eaten putrid.

Insects.—The Greenlanders are tormented with very troublesome insects. The *culex pipiens*, a kind of musquitoes, appear in the months of June, July, and August in myriads. But a great number of other insects increase, from the incredible filthiness of the natives.

The insects, which contribute to the comforts of life, are, *Cancer phalangium*, a species, which has some resemblance to *cancer longimanus*, the cancer *squilla*, and cancer *homaroides*. The minute species of *Cancer pedatus*, and *Cancer oculatus*, afford food to the whale, and their existence is therefore of great importance to the natives. Numerous species of *oniscus* are found partly in the sea, and partly attached to the bodies of several marine animals.

Vermes.—Numerous species of *gordius* and *lumbricus* are found, and the intestines of the arctic quadrupeds, birds, and fishes, swarm with different species of *ascarides*. Of the interesting family of *Nereis* occur ten species.

Shells.—The coast of Greenland cannot boast of numerous varieties of beautiful shells, of which the seas of the warm climates abound. Of *Asterias* occur the *asterias rubens*, with 6 rays; the *spongiosa*, with 5 conical rays; the *papposa*, with 12 and 13 rays; the *minuta*, with 6 rays, and the *ophiura*, with 5 rays. In Discofiord is found the *asterias caput medusæ*. Of *Echinus* exists only the *saxatilis*; 12 species of *Serpula*; 3 species of *Chiton*, one of which is new, and not yet described; its testæ are marbled of a yellow and red colour. Of *Lepas* occurs on the shores, *lepas balanus*, and *balanoides*; and on the skin of the Balæna bonps, the *lepas balænarus*, or *diadema*.

Of Bivalvia are found the *mya* arenaria, arctica, truncata and byssifera, the latter a new species; only one *Cardium*, viz. ciliare; three *Veneres*, the islandica, minuta, and fragilis. The *pecten* islandicus. The *mytilus* edulis, discors and faba. The myæ and mytili are eaten by the natives, and the shells used as spoons.

Univalvia are: some *patellæ*, *argonauta*, *arctica*, the favourite food of the balæna mysticetus; the *helix* pellucida, nitida, and haliotoides; the *trochus* cinerarius, divaricatus and helycinus; the *tritonium* undatum, despectum, antiquum, glaciale, lapillus, fornicatum, clathratum, craticulatum, and ciliatum; the two latter are new species. Of *Nerita*, the littorea only is found.

In the friths and inlets are found various *tubiporæ*, *madreporæ*, *milleporæ*, and *celleporæ*, but all very minute. *Flustræ* and *sertulariæ* grow on the whole coast in great numbers; *alcyonia* and *spongia* occur very seldom.

It will no doubt be interesting to our readers to have a catalogue of works concerning Greenland, which have been published at different times.

The oldest accounts of Greenland will be found in *Kongs-speilet*, or *Speculum regale*. More in Whitfeldt's *Chronica*, and in Lychsander's *Chronike*. Copenhagen, 1602. Part of it is translated into English, and published in Purchas' *Pilgrims*.

Jens Munks *Navigatio Septentrionalis*, in Danish, was published at Copenhagen, 1624, 8vo. It contains his voyage for discovering a north-western passage, and some account of Greenland.

Isaac de la Pereyre wrote a *Relation de la Groenlande*. Paris, 1643, 8vo. It was translated into the Danish and German language.

From this time to the year 1721, some curious critical pamphlets were written concerning East and West Greenland, viz.

Rudolph Cappel, *Orbis Arcticus*. Hamburgi, 1675, 4to.

Arngrimi Jonæ, *Groenlandia*, (in Latin.) Hafniæ, 1688. 8vo.

Thormodi Torfæi, *Historia Vinlandiæ Antiquæ*. Havniæ, 1705, 8vo.

Thormodi Torfæi *Groenlandia antiqua*. Havniæ, 1706, 8vo. and 1708, 8vo. *cum tabulis geographicis*.

Pierre de Mesange, *les aventures et les voyages de Groenlandt, avec une relation de l'origine, de l'histoire, des mœurs, et du paradis des habitants du pole arctique*, à Amsterdam, 1720, 2 vols. 8vo.

Zorgdrager *oud en nieuwe Groenlandish Walvischery*, 4to. Amst. translated into German, Hamb. 1724, 4to.

Hans Egede, the celebrated Danish missionary, went to Greenland in the year 1721, and published, in the year 1729, at Copenhagen, in 4to. *Den gamle Groenlands nye perlustration*. It was soon translated into English, German, Dutch, and French.

Afterwards he published, in the year 1738, at Copenhagen, in 4to, *Omstandelig og udforlig Relation angoende den Gronlandske Missions Begyndelse og Fortsættelse*, (containing his journal.)

Paul Egede, his son, the second Danish missionary, published soon afterwards, continuation of *Relationerne betreffende den Gronlandske Missions Tilstand* from 1734 to 1740.

In the year 1788 he published his last work, *Efterretningerne om Groenland, uddragne af en Journal holden fra Aarene*, 1721 till 1788. Copenhagen, 8vo. with plates.

Nils Egede, his brother, who was a merchant in Greenland, published a continuation of *De Gronlandske Relationer*, from 1739—1743.

In the year 1761, David Crantz, of the German Unitas Fratum, visited their settlements on the coast of West Greenland, and remained there till August, 1762. In the year 1765 he published, *Historie von Groenland*. 2 Bande, 8vo. with plates. Barby; and in the year 1770, Fortsezzung (continuation) *Der Historie von Groenland*. His account was translated into English, Dutch, and Swedish.

The Rev. Otto Fabricius, who was a missionary in Greenland during five years, published his *Fauna Groenlandica* at Copenhagen, in 1780, in 8vo.

The first Greenlandish Grammar was published by Paul Egede in the Danish and Latin language at Copenhagen, in 1760, in 8vo.

The first dictionary in Greenlandish, Danish, and Latin, was published by Paul Egede, in 1750, in 8vo.

Both works were very much improved by Otto Fabricius, the Grammar in 1791, and in a second edition in 1801, and the Dictionary in the year 1804, 8vo.

Paul Egede was also the first who translated the New Testament into the Greenlandish language. It was reprinted in the year 1803, and very much improved by Otto Fabricius.

Besides this, partly by the Danish Society for the furtherance of the missions, partly by the Unitas Fratrum, psalm-books, prayer-books, and other religious books, have been printed, and distributed gratis amongst the Greenlanders.

GREENLAW, is a small town of Scotland in Berwickshire, and is situated on a plain, watered by the Blackadder, nearly in the centre of the county. There are here the remains of two religious houses, which were dependent on the priory of Kelso. Marchmont house, the seat of the family of Marchmont, is about two miles from the town. Greenlaw is the county town of Berwickshire. Its population is about 600.

GREENOCK, is a sea-port town in Scotland, situated on the Frith of Clyde, about 22 miles below Glasgow, and 46 above Ayr. It contains many neat and well built houses, but its streets are irregular and narrow; and its general appearance is far from being elegant. Of late years, it has extended very much to the west, and there, as might have been expected from the opulence and taste of the inhabitants, a great improvement has taken place, both in the general plan and in the structure of individual edifices. The principal public buildings of Greenock consist of the infirmary, which was erected in the year 1808 at an expence of nearly 2400*l*. and contains good accommodation for a considerable number of patients; the theatre, erected the same year, at an expence of 2500*l*.; a bridewell, erected in 1809, at an expence of 1340*l*.; and a tontine inn, erected in 1802, at at expence of 10,000*l*. There are three established churches, viz. the West Church, which serves the country part of the parish, is very old, and very uncomfortable; the New Church, built in 1762, a large commodious place of worship in the centre of the town, and having a steeple attached to it 146 feet high; and the East Church, originally built in 1774 as a chapel of ease, but erected into a parish church in 1809. There is also a Chapel of Ease for the Gaelic population, built in 1791, at an expence of 1700*l*. and containing 1600 people. Besides these, there are various dissenting meetings: the Burgher meeting, erected in 1791, at an expence of 1300*l*. and containing 1000 sitters; the Antiburgher, erected in 1803, at an expence of 1122*l*.; the Relief, erected in 1808, at an expence of 2,200*l*., and containing 1700 sitters. There is also a Tabernacle, a Methodist meeting, and a Roman Catholic chapel. A Unitarian preacher in the theatre on Sunday evenings. There are public schools for all the various branches of literature and science. A free school, established in 1790, is under excellent management, and gives useful and religious education to hundreds of poor boys and girls, at an expence of 6*s*. 8*d*. per annum for each child. In 1812, a society was instituted in Greenock and Port Glasgow for the encouragement of arts and sciences. About 150 subscribers, at 5*s*. each per annum, were obtained, and the whole funds are distributed in prizes to persons of genius and merit. For some years, there has been connected with this an exhibition of paintings. Since 1793, there has existed an institution, under the title of the Greenock and Innerkip Farmer and Agricultural Society. There are several subscription and circulating libraries, with extensive collections of books. One newspaper, the Greenock Advertiser, is published thrice a week. The poor, who are very numerous, are supported partly by the public collections, partly by voluntary assessments, and partly by the interest of sums, which from time to time have been bequeathed to them by the charitable. There are various societies established by particular trades and professions, whose principal object is to afford relief to their decayed members: Such as the Ship-carpenters Society, instituted in 1732; Master Wrights Society, instituted in 1754; Shoemakers Society, instituted in 1754; Journeymen Coopers Society, instituted in 1792; Widows Society, instituted in 1796, &c. The Merchants House Society was instituted in 1787; five guineas are paid on admission, and 5*s*. annually for the support of those families or individuals belonging to it, who have grown indigent. There was formerly in Greenock a society, designed the Clyde Marine Society; but in 1786 it was incorporated by act of parliament with the Glasgow Marine Society. This institution is very rich and very useful. There are several banks and branches of banks established at Greenock, which do a great deal of business.

The old harbour of Greenock, begun to be built in 1707, contains about 10 acres. These are inclosed within two circular quays, in the middle of which is another quay built in 1712, projecting like a tongue. The original cost was 10,000 merks Scots, or 5625*l*. sterling, which was to be defrayed by a malt duty, and was liquidated in 1740, leaving a surplus of 1500*l*. In 1801 and 1803, acts of parliament were obtained for enlarging and improving the harbour; and when all the plans are executed, the accommodation for shipping, &c. in this port will be of a very complete and superior kind. The new harbour will contain about 8 acres of ground, which were obtained from Sir John Shaw Stuart and Lord Cathcart at 5 guineas per fall, and a shilling per fall of feu duty. During the last ten years, 85,000*l*. have been expended in extending the harbours, by building new quays, sheds, &c. and an additional sum of 25,000*l*. will be required to finish the work, including the expence of building a new graving dock.

The expence of erecting the present sheds, and keeping them in repair, has cost the trustees of the harbour 9868*l*. and those yet to be erected will not cost less than 3132*l*., making together 13,000*l*.

The revenue received from them for the year ending
September 1812, was 1201*l*.
Do. 1813, 1472
Do. 1814, 2052
Do. 1815, 2053

And the yearly rent on an average for five years ending in April last, is 1609*l*.

The anchorage or ring money for the year ending
September 1813, was 175*l*. 13
Do. 1814, 181 17
Do. 1815, 218 12

making the yearly rent on an average for three years 192*l*.

Ship-building is not so much followed as might have been expected at such a port as that of Greenock. On an average, there are about 10 or 12 vessels built annually. As to quality and construction, these vessels are equal to any in the united kingdom. There is a graving dock, which was erected by share holders in 1783. The building yard of Messrs John Scott & Co. containing a graving dock, a basin, boat and mast sheds, blacksmith's shop, &c. is, in point of size and convenience, superior to any private establishment of this kind in the kingdom. Mr Steele also has excellent premises for building and repairing ships.

There are four large rope works, and several smaller ones. They employ from 200 to 300 hands, and manufacture annually about 1000 tons of cordage, which is sold for the use of the shipping of the port, and for exportation to the colonies. There is one rope-work for making patent cordage. Sailcloth is also manufactured here to a considerable extent. There are two manufactories for this article. Greenock contains two soap and candle manufactories, which are carried on to a large extent, principally for supplying our North American and West India colonies with these articles. One of them is an old establishment, having existed since the year 1772. There are also two extensive breweries, both of which export large quantities, solid and in bottles. While the French West India islands were in our possession, the supply of this article was very great, particularly light coloured table beer. There are two iron and brass founderies; one large hat manufactory, and several smaller ones; a green glass and a flint glass work; three tan works; a pottery; and a lamp-black manufactory. All these depend greatly on the export trade, and the demand for the shipping.

An account of the number of ships and vessels, with their tonnage, and number of men and boys usually employed, registered, and belonging to the port of Greenock for the years ending 30th Sept. 1814 and 1815:

| | Ships. | Tons. | Men. |
|---|---|---|---|
| Year ending 30th Sept. 1814, | 360 | 34,159 | 3325 |
| Do. 30th Sept. 1815, | 336 | 35,210 | 3220 |

At present there are 379 ships, brigs, sloops, &c. registered at the custom-house, admeasuring 47,268 tons, and navigated by 3457 men.

An account of the number and tonnage of ships and vessels, which were of, and belonging to, the port of Greenock, with their number of men, that have traded to and from foreign parts, or coastwise, or been employed in fishing, in the years ending 5th January 1815 and 1816, accounting each vessel but once in the year.

| *Years ending* | *Foreign Trade.* | | | *Coasting.* | | | *Fishing.* | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ships. | Tons. | Men. | Ships. | Tons. | Men. | Ships. | Tons | Men. |
| Jan. 5. 1815, | 187 | 37,694 | 2428 | 103 | 7590 | 409 | 60 | 2721 | 368 |
| Jan. 5. 1816, | 187 | 35,205 | 2318 | 100 | 7410 | 441 | 71 | 3199 | 511 |

An account of the total number of ships, with their tonnage and men, including their repeated voyages, that have entered inwards and cleared outwards at this port, from and to foreign parts in the years ending 5th January 1815 and 1816, distinguishing British ships from foreign, but omitting such ships as have entered or cleared before at any other port in England or Scotland.

| | Inwards. | | | | | | Outwards. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | British. | | | Foreign. | | | British. | | | Foreign. | | |
| | Ships. | Tons. | Men. | Snips | Tons. | Men. | Ships. | Tons. | Men. | Ships. | Tons. | Men. |
| Year ending 5th Jan. 1815. | 327 | 55,229 | 3392 | 5 | 999 | 60 | 354 | 59,490 | 4149 | 5 | 1007 | 69 |
| Do. 5th Jan. 1816, | 347 | 55,337 | 3309 | 30 | 8155 | 396 | 350 | 55,524 | 3615 | 28 | 7087 | 376 |

An account of all vessels entered inwards and cleared outwards coastwise at this port, in the years ending 5th January 1815 and 1816.

| | Inwards. | | | Outwards. | | |
|---|---|---|---|---|---|---|
| | Ships. | Tons. | Men. | Ships. | Tons. | Men. |
| Years ending Jan. 5. 1815, | 562 | 27,386 | 1894 | 557 | 28,061 | 1885 |
| Do. 1816, | 513 | 27.128 | 1813 | 545 | 28.591 | 1904 |

The herring fishery has been long an object of importance to the town of Greenock. So far back as the year 1688, it was carried on to a considerable extent. Since that period, it has experienced frequent vicissitudes. The following statement will shew its present situation:

In the year ending the 5th of April 1815, there cleared out for the herring fishery 177 vessels, 6896 tons, manned with 958 men. Carried out 688,171 square yards of netting, 68,205½ bushels of British salt, and 36,861½ barrels.

Entered inwards from do. 174 vessels, 6612½ tons. Carried in 24,503½ bushels salt, 11,394½ barrels (not filled) with herrings, and 23,603½ barrels of herrings.

Exported to Ireland, 5828 barrels; to the north of Europe 350; to the West Indies 24,203. Total exported 30,381 barrels.

In the year ending the 5th of April 1816, there cleared out for the fishery 149 vessels, 5623 tons, manned with 814 men. Carried out 547,167 square yards of netting, 53,434½ bushels of salt, 30,172 barrels.

Entered inwards from the fishery 157 vessels, 5975 tons. Carried in 15,382 bushels salt, 6941 empty barrels, and 24,275½ barrels of herrings.

Herrings exported to Ireland, 4478 barrels; to the north of Europe 859; and to the West Indies 23,368. Total exported 28,705 barrels.

An account of the amount of duties received at the port of Greenock, for the two years ending 5th January 1815 and 1816.

| | | |
|---|---|---|
| Year ending | 5th January 1815, | L.376,713 15 10½ |
| Do. | 5th January 1816, | 403,176 6 8 |

Account of the amount of drawbacks and bounties paid forthe same period.

| | | Drawbacks. | Bounties. |
|---|---|---|---|
| Year ending | Jan. 5. 1815, | L.41,120 5 7¼ | L.67.978 8 3¾ |
| Do. | Jan. 5. 1816, | 32,924 2 3¾ | 81,617 19 1¾ |

The excise duties and drawbacks are not included in the above.

The total receipt of the duties of customs at the port of Greenock, year ending 5th January 1816, was 403,176*l.* 6*s.* 8*d.* principally under the following heads:

| | |
|---|---|
| Upon general goods imported | L.115,717 13 11¾ |
| Upon sugar, rum, coffee, tobacco, wine, &c. for home consumption . . . . . . . . . . | 275,111 10 2¼ |
| And upon general goods exported | 12,347 2 6 |
| | 403,176 6 8 |

And there was paid during said year for bounties, on linen, sail cloth, silk, sugar, and cordage, exported, 81,617*l.* 19*s.* 2¼*d.*

Vessels entered and cleared at the custom-house 1815, and paid harbour dues in and out.

| | Harbour Dues |
|---|---|
| 1638 vessels, 177,906 tons, . . . . . | L.4811 13 4 |
| 150 lighters employed on the river . . | 214 18 3 |
| From steam boats . . . . . . . . | 312 0 0 |
| Anchorage revenue . . . . . . . . | 350 0 0 |
| | L.5688 11 7 |

The slaughter of cattle, &c. for the years ending September 1813, 1814, and 1815.

| Year. | Cows. | Calves | Sheep. | Lambs. | Goats. | Hogs. | Revenue. |
|---|---|---|---|---|---|---|---|
| 1813 | 1721 | 1777 | 13,363 | 7003 | 1 | 224 | L 223 8 9 |
| 1814 | 1972 | 1904 | 13,911 | 7692 | 12 | 488 | 246 2 6 |
| 1815 | 2391 | 1996 | 15,105 | 8500 | — | 285 | 272 6 3 |

Making an average per year for three years of 247*l.* 5*s.* 10*d.*

In 1757, the population of Greenock was 3900. In 1781, it was 12,000. In 1792, it was 14,299. In 1797, it was 15,000. In 1802, it was 17,458, the number of houses being 1029; of males 8194, and of females 9262. In 1804, it was 20 000. And in 1811, it was, exclusive of those at sea, 19,042, having increased in the preceding 20 years 4743, or 1212 males, and 3531 females. Greenock is a burgh of barony. It was erected in 1757, by Sir John Shaw Stuart the superior, and is governed by a council of 9 feuers, 2 of whom are annually elected to the office of bailies, with corresponding powers. In 1795, the rental of the parish, comprising 5065 Scots acres, was 3500*l.* sterling, its valued rent being 2285*l.* Scots. In 1810, the rental was 10,000 sterling. (*r*)

GREENWICH, is a market town of England, in the hundred of Blackheath, and county of Kent. It is delightfully situated on the south bank of the Thames, where the river is from 320 to 360 yards broad at low water, and is principally celebrated for its splendid naval hospital, and for the Royal Observatory. The kings of England had a royal residence at Greenwich since the reign of Edward I. A. D. 1300. After the restoration of Charles I. when the buildings had fallen almost into ruin, this monarch ordered them to be taken down, and a magnificent palace of freestone to be erected on the spot, from the designs of Webb, the son-in-law of Inigo Jones. Only one wing of this edifice was completed, at the expence of 36,000*l.* Charles occasionally resided in it; but it was not till the reign of William III. that any farther progress was made in the building. The government having resolved, on the suggestion of the queen, to provide an asylum for old and disabled seamen, Sir Christopher Wren recommended that the unfinished palace should be devoted to this purpose. A grant of the palace and adjoining lands was made in 1699 to commissioners. The foundation stone was laid on the 3d June 1696, and was gradually enlarged and improved till it reached its present state of splendour and magnificence.

The following account of Greenwich hospital has been abridged from a very full and excellent description of it in the *Beauties of England and Wales.*

Greenwich hospital is principally built with Portland stone, and consists of four distinct quadrangular masses of buildings, distinguished by the names of the respective sovereigns, in whose reigns they were founded or built. The grand front opens on a terrace, skirting the southern bank of the Thames, and extends 865 feet in length, in the centre of which is a descent to the river, by a double flight of steps. The ground plan of the whole edifice forms nearly a square, of which King Charles's building occupies the north-west angle; Queen Anne's, the north-east; King William's, the south-west; and Queen Mary's, the south-east. The interval between the two former buildings forms a square 270 feet wide, in the middle of which is a statue of George II. sculptured by Rysbrach, out of a single block of white marble, which weighed 11 tons, and was taken from the French by Admiral Rooke: this statue was given to the hospital by Sir John Jennings, who was governor from 1720 to 1744. The inscriptions on the pedestal were by Mr Haugan. The space between the two latter buildings, which include the hall and chapel, with their elegant domes, and the two colonnades, forms a lesser square. The two squares are intersected by a spacious avenue, leading from the town through the hospital. The buildings which immediately front the Thames have a general correspondence in style and arrangement. The north and south fronts of each exhibit the appearance of a double pavilion, conjoined above by the continuation of an Attic order, with a balustrade, which surmounts the whole, but is separated below by an open portal. The centre of each pavilion displays an elegant pediment, supported by four Corinthian columns, and the sides a double pilaster of the same order. King Charles's building contains the apartments of the governor and lieutenant-governor, the council-room, and anti-chamber; with 14 wards, wherein 300 pensioners may be accommodated. In the council-room are several portraits: in the anti-chamber two large sea-pieces, given to the hospital by Philip Harman, Esq.; and a series of six small pieces, representing the loss of the Luxemburgh galley, in 1727. Queen Anne's building, which was erected between 1698 and 1728, contains several apartments for inferior officers, with 24 wards for 437 pensioners. King William's building stands to the south-west of the great square, and comprises the great hall, vestibule, and dome, designed and erected by Sir Christopher Wren, between the years 1698 and 1703. To the inner side of each range is attached a colonnade 347 feet in length, supported by Doric columns, and pilasters 20 feet in height. The great hall, or saloon, is 106 feet in length, 56 in width, and 50 high: the ceiling and sides are covered with portraits and emblematical figures, executed by Sir James Thornhill, for which he was paid at the rate of 3*l.* per square yard for the ceiling, and 1*l.* for the sides, amounting in the whole to 6685*l.* The west front of King William's building, which is of brick, was finished about 1725 by Sir John Vanbrugh: the building contains 11 wards, wherein are 551 beds. The foundation of the eastern colonnade, which is similar to that on the west side, was laid in 1699; but the chapel, and the other parts of Qeen Mary's building which adjoin to it, were not finished till 1752. It corresponds with King William's, and is furnished with 1092 beds, in 13 wards. The chapel which forms part of Queen Mary's building, is one of the most elegant specimens of Grecian architecture in this kingdom, and was erected from the classical designs of the late James Stuart, Esq. It is 111 feet in length, and 52 in width, and is capable of accommodating 1000 pensioners, nurses, and boys, exclusive of the seats for the directors and other officers. The entrance portal consists of an architrave, frieze, and cornice, of statuary marble: the folding-doors are of mahogany, highly enriched by carving. The interior is finished in an elegant style, and is adorned with many appropriate paintings, the most distinguished of which is the altar-piece, executed by West, and representing the preservation of St Paul on the island of Melita. There is a double range of windows on each side of the chapel. Without the walls of the hospital stands the infirmary, erected in 1763, after a design by Stuart: it forms an oblong quadrangle, 198 feet long and 175 broad, consists of two stories, and is divided into two principal parts, appropriated respectively to those whose cases require surgical aid, and to those who need only medical assistance. It contains sixty-four rooms, and each is fitted up for the accommodation of four patients. It also includes a chapel, hall, kitchen, and apartments for the physician, surgeon, and apothecary; with hot and cold baths, and other necessary offices. Near the hospital is the school, where 200 poor children are educated. The school-house was erected in 1783, by Stuart. It is 146 feet long, 42 broad, exclusive of a Tuscan colonnade, in front 180 feet long, and 20 broad, for the boys to play in during bad weather. The pensioners, who are the objects of this noble charity, must be seamen disabled by age, or maimed either in the king's service, or in the merchant service, if the wounds were received in defending or taking any ship, or in fight against a pirate. Foreigners, who have served two years in the British navy, become entitled to the benefits of this institution in the same manner as natives. The widows of seamen are provided for, having the exclusive privilege of being nurses in the hospital. The number of pensioners is upwards of 2400, (of whom at an average 203 die annually,) who are furnished with clothes, diet, and lodging, with a small allowance of pocket-money. The nurses are 144, each of whom receives eight pounds per annum as wages, with every necessary of life. The commissioners of the hospital are about 100, and consist of all the great officers of state, the archbishops, the lord chancellor, the judges, the master and five senior brethren of Trinity-house, the lord mayor, and three senior aldermen of London, with some of the principal officers of the hospital. The annual average expence of each pensioner, according to the report of the commissioners of naval enquiry, was estimated at 27*l.* 10*s.* 9*d.* per man; and of the nurses 29*l.* 15*s.* each, the total annual expence being 69,206*l.* 5*s.* The funds of the establishment are principally derived from a duty of sixpence per month, paid by every mariner, either in the king's or merchant's service; the forfeited estates of the Earl of Derwentwater, containing many valuable lead and other mines; various benefactions from different sovereigns, from parliament, and from private persons, from fines for offences committed on the Thames, from the half-pay of such of its officers as have regular salaries, and from other sources of less importance.

Greenwich park, which is vested in the crown, was encircled with a wall by James I. and contains 188 acres. It is planted chiefly with elms and Spanish chesnuts, some of which are of a very large size. In one part of the park are the remains of many ancient barrows, in some of which were found human bones, spear heads, &c. The upper part of the park is considerably elevated above the Thames; and on one of the eminences stands the Royal Observatory, which was built by Charles II. in 1675, on the site of the ancient tower erected by Duke Humphrey in the reign of Henry VI. It is built of brick, and is by no means an elegant structure; but it contains excellent apartments for the Astronomer Royal, and commodious rooms for the admirable instruments, with which it is now furnished. Flamstead, the first Astronomer Royal, died in December 1719, and was succeeded by Dr Halley. Dr Bradley succeeded upon the death of Halley in 1742, and died in 1762. Dr Bliss held the office for two years, and was succeeded in 1764 by Dr Maskeline. Mr Pond, the present Astronomer Royal, succeeded Dr Maskelyne in 1811, and, by means of the fine mural circle constructed by Troughton, has already made a series of the most valuable observations, decidedly the most accurate that have been made in any of the other observatories of Europe.

A farther account of the institution, and of the instruments it contains, will be found in our history of ASTRONOMY, and in the articles CIRCLE and OBSERVATORY.

The church of Greenwich is an elegant stone building, and was erected in 1718. Greenwich contains two hospitals for poor people, and several schools for the education of the poor, and some excellent boarding schools. The following is the population abstract for 1811, for the town of Greenwich:

| | |
|---|---|
| Number of houses | 2,315 |
| Number of families | 3,276 |
| Ditto employed in agriculture | 96 |
| Ditto in trade and manufactures | 1,002 |
| Males | 8,723 |
| Females | 8,224 |
| Total population | 16,947 |

GREGORIAN CALENDAR. See CHRONOLOGY.

GREGORIAN TELESCOPE. See OPTICS.

GREGORY, St VINCENT. See GEOMETRY.

GREGORY, JAMES, an eminent Scotch mathematician and natural philosopher, was born at Aberdeen in the month of November 1638. He was a son of the Rev. Mr John Gregory of Drumoak, in Aberdeenshire,* who was married to the daughter of Mr David Anderson of Finshaugh, the brother of Alexander Anderson, who was professor of mathematics at Paris: (See ANDERSON.) Having lost his father in the 13th year of his age, the charge of his education devolved upon his elder brother David Gregory, who put into his hand the Elements of Euclid, and stimulated the ardour which he had begun to show for mathematical learning. After having completed his philosophical studies at the Marischal College of Aberdeen, James Gregory directed his particular attention to the subject of optics, and he published the results of his labours in a work, entitled *Optica promota seu abdita radiorum reflexorum et refractorum mysteria, geometrice enucleata, cui subnectitur Appendix subtilissimorum astronomiæ problematum resolutionem exhibens*, Lond. 1663. It was dedicated to Charles II. and was completed with the assistance and encouragement of his brother David, after he had been stopped a long time at the twenty-sixth problem.† This work is remarkable, as containing the description of a new reflecting telescope, and the deduction of the true law of refraction. The method in which he has investigated this law is remarkable for its elegance and originality; and, in his experimental demonstration of it, we are furnished with a striking proof of the accuracy of his observations. In comparing the refractions calculated by the law with the experiments of Vitellio on the refractions of water and glass, the greatest error amounts to 61′ in water, and 94′ in refractions from glass into water. When compared with the experiments of Athanasius Kircher, the greatest error in water is 89′, in wine 110′, in oil 104′, and in glass 93′; but in comparing them with his own observations, the greatest error is only 15′; and it is remarkable that he made the index of refraction for water 1.3347, differing only 0.0018 from 1.3358 the most accurate measure, whereas Vitellio made it 1.306. Before the publication of the *Optica Promota*, Gregory was informed, that he was anticipated in the discovery of the law of refraction by Descartes, and he thus alludes to it in his preface:—*Et ex analogiis in prima hujus tractatuli propositione declaratis, inveni primam hujus opticæ partem, de genuina refractionum hypothesi et mensura nescius scilicet* (*propter inopiam novorum librorum Mathematicorum in alias inclyta Bibliotheca Abredonensi*) *hæc eadem a Cartesio fuisse inventa.*

The invention of the reflecting telescope formed an epoch in optics and astronomy. Gregory was not acquainted with the errors in dioptric instruments, arising from the unequal

* The following quotations, relative to the Rev. John Gregory of Drumoak, are taken from Spalding's *History of the Troubles in Scotland*, from 1624 to 1645:

"Upon the second day of June, 1640, Mr John Gregory, minister at Drumoak, was brought into Monro by a party of soldiers: He was taken out of his bed naked upon the night, and his house pitifully plundered. He was closely keeped in Skipper Anderson's house, having five musketeers watching him night and day, and sustained upon his own expences. No not his own wife could have private conference with him, so strictly was he there watched. At last he is fined to pay Major-General Monro 1100 merks, for his outstanding against the covenant, and syne got liberty to go; but in the General Assembly holden in July, he was nevertheless simplicieter deprived, because he would not subscribe the covenant; and when all was done, he is forced to come in and yield to subscribe the covenant.

"Next, Mr John Gregory having been summoned to appear before the General Assembly (1640), by and attour his being fined in 1000 merks, as ye have before, was deposed from the ministry of Drumoak. The Laird of Drum deals for him, being his own pastor, and upon swearing and subscribing the covenant, and teaching penitentially, with great difficulty he was again restored (1641) to his own parish-kirk.

"Upon Thursday, the 15th of April, 1641, being a presbytery day, Mr John Gregory, of whom ye heard before, teached a penitential sermon in New Aberdeen. It was not found satisfactory by Mr James Hervie, Moderator, and the remnant members of the Presbytery, and he was ordained to put the same in write. The brethren advised the same with the next Provincial Assembly, who found it not satisfactory, and therefore they ordained him to preach penitentially at certain kirks, till he gave content to the next ensuing General Assembly; which he obeyed. He was received and reinstated in his kirk (1641).

"Upon Tuesday, the 6th of September, 1642, Mr John Gregory, at the visitation of the kirk of New Aberdeen, teached most learnedly upon the fourth verse of the second chapter of the Colossians, and reprehended the order of our kirk, and new brought in points. Mr Andrew Cant, sitting beside the reader, as his use was, offended at this doctrine, quickly closed the reader's book, and laid down the glass before it was run, thinking the minister should the sooner make an end; but he beheld and preached half an hour longer than the time. Sermon being ended, the brethren conveen to their visitation, where Mr Andrew Cant impugned this doctrine, desiring the said Mr John to put the same in write. He answered, he would not only write, but print his preaching, if need so required, and abide by all that he had teached as orthodox doctrine. The brethren heard all, and had their own opinions, but without any more censure they dissolved, somewhat perturbed with Cant's curiosity.

"Upon Thursday he railed out in his sermon against the said Mr. John Gregory's doctrine, and on Sunday likewise. At last, by mediation of the town's baillies, at a cup of wine, they two were agreed, and settled, with small credit to Cant's business."

Mr Gregory of Drumoak was one of the first persons in Scotland who understood the use of the barometer as an instrument for predicting the weather. Having one day observed that the mercury was falling rapidly, he advised his parishioners to remove the sheaves of corn from the low grounds on the banks of the river Dee. They immediately followed his advice, and when they found his prediction verified by an unusual rise of the river, they were naturally led to regard him as a being of a superior order. Mr Gregory died about the year 1652.

† "Ubi diu hæsi omni spe progrediendi orbatus; sed continuis hortatibus et auxiliis fratris mei Davidis Gregorii in mathematicis non parum versati (cui siquid in hisce scientiis prestitero, me illud debere non inficias ibo) animatus tandem incidi in seriam imaginis considerationem, &c." *Pref. ad Optic. Promot.*

refrangibility of the rays of light; and his principal object in proposing this new instrument, was to avoid the error arising from the spherical figure of the lenses. It consisted of a parabolic concave mirror, near whose focus is placed a small concave elliptic speculum, having a common focus with the parabolic one. This instrument gave rise to the Newtonian telescope, in which the small mirror is plane, and reflects the image to the side of the tube where the eye-glass is placed; and also to the Cassegrainian telescope, which differs only from that of Gregory in having the small speculum convex instead of concave. The Gregorian principle has been almost universally used for telescopes of a moderate size. The Newtonian form has been adopted in the magnificent instruments used by Dr Herschel; but it is extremely probable, that the Cassegrainian telescope, in which the rays never cross each other at a focus,* will hereafter be considered as the most valuable of the reflecting telescopes. The *Optica Promota* is terminated by a collection of astronomical problems. The object of one of these, is to determine the paralaxes of two planets from their conjunction; and, in a scholium to this problem, he points out the great use of the transits of Venus and Mercury, in determining the sun's parallax.† This happy idea, which has since been of such service to astronomy, has always been ascribed to Dr Halley.

Mr Gregory went to London about the year 1664 or 1665, and was introduced to Mr Collins, the secretary to the Royal Society, who introduced him to some of the best practical opticians, for the purpose of having his reflecting telescope executed. A Mr Rives was employed for this purpose, but he could not polish the speculum upon the tool, and was therefore obliged to do it with a cloth and putty. The success of this trial was so little, that Gregory was discouraged from making any farther attempts, and a tube was never even made to hold the mirrors. He afterwards, however, made some trials with a little concave and convex speculum; but, to use his own words, "they wer but rude, seeing I had but transient views of the object; being so possessed with the fancie of the defective figure, that I wold not be at the pains to fix every thing in its due distance."

After these unsuccessful attempts to construct a reflecting telescope, Gregory left England, and fixed his residence at Padua, which was then in high repute as a seat of mathematical learning. Here he published, in 1667, 1668, his work, entitled, *Vera Circuli et Hyperbolæ Quadratura in propria sua proportionis specie inventa, et demonstrata*, which contains his discovery of an infinitely converging series for the areas of the circle, ellypsis, and hyperbola. A copy of this work was laid before the Royal Society by his friend Mr Collins, and was honoured with the approbation of Lord Brouncker and Mr Wallis. In the following year he reprinted it at Venice, and added a new work, entitled, *Geometricæ pars universalis quantitatum curvarum transmutationi et mensuræ, inserviens*, which contains a new method for the transmutation of curves. This work had previously appeared at Padua in 1668; and, upon its arrival in England, was read by Mr Collins to the Royal Society.

In the year 1670, Mr Gregory received, in a letter from Mr Collins, a series for the area of the zone of a circle, and being informed that Newton had invented an universal method by which he could square all curves geometrical and mechanical by infinite series of that kind, Gregory applied himself to the investigation of the subject, and discovered an universal method of series, which he communicated to Newton, and the other English mathematicians, by a letter to Collins, dated February 1671. His brother David urged him to publish this method without delay; but he declined this from the most honourable motives; for Newton having been the first inventor, he thought himself bound to wait till his method should be published.

Upon Mr Gregory's return to London, we believe in 1668, he was elected a fellow of the Royal Society, and laid before them an account of a dispute in Italy relative to the earth's motion, which Riccioli and his followers had denied. About this time also he engaged in a dispute with the celebrated Huygens through the medium of the *Philosophical Transactions*. Huygens published in the *Journal des Sçavans*, July 2d 1668, some animadversions on Gregory's quadrature of the circle, and particularly objected to the proposition which stated the impossibility of expressing perfectly the area of a circle in any known algebraical form besides that of an infinite converging series. Gregory defended himself in the 37th Number of the *Philosophical Transactions*, and the dispute was carried on with considerable warmth by both parties. The whole of the controversy will be found in Huygens' *Opera Varia*, vol. ii. p. 463.

In 1668, Gregory published in London his *Exercitationes Geometricæ*, a small work of twenty-six pages, which contains the following subjects:

Appendicula ad verum Circuli et Hyperbolæ Quadraturam.

N. Mercatoris Quadratura Hyperbolæ Geometrice demonstrata.

Analogia inter Lineam Meridianam Planispherii Nautici et Tangentes Artificiales Geometrice demonstrata; seu quod secantium Naturalium additio efficiat Tangentes Artificiales.

Item, Quod Tangentium Naturalium additio efficit Secantes Artificiales.

Quadratura Conchoidis.

Quadratura Cissoidis.

Methodus Facilis et Accurata componendi Secantes et Tangentes Artificiales.

The preface to this work, and the introduction to the *Appendicula*, &c. are remarkably interesting, in so far as they throw considerable light on the dispositions of our author. He speaks with great severity of the jealousy and injustice of his contemporaries, and alludes to the treatment which he had received from Huygens. In the introduction to the *Appendicula*, he resumes this subject with more keenness. He declares, that Huygens had accused him of ignorance and plagiarism; and after arguing against Huygens' claim to the discovery, he concludes with this remarkable passage: "At parum refert quis sit ejus primus inventor, satis enim constat me primum esse publicatorem; neque mihi esset difficile affirmare (si modo mentiri vellem) me ante 20 annos illam cognovisse: utcunque sit, conabor hic circuli et hyperbolæ quadraturam ad talem per-

* The effect of the collision of the rays in the focus was first noticed by Dr Brewster, in the most perfect achromatic telescopes: (See *Treatise on New Philosophical Instruments*, p. 44. and 193.) It was afterwards observed in reflecting telescopes by Mr Kater, who has examined the subject with much attention and success: (see *Phil. Trans.* 1813, 1814.) We have found from experiment, that the heat of a burning lens, as well as the light, is more intense within than without the focus, and that radiant heat is also most intense within the focus. Mr Leslie had long before obtained the same result with regard to radiant heat. It is therefore certain, that this diminution of effect must arise from the collision of the luminous as well as of the calorific rays. We may therefore lay it down as a principle in the construction of optical instruments, that the rays should, if possible, never be brought to a positive focus.

† "Hoc Problema pulcherrimum habet usum, sed forsan laboriosum in observationibus Veneris vel Mercurii particulam solis obscurantis: ex talibus enim solis parallaxis investigari poterit." *Optic. Promot.* schol. prop. 87.

fectionem promovere, ut Hugenius prolem suam vix cognoscat."

Mr Gregory was about this time elected professor of mathematics in the university of St Andrew's. In 1669, he married the daughter of George Jamieson, the celebrated Scottish painter, by whom he had a son, James, the father of Dr John Gregory, (the subject of a succeeding article,) and two daughters. In August 1672, he began a correspondence with his friend Mr Collins, relative to the comparative merits of his own telescope, and that of Sir Isaac Newton. The sentiments of the two philosophers were communicated to each other by their respective friends, and the dispute was thus carried on in the most amicable manner. The correspondence has been published by Dr Desaguliers, at the end of his edition of Dr David Gregory's Catoptrics and Dioptrics.

In the year 1669, a work was published at Rotterdam, by Mr George Sinclair, professor of philosophy in the university of Glasgow, entitled *Ars Nova et Magna Gravitatis et Levitatis;* and another work on hydrostatics, by the same author, appeared at Edinburgh in 1672. Mr Sinclair had been dismissed from his professorship soon after the restoration, on account of his political principles, and had given offence to the Royal Society of London, by charging them with negligence and injustice. He appears also to have acted improperly towards one of Mr Gregory's colleagues, and thus to have incurred the displeasure of that mathematician. In the year 1672, Gregory, under the assumed name of Patrick Mathers, archbedal to the university of St Andrew's, attacked Sinclair, in a tract, entitled *The great and new art of weighing Vanity, or a discovery of the Ignorance and Arrogance of the great and new Artist, in his Pseudo-philosophical writings.* To this work is annexed *Tentamina de motu penduli et projectorum.*

In 1674, Gregory was called to the mathematical chair in the university of Edinburgh, a situation which he did not live long to enjoy. In the month of October 1675, when he was walking home from supper, he was struck suddenly blind, and expired a few days afterwards, in the 36th year of his age.

The following is a list of the inventions and discoveries of James Gregory, as given by Dr Hutton. The reflecting telescope; burning mirror;* quadrature of the circle, ellipse, and hyperbola; method for the transmutation of curves; geometrical demonstration of Lord Brouncker's series for squaring the hyperbola; demonstration that the meridian line is analogous to a scale of logarithmic tangents, of the half complements of the latitude; a simple converging series for making logarithms; solution of the famous Keplerian problem, by an infinite series; method of drawing tangents to curves geometrically, without previous calculation; a rule for the direct and inverse method of tangents, depending on the principle of exhaustions; a series for the length of the arc of a circle from the tangent, and *vice versa*, and also for the secant and logarithmic tangent and secant, and *vice versa*; and serieses for the length of the elliptic and hyperbolic curves. See Hutton's *Mathematical Dictionary*, 2d edition, p. 601, &c. and the other works quoted in the article.

GREGORY, David, Dr, a celebrated astronomer and mathematician, was the nephew of the subject of the preceding article, and the eldest son of David Gregory of Kinnairdie. He was born at Aberdeen in the year 1661, and after receiving his education at the grammar school of that town, he went to Edinburgh for the purpose of completing his studies. In 1684, when he was only 23 years of age, he was appointed professor of mathematics in the university of Edinburgh, and in the same year he published his work, entitled *Exercitatio Geometrica de Dimensione Figurarum sive specimen methodi generalis Dimetiendi quasvis figuras.* Mr Gregory having found among his uncle's papers particular examples of infinite series, without any of the methods, proposes in this treatise to explain a method which may suit the examples given by his uncle; and he does this by applying the principles of indivisibles, and the arithmetic of infinites, to particular cases in hyperbolas, parabolas, ellipses, spirals, cycloids, conchoids, and cissoids. He also explains several methods of reducing compound quantities into infinite series, so that the method of infinites may be conveniently applied to them.

Dr Gregory seems to have been one of the earliest supporters of the Newtonian philosophy in Britain; and while the doctrines of Descartes were in the highest esteem at Cambridge, the true system of the universe was publicly taught in the university of Edinburgh.

In consequence of a report that Dr Bernard proposed to resign the Savilian professorship of astronomy at Oxford, Gregory went to London in 1691, and, in spite of the brilliant talents of his competitor Dr Halley, he was appointed to succeed Dr Bernard, through the friendship and influence of Sir Isaac Newton and Mr Flamstead. Halley, who lost this appointment in consequence of his attachment to infidelity, became afterwards the colleague of Dr Gregory, when, in 1703, he succeeded to Dr Wallis as Savilian professor of geometry. During Mr Gregory's residence in London, he was elected a fellow of the Royal Society, and before his appointment to the mathematical chair, the university of Oxford had conferred upon him the degree of doctor of physic.

In the year 1692, Viviani, one of the disciples of Galileo, had proposed to mathematicians the Florentine problem of the quadrable dome. Leibnitz and Bernoulli had resolved this problem on the very day on which they had received it, and the Marquis L'Hospital had also given a solution. Dr Wallis and Dr Gregory were equally successful, and the latter published his solution in the *Philosophical Transactions* for 1693, under the title of *Solution of the Florentine Problem, concerning the Testudo veliformis Quadrabilis.* In 1694, he published another paper in the *Transactions*, containing a vindication of his uncle from a charge preferred by the Abbot Galloise,* that James Gregory and Dr Barrow had stolen from Roberval their general propositions concerning the transformation of curves. Galloise replied in the *Memoirs of the Academy* for 1713; and Dr Gregory put an end to the controversy by a very sharp answer, which appeared in the *Philosophical Transactions* for 1716, and which was the last of his communications to that learned body.

In 1695, Mr Gregory published at Oxford his *Catoptricæ et Dioptricæ Sphericæ Elementa*, a work which formed the substance of lectures which he delivered in 1684, in the university of Edinburgh, and which require no higher mathematical knowledge than the Elements of Euclid. This work was republished and translated by Dr William Browne, with several important additions; and a third edition of it by Dr Desaguliers, appeared in 1735. In this work it is stated, that, in the construction of telescopes, "it would perhaps be of service to make the object lens of a different medium, as we see done in the fabric of the eye, where the crystalline humour (whose powers of refracting the rays of light differs very little from that of glass) is by nature, who never does any thing in vain, joined with the aqueous and vitreous humours, (not differing from water as to their power of refraction,) in order that

* See our article Burning Instruments.

† See *Hist. Acad. Par.* 1693.

the image may be painted as distinct as possible on the bottom of the eye. We cannot agree with the biographers of Dr Gregory, in considering this suggestion as any thing like an anticipation of the principle of the achromatic telescope; for it was impossible to form an idea of the construction of that instrument, till it was discovered that bodies possess different dispersive powers. This remarkable property of light, even the penetrating mind of Newton failed to discover; and we must not allow ourselves to diminish the well-earned reputation of Dollond, by giving to another any portion of the praise which is so exclusively due to himself. In the year 1747, more than 50 years after this conjecture of Dr David Gregory was published, the celebrated Euler suggested the human eye as the model of an achromatic telescope, and several ignorant foreigners have ventured to claim a share of Dollond's merit for this illustrious mathematician. Whatever credit therefore may be given to Euler, must now be claimed for our countryman David Gregory.

In the year 1697, our author published, in the *Phil. Transactions*, a long paper *On the properties of the catenaria or curve line, formed by a heavy and flexible chain, hanging freely from two points of suspension.* The leading properties contained in this communication, had been previously discovered and published by Huygens, Leibnitz, and Bernoulli, but without demonstrations; and Mr Gregory proposed to himself to demonstrate these properties. An anonymous writer in the Leipsic Acts for February 1691, attacked this paper as destitute of originality. Dr Gregory replied to this attack in the *Phil. Trans.* for 1699, and claimed as his own discovery the property of the catenaria as being the true geometrical figure of an equilibrated arch. This discovery, however, had been previously made by Dr Hooke *.

The greatest of Dr Gregory's works, and that on which his fame must rest, appeared at Oxford in 1702, entitled *Astronomiæ Physicæ et Geometriæ Elementa*, Fol. In this valuable work, all the physical explanations are founded on the principles of the Newtonian philosophy; and the geometrical parts are either proved by reference to the writings of standard authors, or demonstrated by lemmas inserted in their proper places. A very admirable analysis of this work was given, apparently by Dr Halley, in the *Phil. Trans.* for 1703. Newton himself considered these elements as an excellent defence and exposition of his philosophy.

This work was followed, in 1703, with an edition of Euclid, entitled *Euclidis quæ supersunt omnia, Gr. et Lat. ex recensione Davidis Gregorii*, M. D. &c. It was published in prosecution of a plan of Sir Henry Saville to print the works of the ancient mathematicians. It contains the Elements; the Data; two musical tracts; the Optics and Catoptrics; the tract *De Divisionibus;* and a fragment, *De Levi et Ponderoso.*

In the year 1704, Dr Gregory published, in the *Philosophical Transactions*, a paper on *Cassini's Orbit of the Planets*, in which he shewed that the hypothetical curve proposed by that astronomer, is not consistent with the received doctrines of astronomy.

After Dr Halley had been appointed to the Savilian professorship of Geometry in 1703, he embarked with Dr Gregory in the prosecution of Sir Henry Saville's plan, and had begun the publication of the Conics of Apollonius; but after having proceeded a short way in this undertaking, he was seized with an illness of which he died, at Maidenhead in Berkshire, on the 10th of October 1710, in the 49th year of his age.

He left behind him four sons by his wife Elizabeth, daughter of Mr Oliphant of Langtown, to whom he was married in 1695. Among his manuscripts were found, *A Short Treatise of the nature and Arithmetic of Logarithms*, which was afterwards published in Dr Keill's translation of Commandine's Euclid; a *Treatise of Practical Geometry*, which was translated and published by Mr Maclaurin in 1745; and a commentary on the *Principia*, which Newton kept by him many years after the author's death. Sir Isaac had entrusted Gregory with a manuscript copy of the *Principia* for this purpose, and he availed himself of the annotations of his friend in the second edition of that immortal work. A complete copy of these observations was presented, by the present Dr James Gregory, to the library of the University of Edinburgh, where it is carefully preserved. There are some paragraphs in this manuscript in the handwriting of Huygens, concerning his theory of light.

His wife, who survived him, erected an elegant monument to his memory in the church of St Mary, Oxford, with the following inscription:—

P. M.
DAVIDIS GREGORII, M. D.
Qui Aberdoniæ natus, Jun. 24, 1661,
In Academia Edinburgensi
Matheseos prælector publicus,
Deinde Oxonii
Astronomiæ Professor Savillianus,
Obiit Oct. 10. A. D. 1710;
Ætatem illi heu brevem Natura concessit,
Sibi ipsi longam prorogavit
Scriptor illustris.
Desideratissimo viro
Elizabetha Uxor.

David Gregory, of Kinnairdie, the brother of the celebrated James Gregory, was born in 1627, and served an apprenticeship to a mercantile house in Holland; but having a great passion for knowledge, he returned to Scotland in 1655, when he was 28 years old, and having succeeded to the estate of Kinnairdie, by the death of an elder brother, he devoted his time to mathematics and philosophy. He appears to have been the first person in the country who had a barometer, and he had the honour of corresponding, upon meteorological subjects, with the celebrated Mariotte. "About the beginning of the last century," says Dr Reid, "he removed with his family to Aberdeen, and, in the time of Queen Anne's war, employed his thoughts upon an improvement in artillery, in order to make the shot of great guns destructive to the enemy, and executed a model of the engine he had conceived. After making some experiments with this model which satisfied him, the old gentleman was so sanguine in the hope of being useful to the allies in the war against France, that he set about preparing a field equipage with a view to make a campaign in Flanders, and in the mean time sent his model to his son, the Savilian Professor, that he might have his and Sir Isaac Newton's opinion of it. His son shewed it to Newton, without letting him know that his own father was the inventor. Sir Isaac was much displeased with it, saying, that if it tended as much to the preservation of mankind as to their destruction, the inventor would have deserved a great reward; but as it was contrived solely for destruction, and would soon be known by the enemy, he rather deserved to be punished, and urged the professor very strongly to destroy it, and if possible to suppress the invention. It is probable the professor followed this ad-

* See Robison's *System of Mechanical Philosophy*, Vol. I.

vice; for at his death, which happened soon after, the model was not to be found.

When the rebellion broke out in 1715, the old gentleman went over a second time to Holland, and returned when it was over to Aberdeen, where he died, about 1720, in the 93d year of his age. He left behind him a historical manuscript of the transactions of his own time and country."

Mr Gregory had twenty-nine children by two wives, and he had the good fortune to see three of his sons professors of mathematics at the same time, viz. David Gregory at Oxford, James at Edinburgh, and Charles at St Andrews. James was first a professor of philosophy at St Andrews, and succeeded David when he removed to Oxford. Charles was created professor of mathematics at St Andrews in 1707, and in 1739 he resigned that office in favour of his son, Professor David Gregory, who died in 1763, and left behind him a good compendium of arithmetic and algebra, with the title, *Arithmeticæ et Algebræ compendium, in usum Juventutis Academicæ*, Edin. 1736. His son David was master of an East India ship. David Gregory, the eldest son of the Savilian professor, was appointed Regius Professor of Modern History, at Oxford, and died in 1767, after having filled, for many years, the situation of dean of Christ's church. The celebrated James Gregory, the inventor of the reflecting telescope, had only one son, James, born in 1674, who was professor of medicine in King's College, Aberdeen. His youngest son was Dr John Gregory (the subject of the next article), and the father of the present Dr James Gregory, professor of the practice of medicine in the university of Edinburgh.

GREGORY, John, Dr, an eminent physician, was born at Aberdeen on the 3d of June 1724, and was the youngest child of Dr James Gregory, professor of medicine in King's College, Aberdeen, by his second wife, Anne Chalmers, the only daughter of the Rev. Principal Chalmers of King's College.

In consequence of the death of his father when he was only seven years old, the charge of his education devolved upon Principal Chalmers, his elder brother Dr James Gregory, who had succeeded his father as professor of medicine, and his cousin, the late celebrated Dr Reid. After receiving the first rudiments of his education at the grammar school of Aberdeen, he entered King's College, and made rapid progress in the knowledge of ethics, mathematics, and natural philosophy.

In 1742, he went to Edinburgh, accompanied by his mother; and having resolved to pursue the study of medicine, he attended the different medical lectures, and became a member of the Medical Society, at a time when his friend, the celebrated Dr Akenside, was a member of the same institution. In the year 1745, Mr Gregory went to Leyden, to complete his professional studies, under the care of Albinus, Gaubius, and Van Royen, who were at that time the ornaments of the university. Here he became acquainted with the famous John Wilkes and the Hon. Charles Townshend, two of the greatest wits of the age; and before he left this university, he received from King's College, Aberdeen, an unsolicited degree of doctor of medicine. Upon his return from Holland, he was chosen professor of philosophy in the same college; and during the years 1747, 1748, and 1749, he read lectures in mathematics, experimental philosophy, and moral philosophy.

Having resolved, however, to establish himself as a physician at Aberdeen, he resigned his professorship in the end of 1749, and went for a few months to the continent.

After he returned to Scotland, he married, in 1752, Elizabeth, daughter of William Lord Forbes, who brought him a handsome addition to his fortune. This accomplished and amiable woman, who possessed the rare combination of great beauty and great intelligence, lived only nine years after her marriage, and left her husband and six children to lament their premature loss.

Perceiving little prospect of succeeding in Aberdeen to the full extent of his wishes, Dr Gregory resolved to settle in London, where he arrived in 1754. He was chosen a Fellow of the Royal Society in the same year; and, from the influence and attachment of his friends, as well as from his own professional talents, he had the best prospects of an extensive practice. The death of his elder brother, however, occasioned a vacancy in the professorship of physic in King's College, Aberdeen; and being solicited to accept of this situation, he returned to his native country in 1756, and began to discharge the duties of his new office.

Among the eminent young men who at that time adorned the university, were Reid, Campbell, Beattie, Gerard, John Stewart, professor of mathematics in Marischal College, and David Skene, a correspondent of the celebrated Linnæus. These young men established a literary society or club, which met weekly at a tavern. A short essay was read by each member in rotation, and a literary or philosophical question was proposed every night as a subject of discussion at the following meeting. The proposer of the question was obliged not only to open the discussion, but to digest the opinions of the different members in the form of an essay, which was ingrossed in the album of the society. Several of those composed by Dr Gregory, on philosophical, moral, and political questions, still exist, and contain some of his favourite opinions. Some of the separate essays which Dr Gregory contributed were afterwards corrected and published in 1765, under the title of *A Comparative View of the State and Faculties of Man with those of the Animal World*. It was considerably enlarged by the author in a second edition, and has passed through other editions since his death.

About the end of the year 1764, Dr Gregory removed from Aberdeen to Edinburgh. In 1766, he was appointed professor of the practice of physic, on the resignation of Dr Rutherford; and in the same year, he succeeded Dr Whytt as first physician to his Majesty for Scotland. His lectures on the practice of physic were delivered in the years 1767, 1768, and 1769; but, in consequence of an arrangement with Dr Cullen, professor of the theory of physic, these celebrated individuals gave alternate courses of the theory and practice of medicine. The lectures of Dr Gregory were never committed to writing. Having made himself fully master of his subject by previous meditation, he required no other aid than a few notes, containing the heads of his lecture. The introductory lectures, however, were carefully composed, and related principally to the duties and qualifications of a physician. Many copies of these lectures having been taken by his pupils, one of them was offered for sale to a bookseller. It therefore became necessary to anticipate this fraudulent design, by the publication of a correct copy, which appeared in 1770, and afterwards in a more enlarged and perfect form, in 1772. In the same year, Dr Gregory published *Elements of the Practice of Physic, for the use of Students*, a work intended as a text-book for the use of his pupils. He proposed to embrace all the diseases of which he treated in his lectures; but he did not live to bring the work farther down than to the end of the class of febrile diseases.

After the death of his wife in 1761, Dr Gregory occupied his solitary hours in the composition of a *Father's Legacy to his Daughters*. This admirable work, which every mother should study, and every daughter read, was written under the impression of an early death. It is marked by a deep knowledge of the world and of human character, and abounds with the finest lessons of piety and virtue.

From the eighteenth year of his age, Dr. Gregory had been, at irregular intervals, attacked with the gout; a disease which he inherited from his mother, who died suddenly, in 1770, while sitting at table. Dr Gregory anticipated a similar event for himself, and often mentioned this impression to his friends. In January 1773, when conversing with his son, the present Dr Gregory, the latter remarked, that having had no attack for the three preceding years, he might expect a pretty severe fit of it that season. His father was displeased with the prediction, which was unfortunately too correct; for he was found dead on the morning of the 10th of February, although he had gone to bed in his usual health.

"Dr Gregory," says his friend and biographer, Mr Tytler, "was in person considerably above the middle size. His frame of body was constructed with symmetry, but not with elegance. His limbs were not active; he stooped somewhat in his gait; and his countenance, from a fulness of feature, and a heaviness of eye, gave no external indication of superior powers of mind or abilities. It was otherwise when engaged in conversation. His features then became animated, and his eye most expressive. He had a warmth of tone and of gesture, which gave a pleasing interest to every thing which he uttered. But, united with this animation, there was in him a gentleness and simplicity of manner, which, with little attention to the exterior and regulated forms of politeness, was more engaging than the most finished address. His conversation flowed with ease; and when in company with literary men, without affecting a display of knowledge, he was liberal of the stores of his mind.

"He possessed a large share of the social and benevolent affections, and which, in the exercise of his profession, manifested themselves in many nameless, but important, attentions to those under his care; attentions which, proceeding in him from an extended principle of humanity, were not squared to the circumstances or rank of the patient, but ever bestowed most liberally where they were most requisite. In the care of his pupils, he was not satisfied with a faithful discharge of his public duties. To many of these, strangers in the country, and far removed from all who had a natural interest in their concerns, it was a matter of no small importance to enjoy the acquaintance and countenance of one so universally respected and esteemed."

Dr. Gregory left behind him three sons and two daughters, the eldest of whom is Doctor James Gregory, professor of the practice of medicine in the university of Edinburgh, who fully inherits the virtues and talents of his ancestors. The works of Dr John Gregory were published at Edinburgh in 1788, in 4 vols duodecimo, and were enriched with a well written life of the author, by the late Mr Tytler, Lord Woodhouselee, to which we have been indebted for the preceding facts.

GRENADA, the most southerly of the Caribbee islands in the West Indies, is situated between 12° 20′ and 11° 58′ North Lat. and between 61° 20′ and 61° 35′ West Long. It is twenty leagues north-west of Tobago, and the same distance from the nearest point of the American continent. It is about twenty-five miles in length from north to south, and fifteen at its greatest breadth, contracting gradually towards both extremities. A chain of mountains traverse the whole island from north to south, and give rise to a great number of small rivers; and in the highest ground is a circular lake called Grand Etang, from which several of these streams derive their source. There is a bay on the north-west coast (which has been recently fortified at great expence,) so capacious and secure, that sixty men of war may ride in it safely almost without casting anchor. The air is salubrious, and the soil fruitful in the productions of the climate.

Grenada was discovered by Columbus in 1498, and was at that time inhabited by a warlike people called Charaibes or Caribbees. The Spaniards do not appear to have made any attempt to form a settlement on the coast, and the natives remained free and undisturbed till the year 1650. At this period, the French governor of Martinico, Du Parquet, landed on the island with 200 adventurers, who seem to have been resolved upon a wanton destruction of the unoffending inhabitants, and an unwarrantable possession of the country; but being hospitably received by the unsuspecting objects of his unjustifiable attack, they pretended to make a purchase of the island for a few knives and hatchets, a quantity of glass beads, and a barrel of brandy to the chief. Immediately assuming the sovereignty, and having roused the natives to resistance by their tyrannical proceedings, they took measures to extirpate the whole race as lawless rebels. This they are said to have speedily accomplished by a course of atrocious massacres; and a few wretched survivors of their butcheries having thrown themselves headlong from a steep rock, rather than fall into the hands of such merciless enemies, the French settlers, with characteristic levity, gave to the spot the name of *Le Morne des Sauteur*, the Hill of the Leapers. The perpetrators of these enormities soon began to quarrel among themselves, and to suffer, in their turn, the oppressions of tyrannical governors. By a succession of calamities and revolutions, the narration of which would interest few readers, the prosperity of the settlement was so much impaired, that, in the year 1700, more than twenty years after the sovereignty had been vested in the crown of France, there were found on the whole island only 151 white inhabitants, 53 free negroes or mulattoes, 525 slaves, 64 horses, 569 horned cattle, 3 plantations of sugar, and 52 of indigo. Above fourteen years afterwards, however, an active commercial intercourse was opened with the island of Martinique, cultivation was rapidly extended, and, notwithstanding the interruption which these improvements sustained by the war in 1744, Grenada was found, in 1753, to contain 1262 white inhabitants, 175 free negroes, 11,991 slaves, 2298 horses or mules, 2456 horned cattle, 3278 sheep, 902 goats, 331 hogs, 83 sugar plantations, &c.; and in 1762, when it surrendered to the British arms, it is said to have yielded annually, together with its dependencies the Grenadines, a quantity of clayed and muscovado sugar, equal to 11,000 hogsheads of 15 cwt. each, and 27,000 lbs. of indigo. Having been finally ceded to Great Britain by the treaty of peace in 1763, a duty of 4½ per cent. upon all exported produce was ordered to be levied, in place of all customs and duties formerly paid to the French king; a measure which gave rise to a great constitutional question, in which, after a long and elaborate law discussion, judgment was given by Lord Mansfield against the crown, and the duty was abolished in Grenada and the other ceded islands. Great commotions and divisions also were excited in the island, respecting the election of Roman Catholic inhabitants as members of assembly. By these party-contentions, the colony continued to be disturbed till its recapture by the French in 1779: and they were again renewed, with additional violence, after its restoration to Great Britain in the general pacification which took place in 1783.

The island of Grenada is divided into six parishes, viz. St. George's, St. David's, St. Andrew's, St. Patrick's, St. Mark's, and St. John's; and, since its restoration to Great Britain in 1783, a Protestant clergy have been established by law. Four clergymen are allotted to the whole, and each is provided with an annual stipend of 330*l.* currency,* 60*l.* for house rent, and a considerable portion of the valuble glebe lands which had formerly been appropriated to the support of the Romish clergy, for whose benefit a part of the amount is still reserved. The capital of Grenada, formerly named Fort Royal, but now St George, is situated close to the spacious bay on the west coast, already described, and is divided by a ridge into two towns; the Bay-town, in which is a handsome square and market-place; and the Carenage-town, where the principal merchants reside. On the ridge, between the two towns, stands the church; and on the promontory above it is an old fort built of stone, and capable of accommodating an entire regiment. The other towns are only villages or hamlets, which are generally situated at the bays or shipping places.

The governor of the island is also chancellor-ordinary and vice-admiral, and his salary is 3200*l.* currency per annum, which is raised by a poll-tax on all slaves.* The council consists of twelve members, and the assembly of twenty-six. A freehold or life estate of fifty acres in the country, and of fifty pounds house rent in the capital, qualifies for a representative. An estate of ten acres in fee, or for life, or a rent of ten pounds in any of the country towns, and a rent of twenty pounds out of any freehold or life estate in the capital, gives a vote in the election of the representatives. The law courts, besides those of chancery and ordinary, in which the governor presides, are the court of grand sessions of the peace, held twice a year, in which the person first named in the commission of peace presides; the court of common pleas, in which a professional judge, with a salary of 600*l.* presides; the court of exchequer, lately fallen into disuse; the court of admiralty, and the court of error, composed of the governor and council, for trying appeals. In all cases the common statute law of England is the rule of justice, unless where particular laws of the island interfere.

The white population of Grenada has decreased considerably since it came into the possession of the British. In 1771 their number was above 1600; in 1777, they had diminished to 1300: and in 1791, they were not supposed to exceed 1200. Of these about two-thirds are able to bear arms, and are incorporated into five regiments of militia, with a company of free blacks, or mulattoes, attached to each. There are likewise about 500 regulars from Great Britain, for the defence of the island. The negro slaves, also, which, in 1779, were stated at 35,000, including those which were in the smaller islands, were found, in 1785, to have decreased to 23,926. The free people of colour amounted, in 1787, to 1115, whose evidence is received in the courts of law, upon proofs of their freedom being produced: and who are allowed to possess lands or tenements to any amount, provided they are not aliens.

There are 80,000 acres of land in the island, but only 50,000 were brought into cultivation in 1791. The face of the country is mountainous, but every where accessible, and well provided with rivulets and springs. On the west side, the soil is a rich black mould, lying on a substratum of yellow clay; on the north and east, it is a brick mould; on the south, and in the interior, it is of a reddish hue, and generally poor. In 1776, the exports from the island and its dependencies were 14,012,157 lbs. of muscovado, and 9,273,607 lbs. of clayed sugar; 818,700 gallons of rum; 1,827,166 lbs. of coffee; 457,719 lbs. of cocoa; 91,943 lbs. of cotton; 27,638 lbs. of indigo, and some smaller articles, the whole of which, at a moderate computation, was worth, at the ports of shipping, 600,000*l.* sterling. The sugar was the produce of 106 plantations, worked by 18,293 negroes, which gives rather more than a hogshead of muscovado sugar of 16 cwt. from the labour of each negro,—a return which Mr Edwards affirms to be unequalled by any other British island in the West Indies, except St Christopher's. In 1787, the exports were 175,548 cwt. of sugar, 670,390 gallons of rum, 8812 cwt. of coffee, 2,062,427 lbs. of cotton, and 2810 lbs. of indigo. In 1810, the value of the exports amounted to 388,936*l.*, and of the imports to 173,366*l.*

*The following Table shews the Articles imported into Grenada in the Years* 1804, 1805, *and* 1806.

| | 1804. | | | | 1805. | | | | 1806. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Articles imported. | Great Britain. | British Colonies. | United States. | Other Countries. | Great Britain. | British Colonies. | United States. | Other Countries. | Great Britain. | British Colonies. | United States. |
| Corn . . . . | Bushels. 13,558 | — | 17,626 | — | Bushels. 10,414 | 234 | 14,987 | 408 | Bushels. 21,285 | 314 | 9966 |
| Bread, flour and meal | Cwts. 2,860 | 773 | 22,456 | — | Cwts. 2525 | 23 | 21,658 | — | Cwts. 3085 | 609 | 12,812 |
| Rice . . . . | — | — | Barrels. 395 | — | — | — | Barrels. 471 | — | — | — | Barrels. 436 |
| Beef & Pork | Barrels. 1361 | — | 1875 | — | Barrels. 572 | — | 2891 | — | Barrels. 979 | 1 33 | 817 |
| Dry Fish . . | Bar. Quint. 0 399 | 0 13,112 | 228 1575 | — | Bar. Qt. 45 542 | 0 18,181 | 0 735 | — | Bar. Qt. 0 616 | 0 19,454 | 0 981 |
| Pickled Fish | Barrels. 2205 | 184 | 805 | — | Barrels. 822 | 316 | 190 | — | Barrels. 726 | 268 | 9 |
| Butter . . . | Firkins. 3019 | 16 | 68 | — | Firkins. 818 | — | 240 | — | Firkins. 1769 | 72 | 200 |
| Cows & Oxen | — | — | Number. 134 | 48 | — | — | Number. 183 | 34 | — | — | Number. 156 |
| Sheep & Hogs | — | — | Number. 175 | 7 | — | — | Number. 160 | 49 | — | — | Number. 125 |
| Oak & Pine Boards, & Timber | — | Feet. 6000 | 1,793,641 | — | — | Feet. 18,479 | 2,875,399 | — | — | Feet. 2650 | 2,090,862 |
| Shingles . . | — | — | Number. 1,328,700 | — | — | — | Number. 2,391,200 | — | — | Number. 21,000 | 2,281,400 |
| Staves . . . | — | — | Number. 9000 | 539,897 | — | Number. 15,100 | 843,000 | — | — | Number. 14 880 | 920,883 |

* The currency of Grenada, or rate of exchange, is commonly 65*l.* per cent. worse than sterling

The sugar plantations in this colony are subject to great ravages from the carnivorous or sugar ant, an insect which is thought to be common to all the West India islands, but which has been peculiarly destructive in Grenada. It is the *Formica omnivora* of Linnæus, and is described by Sloane as the *Formica fusca minima antennis nis longissimis.* They are of an ordinary size, a slender shape, a dark red colour, remarkable for the quickness of their motions; but are distinguished from every other species, chiefly by the sharp acid taste which they yield when applied to the tongue, and the strong sulphureous smell which they emit when rubbed together between the palms of the hands. Their numbers have often been so immense, as to cover the roads for the space of several miles; and so crowded in many places, that the prints of the horses' feet were distinctly marked among them, till filled up by the surrounding multitudes. They were never seen to consume or carry off any vegetable substance whatever, but always laid hold of any dead insect or animal substance that came in their way. Every kind of cold victuals, all species of vermin, particularly rats, live poultry, and even the sores of the negroes, were exposed to their attacks. But they were chiefly injurious by constructing their nests among the roots of the lime, lemon, orange trees, and sugar canes, and so obstructing their growth, as to render the plants sickly and unproductive. A premium of 20,000*l.* from the public treasury, was offered to the discoverer of any effectual method of destroying them; and the principal means employed were poison and fire. By mixing arsenic and corrosive sublimate with animal substances, myriads were destroyed; and the slightest tasting of the poison rendered them so outrageous as to devour one another. Lines of red hot charcoal were laid in their way, to which they crowded in such numbers, as to extinguish it with their bodies; and holes full of fire were dug in the cane grounds, which were soon extinguished by heaps of dead. But, while the nests remained undisturbed, new progenies appeared as numerous as ever; and the only effectual check which they received, was from the destructive hurricane of 1780, which, by tearing up altogether, or so loosening the roots where they nestled, as to admit the rain, almost extirpated the whole race, and pointed out the frequent digging up and consuming by fire of those stools and roots in which they take refuge, as the best preventative of their future increase. See Edward's *History of the West Indies*, vol. i.; Ablè Raynal's *History of the Indies*, vol. v.; and Gray's *Letters from Canada*, p. 379. (*q*)

GRENOBLE, a city of France, the capital of the former province of Dauphiny, and under the late government, the chief town of the arrondissement or district of Grenoble, and of the department of the Isere. This city stands at the confluence of the rivers Drac and Isere, the latter dividing it into two unequal parts; the former, which is crossed by a bridge with a single lofty arch, is liable to overflow its banks, and commit considerable devastation both in the city and its environs. Grenoble is situated at the foot of the Alps, in an agreeable country, abounding in wood and water, but of a climate so variable, that the thermometer sometimes ranges through nearly 30° in a day: the greatest heat is from the 10th of July to the 15th of August, and the greatest cold from the 20th of December to the 20th of January. The city stands 900 feet above the level of the sea, and the medium height of the barometer is 27 inches two lines. Nine-tenths of the city are on the left bank of the Isere, constituting the portion chiefly exposed to inundations, several of which have done much damage, and the water has been known to rise three feet deep in the streets.

Grenoble is surrounded by a wall, and is commanded by a citadel; but, unless its fortifications have been lately augmented, it is not considered a strong place. Within the walls, its area occupies about 64,000 square feet. It consists of 1200 or 1300 houses, and is inhabited by 23,500 souls, according to recent computations, for those of older date increase that population above a fifth. The streets are broad, and tolerably regular; and the houses, in general well built, consist of four or five stories. There are several fine public edifices, particularly the Episcopal palace, and that wherein the parliament formerly held its sittings. Among the charitable institutions which sufficiently illustrate the disposition of the citizens, the general hospital is the chief, and is governed by directors selected from the most distinguished of the inhabitants. The building, which is very spacious, is appropriated for incurables; persons insane; the indigent, who commonly amount to 400; and the foundlings of the city, about 150 in number, are also received here. This institution occupies an inclosure, to the south-east of the city, and adjoining to it is the military hospital. In the hospital of Providence, there are 60 beds, and in the hospital of the Ladies of Charity, for females, there are 20; besides which institutions, there is a poor's house in the suburbs. Grenoble has also a museum of the arts, and a botanical garden well managed. A garrison, consisting of a small body of troops, is kept here.

The principal manufactures of this city, are woollen cloths, muslins, hats, and particularly gloves, the principal towns of France, Spain, Italy, and Britain, being supplied with them. Marble cutting is also carried on to some extent, for which purpose there are mills driven by water from the adjoining rivers.

Grenoble is the see of a bishop, who formerly arrogated the title of Prince of Grenoble, and enjoyed those peculiar privileges, which, in less enlightened ages, were reserved almost exclusively for ecclesiastics. Besides the parish churches, there are several monastic institutions.

Grenoble is celebrated for the complaisance and polished manners of its inhabitants, many of whom have shewn a distinguished taste for letters. Condillac and Mably, well known among the modern literati of France, were both natives of this place. It has also to boast of having given birth to the Chevalier Bayard, characterised by his sovereign Francis I. as one *sans peur et sans reproche*, and who, if we are to credit history, singly defended the narrow pass of a bridge against 200 horsemen. The Baron Adrets, a sanguinary chief of the Huguenots, during the wars for the reformation of religion, was born here, and distinguished himself by his cruelty on the miserable prisoners who fell into his power.

As the site of this city is elevated only 15 feet above the level of the river Isere, an unusual humidity prevails, which is the source of many serious distempers among the inhabitants. Though standing at the edge of a plain, extending over a square league, and surrounded by fertile fields and gardens, these advantages are counteracted by the miasmata emanating from the depositions of the waters. Certain seasons of the year are extremely unhealthy; slow fevers are seldom eradicated; and it has been remarked, that even the children are, in infancy, of smaller size, and longer of attaining the strength and complexion of those in the neighbouring country. "The river Isere," an intelligent physician observes, "has become a kind of domestic enemy to Grenoble, with which it is necessary to live; the constant humidity, and the mud deposited by its tranquil waters in the neighbouring marshes, are inconveniences with which benificent nature has accustomed the inhabitants; but they excite less attention than the tendency of all the prevalent diseases to terminate in dropsy." It has been proposed to counteract the deleterious effects arising from local circumstances, by digging a canal to drain off the stagnant waters, and which, at the same time, would prevent the overflowing of the river; as also to deepen the bed of the Isere, in order to give it a stronger current.

Grenoble has subsisted from a very ancient period, and was known by the name of *Cularo*, under which it is designed in a letter from Plancus to Cicero. It is said to have been called *Gratianopolis* from the Roman emperor Gratian; but since the period when it was possessed by the Allobroges, and when it was denominated a city, it repeatedly changed its masters. After various revolutions, Dauphiny came under the dominion of the kings of France, and Louis XI. instituted a parliament in Grenoble, founded on the model of the parliament of Paris, since which time it has remained an integral part of the kingdom. (c)

GRETNA, or Graitney Green, is the name of a village and parish in Scotland, in the county of Dumfries. The village of Gretna, which is the first stage in going from Longtown in England, to Annan in Scotland, is built on each side of the road, and has, for more than 70 years, been famous as a place for the celebration of the clandestine marriages of English lovers. This ceremony was generally performed by a blacksmith or tobacconist, and the number of marriages have been calculated at 65, which brought in an annual income of about 1000*l.* at the rate of 15 guineas each. The remains of an oval druidical temple, occupying about half an acre of ground, has been discovered at Gretna Mains. The mansion house of Gretna hall has been fitted up by the proprietor, the Earl of Hoptoun, as an inn. The population of the parish, in 1811, was 1749.

GREW, Nehemiah, a celebrated botanist, was born at Coventry, about the year 1628, and was the son of Dr Obadiah Grew, vicar of St Michaels. At the restoration of Charles II. being a non-conformist, he went abroad, and prosecuted his studies at a foreign university, where he took the degree of Doctor of Medicine. Upon his return to England he settled at Coventry, and, in the year 1664, his attention was first directed to the anatomy of plants; and he was encouraged to proceed in this branch of natural history by his brother-in-law Dr Henry Samson, who pointed out to him a passage in Glisson's work *De Hepate*, in which this subject is represented as an unexplored, but promising line of study. In the year 1670, Dr Samson, who had seen the first book of Grew's *Anatomy of Plants*, put it into the hands of Oldenburg, who gave it to Dr Wilkins, bishop of Chester, by whom the manuscript was read to the Royal Society, under the title of a *Philosophical History of Plants*. This work was highly approved of, and was printed by that distinguished body in 1671, under the title of the *Anatomy of Vegetables begun, with a general Account of Vegetation founded thereon*. In consequence of the reputation which this work acquired for its author, Grew was invited to settle in London, where he arrived in 1671; and, upon the recommendation of Dr Wilkins, he was elected a Fellow of the Royal Society, and admitted on the 30th November 1671. At the suggestion of the same learned divine, Grew was appointed curator to the Royal Society for the anatomy of plants, which led him to draw up the 2d, 3d, and 4th Parts of his work, and the various lectures on the same subject, which form a part of his Anatomy of Plants. All these papers were composed between the years 1670 and 1676, and were read at various meetings of the Royal Society. They were afterwards collected in 1682, with 83 plates, and published in a folio volume, under the title of the *Anatomy of Plants*, a work full of the most important facts in vegetable physiology.

In the year 1673, Dr Grew published in the Transactions, a paper, entitled *Observations on Snow*, in which he supposes, that the snowy particles are formed by the drops of rain containing spirituous particles, and meeting in their descent with others of a saline, partly nitrous, but chiefly urinous or acido-salinous nature. In the year 1677, he was appointed secretary to the Royal Society, in which capacity he published the *Phil. Trans.* from January 1678 to February 1679. In the year 1680, he was made an honorary fellow of the College of Physicians, and attained to considerable practice in the medical profession.

Dr Grew drew up a catalogue of the natural and artificial rarities belonging to the Royal Society, and preserved at Gresham College, which was published in 1681 in folio, with the title of *Museum Regalis Societatis*, containing 22 plates. It was accompanied with another work, entitled the *Comparative Anatomy of Stomachs and Guts begun*, being several lectures read before the Royal Society in 1676. The description of the Museum, though by no means free from mistakes, is a work of merit, and is remarkable for an ingenious scheme or disposition of shells.

The other papers which he printed in the Transactions, were

*The Description and Use of the Pores in the Skin of the Hands and Feet.* Phil. Trans. 1684.

*Some Observations on a diseased Spleen*, Id. 1691.

*Description of the American Tomineius, or Humming Bird*, Id. 1693.

*On the Food of the Humming Bird*, Id. 1693.

*A Demonstration of the Number of Acres in England or South Britain, and the use which may be made of it*, Id. 1711.

One of the last works of Dr Grew, was his *Cosmographia Sacra*, or *a Discourse of the Universe, as it is the Creature and Kingdom of God*. The principal object of this work, was to demonstrate the truth and excellence of the sacred writings. The works of Dr Grew were translated into French and Latin. He died after a short illness on the 25th of March 1711, about the 83d year of his age.

GRIDIRON Pendulum. See Horology.

GRIES, is a mountain of Switzerland, situated in the Alpine chain which separates Piedmont from the Upper Vallais. The road over this mountain leads from Oberghestelen, in the Vallais, to Domo d'Ossola, in the Val-Maggia, and to Locarno. This road rises to the height of 7336 feet, and traverses a glacier a quarter of a league wide, and blackened by the dust of the mica slate. The distance from Oberghestelen to Formazza, at the southern foot of the Gries, is 7¾ leagues. The descent of the Gries is by four different terraces or vallies. The first is called Bettelmatte, celebrated for its fine cheese, and for the small lake from which the Toccia, or Tosa, issues. The second valley is called Morast, and from this the road descends by a very steep path to a third valley, occupied by the hamlet of the Auf der Frout, where the valley of the Toccia, or the Dolgia, commences. Another steep declivity conducts to the south valley, called Froutval, which is celebrated for the cataract of the Tosa, or Toccia, which, excepting the fall of the Rhine, is reckoned the most magnificent in Switzerland. It is about 300 or 400 feet high, and forms a species of pyramid, whose base is extremely wide, while its summit is only 4 or 5 feet in breadth. The rock is inclined about 140° or 150° to the horizon. This cataract is surrounded on all sides with lofty rocks, crowned with wood. The southern side of the Gries is inhabited by Germans as far as the village of Foppiano. The south side of the mountain is composed of gneiss, of veined granite, and of mica slate. In the valley of Egino, there are beds of potstone, which are wrought about a quarter of a league on the east side of the bridge. Slates occur to the south, and lower down the mica slate appears. The first valley is composed of gneiss and calcareous strata. Below the second valley, rocks of argillaceous schistus stretch to the north-east; and, on the other side, are rocks of a ferruginous aspect. All the rocks from the north to the south, as far as Pommat, lie in strata almost vertical, in the direction from north-east to south-west. See Ebel's *Manuel*, &c.

GRIMALDI, Francis Maria, a learned Italian Jesuit, was born in the year 1619, and cultivated the sciences along with his friend Riccioli. Grimaldi was the first person that observed the lengthening of the solar image when refracted by a prism; and he is principally known for his discovery of the diffraction of light; a subject which was afterwards examined by Sir Isaac Newton, under the name of the Inflexion of Light. These discoveries of Grimaldi are contained in his work entitled *Physico-Mathesis de Lumine, Coloribus et Iride*, Bononiæ, 1665. The principal object of this work, is to determine whether light be a substance or a quality; and, after occupying 535 quarto pages in this discussion, he concludes, with the Aristotelians, that it is not a *substantial*, but an *accidental* quality. A full account of this work will be found in the *Phil. Trans.* for 1672, No. 79, p. 3069. Grimaldi died in 1663, in the forty-fourth year of his age. The discovery of the solar spots, and the present nomenclature of the lunar spots, have been erroneously ascribed to him. See *Phil. Trans.* abridged, vol. i. p. 675, Note. See also Optics.

GRIMSBY, or Great Grimsby, is a borough and seaport town of England, in Lincolnshire, situated near the mouth of the Humber. The streets are clean, and the houses in general well built. The church, which is called St James, is spacious and handsome, and is built in the form of a cross, with a tower in the centre. The steeple is a fine specimen of English pointed architecture. A part of the choir fell down in 1600, but the steeple has scarcely suffered from the depredations of time. In the upper part of the steeple is the singular inscription, "Pray for the soul of John Empringham." The church contains many ancient monuments. Grimsby had formerly a monastery of Gray Friars, a convent of Benedictines, and a priory of Augustine canons. Grimsby was once a rich and populous town, with a considerable foreign and inland trade. It was a mayoralty in the reign of King John; and in the reign of Edward III. it furnished 11 ships and 170 mariners to assist at the siege of Calais. The harbour, however, was gradually choked up, and a dangerous sand bank having drifted near its mouth, its trade declined, and was transferred to Hull. Of late, the trade of the place has revived; the harbour has been improved, a dock constructed at great expence, and the town enlarged by additional buildings. A small coasting trade is carried on with sloops. Salt and coals are the chief articles of importation. There was once at Grimsby a castle, but it is entirely decayed. There are some very extraordinary fountains near the town, called Blow Wells, which never overflow, though they rise to a level with the surface of the ground. Grimsby is a port town under that of Hull, and has a deputy collector, comptroller, and coast surveyor. The Grimsby canal is a short canal, which leads from the Humber to Grimsby wet docks. Population of the burgh and parish, in 1811, 2747. See the *Beauties of England and Wales*, vol. ix. p. 689, &c.

GRIMSEL, is the name of a lofty mountain in Switzerland, over which there is a road from the canton of Berne into the Upper Vallais. The distance from Meyringen on the Aar, to the Hospice of Grimsel, is about seven leagues, and from thence to Oberghestelen on the Rhone, is three leagues. This road is bordered in several places with frightful precipices, and it is often necessary to pass over bridges apparently insecure.

After leaving Meyringen, the traveller passes through the forests of Mount Kirchet, by the agreeable valley of Im Grund. The gneiss here appears below the calcareous strata, lying above the primitive rock. The strata of the gneiss are almost vertical, a little inclined to the south. Beyond the forest which occupies the extremity of Grund, the calcareous rocks cease altogether, and the gneiss and micaceous schistus replace it on the side of Guttaner, the southern dip of these rocks being a little increased. In the valley of D'Urbach, the great glacier of D'Urbach or of Gauli descends into the plain; and after passing the Aar by a bridge, a rough and solitary path cut out of the rock leads between the mountains of Urbach, Ritzli, Gauli, and Gouttan, to the hamlet of Im Boden, and thence to the village of Gouttanen, situated 3196 feet above the level of the sea, where there is a tolerably good inn. This village was burnt in 1803, but, in consequence of the liberality of the Swiss, it has been rebuilt. About a quarter of a league above Gouttanen, the granite appears in mass, and extends to the Grimsel. Its stratification is distinctly seen. At first the strata stretch from north-east to south-west, and afterwards from east-north-east to west-south-west. About half a league from Gouttanen, the Aar forms a cascade at the side of the road; and a fine rainbow may be always seen in clear weather between ten and two o'clock. Beyond Gouttanen the road passes Mount Stampf, and, after twice crossing the Aar, the traveller reaches the chalet of Handeck in two hours. The glacier and the lake of Ghelmer are distinctly seen from that mountain to the east, and to the south-west appear the glaciers of Erlen and Ritzli, and the Handeckhorn to the south. At a considerable distance below the chalet, the Aar forms one of the finest waterfalls in Switzerland. It should be visited during sunshine, between half-past nine and eleven o'clock, and from the bed of the river, as near the bottom of the fall as possible. From Handeck to the Hospice is a distance of two leagues, over a terrible road, which is three times crossed by frightful though substantial bridges. About half a league from Handeck appear immense rounded surfaces of granite, in which steps have been cut for the feet of the horses and of travellers. After travelling half an hour longer, we cross the fine Alpine pastures of Roderischboden. At the last bridge, not far from the Hospice, the Aar suffers another remarkable fall.

The Hospice, which was built in 1557, is surrounded with frightful rocks, and is situated at a height of 5628 feet above the level of the sea. The keeper of it is allowed to hunt in any of the cantons of Switzerland, and is bound, in return, to feed and lodge all travellers that cross the Grimsel. He remains at the Hospice from March till the beginning of November. He can furnish seven good beds, though there are sometimes more than a hundred candidates for them. Near the Hospice is a small lake called Kleinsee, from thirty-two to sixty-two feet deep. The Sassbach throws itself into the lake in a fine cascade. After leaving the Hospice, the road continues to ascend for three quarters of a league, and at its most elevated point the height is 6570 feet. The height of the Seidelhorn, which is the highest summit of this mountain, is 8580 feet. From the highest part of the road, there is a fine view of the Furca, of the Galenstock, of the peaks of St Gothard, of the Gries, and of the southern chain of the Vallais, as far as Mont Blanc. The descent to Oberghestelen occupies only about two hours.

On the top of the Grimsel a reddish granite occurs;

mica slate appears in the southern face; and argillaceous schistus at the southern foot of the mountain. A singular grotto, filled with crystals, was opened on Mount Jochli, upon the Zinkenstock, in 1720. It was the richest ever found in Switzerland: It was 120 feet deep and 18 wide, and contained crystals, of which a small number weighed nearly eight quintals, and several four or five quintals. Several thousands of quintals were obtained, of the estimated value of 30 000 florins. One of the largest of these was $3\frac{1}{2}$ feet diameter, $2\frac{1}{2}$ feet long, and one of its six faces $1\frac{1}{2}$ feet wide. It is now in the museum of Natural History at Paris.

The glaciers of the Aar are generally visited by the travellers that cross the Grimsel. In the month of August 1799, the French ascended the mountain, and, after a severe conflict, drove the Austrians from their position on its summit. See Ebel's *Manuel, &c.*

GRINDELWALD is the name of a village of Switzerland, in the canton of Bern. It is situated in a rich Alpine valley, at the height of 3150 feet above the level of the sea. The direction of the valley is N. E. and S. W. and it is encircled with lofty mountains. The Faulhorn, to the north of Grindelwald, is 8020 feet high; the Wetterhorn, to the east, is 11,433; the Eiger, to the south, is 12,268. The Schreckhorn, to the south-east, is 12,530 feet; and the Jungfrau, to the S. S. W. is 12,840 feet. The valley is shut up at the north-east by the Scheideck, which is 6045 feet high.

This valley is one of the most frequented in Switzerland, both from its proximity to Bern, and from the facility with which its two glaciers may be visited. These glaciers are parallel to each other, and are each about a league distant from the Inn. The smaller glacier forms an arm of the immense valley of ice which is situated between the Schreckhorn, the Viescherhorn, and the two Eigers. In the middle of this glacier there is a rock, almost vertical, on which the snow cannot rest, and which has, therefore, received the name of the *warm rock*. The surface of the glacier is extremely unequal, and is formed into many splendid pyramids of ice. Near it is a wood of elder trees, where excellent strawberries may be gathered almost close to the ice.

The great or upper glacier, almost entirely separated from the small one by the rocks of the Schreckhorn, lies between the Mettenberg and the Wetterhorn. Its ancient limits were formed by a hill of debris, thirty feet high, and covered with pines of considerable height. In 1720, the glacier extended thus far, but it afterwards retired, and the space which it left was covered with trees. A new augmentation, however, which it experienced in 1780, destroyed this wood. The torrent which flows from it is the Black Lutschinen. In this valley the traveller frequently hears the thunders of the glaciers, and experiences the violence of the winds which issue from their crevices.

The road from Grindelwald to Meyringen, in the valley of Hasli, by the Scheideck, is extremely interesting. It is only a distance of seven leagues, and may be performed on horseback without any danger. See Ebel's *Manuel, &c.*

GRINDING OF DRUGS. See DRUG MILL.

GRINDING AND POLISHING OF PLATE GLASS. See GLASS, Sect vi.

GRINDING OF LENSES AND MIRRORS for optical instruments. See OPTICS.

GRINSTEAD, EAST, is a borough and market town of England, in Sussex. It is pleasantly situated on a hill, near the northern border of the county. The town is irregularly built, but it contains many neat modern houses. The church, which stands on the east side of the main street, is a spacious and handsome structure. It has a lofty and well-proportioned tower, adorned with pinnacles at the corners. Sackville college, a large quadrangular stone building, stands at the east end of the town. It was built in 1616, as a charitable institution, for the support of 24 old persons of both sexes. A suite of rooms is set apart for the Duke of Dorset, who gave the use of them to the judges when the assizes were held here. There is here a neat chapel belonging to the college, and also a free school here for 12 boys. Population, in 1811, 2804. See *Beauties of England and Wales*, vol. xiv. p. 150.

GRINDSTONES, from the Latin *Gyrandus*, are circular stones, a few inches thick, which are mounted on a spindle, and turned with a common winch, for the purpose of grinding edge tools. When a great number of these stones are driven by machinery for the purpose of cutlery, they are called *blade mills* or *grind mills*. Grindstones are formed of a gritstone, in which the grains of silex are firmly cemented to each other by a siliceous or other hard cement, the interstices not being filled up as in other kinds of sand stone. The following is a list of the grindstone quarries in England, with their degrees of fineness, drawn up, we believe, by Mr Farey, for Dr Rees's *Cyclopædia:*

Ashover, N. W. (hill quarry) Derbyshire, middling.
Beely Moor, E. of the town, Derbyshire, coarse.
Belper, S. E (Hungerhill) Derbyshire, middling.
Biddulph-Hall, N. W. of Leek, Staffordshire, coarse.
Bilstone, S. E. of Wolverhampton, Staffordshire, middling.
Bolsover, N. W. (nunnery) Derbyshire, middling.
Bredsal Moor, N. of Derby, middling.
Brinclif-edge, S. E. of Sheffield, Yorkshire, fine.
Buxton, N. (Corbar) Derbyshire, fine.
Darley Moor, E. of the town, Derbyshire, coarse.
Gate-head fell, $2\frac{1}{4}$ miles south from Chester Ward, Durham.
Glossop, Derbyshire, coarse.
Harthill, S. E. Yorkshire, fine.
Hooton-Roberts, near Rotherham, York, middling.
Horsley, N. of Derby, fine.
Lane-top, N. of Sheffield, Yorkshire, whitening.
Little Eaton, N. of Derby, coarse.
Milford, S. of Belper, Derbyshire, coarse.
Molecopt-hill, S. of Congleton, Cheshire, coarse.
Morley-moor, N. of Derby, fine.
Norton, W. (Hemp-yard lane) Derbyshire, fine.
Overton (Gregory) in Ashover, Derbyshire, coarse.
Polesworth, S. E. of Tamworth, Warwick.
Purton, W. of Wolverhampton, Staffordshire, fine.
Ridgeway (Lum-delph) in Eckington, Derbyshire, fine.
Stanley, N. E. of Derby, fine.
Stanton by Dale, E. of Derbyshire, fine.
Stanton Moor, N E. of Winster, Derbyshire, coarse.
Therberg, near Rotherham, Yorkshire, fine.
Treton, ditto, ditto, fine.
Warton E. of Tamworth, Warwickshire.
Wickersley, near Rotherham, Yorkshire, middling.
Wokes, near Barnsley, Yorkshire.

The most extensive grindstone quarries are those near Gateshead. They are sent to all quarters of the globe, under the name of Newcastle grindstones, and constitute a great branch of the trade of Newcastle and Gateshead.

The explosion of grindstones when in motion is a phenomenon which has frequently happened, and which has been attributed to the effect of the centrifugal force, and to the expansion of the wooden wedges. On the 8th June 1768, a very singular accident of this kind happened to a cutler at Ivry-sur Seine, near Paris, who was grinding kitchen utensils. The stone flew into the air apparently on fire, and burst into innumerable fragments, with a dreadful noise. One of the fragments, of about three pounds weight, flew over a building 40 feet high, and alighted 108 feet beyond it in the garden, where it broke the branch of a lime tree. Another fragment, of nearly the same size, grazed the parasol of a young lady who was standing beside the cutler. A part of the stone was found upon the pavement reduced to powder. A similar accident happened to a cutler at Strasburg, who was killed by the explosion.

Our readers will find some curious facts relative to grindstones, and to their sudden explosions while they are at work, in the *Encyclopedie Methodique*, art. TOURNEUR; *Collection Academique*, tom. xiii. p. 45 48, 413. and tom. xii p. 109; *Mem. Acad. Par.* 1762. *Hist.* p. 37; and *Id.* 1768.

GRISONS, the *Upper Rhetia* of the ancients, is the name of a republic which was formerly independent, but since the year 1798 it has formed one of the nineteen cantons of Switzerland. It is bounded on the north by the canton of Glaris, from which it is separated by a chain of mountains, and by the German districts of Schweiz, and the Voralberg, in Suabia; on the east by the Tyrolese; on the south by the Valteline, and the Ticino; and on the west by the canton of Uri.

This canton is the largest in Switzerland. It contains 140 square geographical miles (15 to a degree), and comprehends no fewer than 60 principal and lateral vallies. From its most eastern part, at Finstermunz on the Inn, to the Mountain Badus at the source of the anterior Rhine, is 32 leagues; and from its most northern part at the Mountain Seesa Plana, to its most southern part near the Mountain St George, is 23 leagues.

The natural divisions of the Grisons form five great vallies, viz. the valley of the Posterior Rhine, the valley of the anterior Rhine, the valley of the Inn or the Engadin, the valley of the Albula, and the valley of the Landquart, or the Prettigau.

1. The valley of the Posterior Rhine includes the vallies of Rhinwald, Schams, Via Mala, and Domlesch. The Rhinwald is about eight leagues long, and is surrounded on all sides by lofty mountains. It is accessible only by one road, which passes through the defile called Rofflen, which leads into the valley of Schams. The surrounding mountains, of which the Avicula and the Piz-val-Rhin are 10,280 feet high, are covered with enormous glaciers, and the valley is exposed to frightful avalanches. The winter continues nine months. The grass does not begin to grow till the end of June, and it is necessary that the hay be got in before the beginning of September. This valley is inhabited by Germans of the Suabian colony, which the Emperor Frederick I. sent, at the end of the 12th century, to ensure a passage into Italy over the Splugen. The two principal roads for crossing the Alps pass through the Rhinwald; one of them over the Splugen, and the other over the Bernardin. In taking the road over the Splugen, eighteen hours are necessary to go from Coire to Chiavenna. From the village of Splugen, the road follows the brook Hansle all the way to the inn on the summit of the hill on the Italian side, which is a distance of three leagues. The height of the road is here 6170 feet; but that of Tombo-horn, the neighbouring summit of the mountain, is 9795. The gorge called the Cardinell is truly horrifying and dangerous. The road then follows the impetuous course of the Lira, and the traveller arrives in two hours at Isola. In two hours more, after passing through the valley of St Jacques, and by Campo Dolcino, where the custom-house officers examine all baggage, he reaches Creston, and then Sta Maria, which is only a league from Chiavenna. General Macdonald crossed this mountain in 1800, between the 27th of November and the 1st of December, and lost many men and horses by the avalanches. The northern side of the Splugen is chiefly composed of gneiss and micaceous schistus. Very fine white marble occurs near the summit of the road. It stretches between the micaceous schistus from south-west to north-east. The inhabitants of the village of Splugen make very fine articles of it. There were once two roads over the Bernardin, but the shortest is passable only in summer. The longest is kept in repair by the commune of Hinter-Rhein. At the highest part is a Hospice, which is three hours distant from the village of Hinter-Rhein on the north, and two hours from the village of Bernardin, in the valley of Misox, on the south. The small lake of Muesa, with several islets, is situated on the summit of this mountain. The water that runs from the southern face of the glacier of the Rhine throws itself into this lake, which again forms the brook of Muesa, and, after running through the valley of Misox, joins the Tesino at Bellinzone. This mountain is composed of gneiss. It was crossed in 1797, on the 7th March, by the French army under General Lecourbe.

In entering the Rhinwald from the valley of Schams by Rofflen, the road passes the villages of Suvers, Splugen, Medel, Ebi or Planura, Noveina or Noufenen, and Hinter-Rhin. The church of Hinter-Rhin is 4770 feet above the level of the sea. From the very bottom of this valley, which extends itself, with a singularly wild aspect, among the horrible rocks of Avicula and the Piz-val-Rhin, the glacier of Rhinwald and the source of the posterior Rhine may be distinctly seen, and can be reached in three hours from Hinter-Rhin. From a station a little way beyond the chalets of Tessini upon Zaport, may be seen the basin formed by the rocks of the Black Muschelhorn, and by a ridge of mountains about two leagues long, from which 13 torrents descend. At the bottom of this basin lies the glacier of Rhinwald. The torrent of the glacier issues from a magnificent vault of ice, and receiving the 13 brooks already mentioned, it forms the true source of the posterior Rhine. On leaving this deep gorge, it receives 16 torrents before reaching Splugen. After this it escapes through the gorge of Rofflen, receives other six brooks from the valley of Schams, throws itself into the abysses of the Via Mala, and still farther enlarged in the valley of Domlesch by ten tributary streams, particularly the Albula, it joins itself at Reichenau to the anterior Rhine, which is considerably less in size, though enlarged by nearly 30 torrents. The Via Mala is one of the most frightful defiles in Switzerland. It extends two leagues from Tousis to Zilis. See VIA MALA.

The valley of Schams, which is two leagues long, contains eight or nine considerable villages, on both sides of the Rhine. It is lower and more fertile than the Rhinwald, and is one of the richest and most populous in Switzerland. See SCHAMS.

The valley of Domlesch, or Tomleasca, is formed by the posterior Rhine, after its junction with the Albula, and before it falls into the anterior Rhine. It is about two leagues long and one wide, and is the most temperate in the Grisons. It derives much of its celebrity from the picturesque and cultivated mountain of Henzenberg, about two leagues long, and stretching along the west side of the valley. The northern entrance to the valley is scarcely 100 paces wide; and on the south it is shut up by the Beverin and the Mouttnerhorn, between which the river forces itself with great fury. Soon after it receives the black stream of the Nolla, and half a league lower that of the Albula. The valley of Domlesch contains no fewer than 22 villages, and 12 ruined and inhabited castles, some of which are remarkable for their antiquity. Excepting at Tousis, the Romansh is here the general language. The base of the mountains is composed of argillaceous schistus, covered with calcareous schistus. Gypsum appears in vertical beds in the Via Mala, and in the western part of the valley. See Tomils and Tousis.

2. The anterior Rhine comprehends the valleys of Tavetsch, Medels, Sumvix, Lugnetz, Petersthal, &c. The valley of Tavetsch forms the upper part of the anterior Rhine. Sadrun is the principal place. Ruaras is the highest Grison village in the south-east. Selva and Camot are the only other places of note. The anterior Rhine is formed by three branches, which unite at Camot. The middle branch comes from the mountain Badus, and is called Rhin-de-Camot. It is formed by the glaciers on the eastern side of that hill, which throw their waters into the small lakes of Lac-de-Toma and Lac-Palidulca, and form the branch already mentioned. The second branch, called the Rhin-Cornara, flows out of the valley of the same name, having risen in the mountains of la Sceina de la Reveca. The third branch comes from Kamerthal, and rises at the foot of the Crispalt. The anterior Rhine, formed by these branches, receives ten brooks before it falls into the middle Rhine, which flows through the valley of Medels. Badus is 9085 feet above the bottom of the valley. It is accessible from the north, south, and east, and commands a grand view of the distant Alps. From Camot and Selva, this mountain may be ascended and descended in one day. The valley of Tavetsch is peculiarly exposed to avalanches. In 1749, an avalanche came from Crispalt, a mountain two leagues distant, and overwhelmed 100 persons, of whom 80 were taken out of the snow alive. On the night of the 13th December 1808, another descended from Rouenatsch on the village of Selva, and killed 42 persons, and 237 cattle.

The valley of Medels is very narrow and picturesque. It is watered by the middle Rhine, and extends five or six leagues. Wheat, barley, flax, and hemp, are here cultivated; but the care of the cattle is the principal concern of the inhabitants. Very fine cheese is also produced in this valley. Beyond the junction of the middle and anterior Rhine, the valley is for $1\frac{1}{2}$ miles very narrow and dark, owing to the height of the rocks, and the fir trees which cover them. The middle Rhine runs in a very narrow channel, and forms many fine cascades. In leaving this defile, the smiling valley of Medels appears. The village of Kurajla is seen situated above the river; and on the left the lateral valley of Platas, which contains the hamlets of Soliva and Bisquolm. At the Hospice of St Maria, on the Lucmanier, the Val-Kadelina opens, in which the middle Rhine has its origin. See Lucmanier.

The valley of Sumvix opens into the Rhine opposite the village of Sumvix, and has the village of Surhein at its mouth. It is about five leagues long, and stretches between huge mountains covered with glaciers. It is rich in mountain pastures, meadows, and forests. The mountain of Tenija, situated at the upper extremity of the valley, divides it into two branches, viz. Val-Vijlots and Val Greina. The torrent which runs through the valley, has its origin in the vast glacier of Medels. Though the valley is more fertile than that of Medels, it has only two chapels, and 121 inhabited houses. There is a sulphureous spring half a league above Surhein. The view of the cascade of the Greina, and the surrounding glacier, is particularly admired.

The valley of Lugnetz opens into the Rhine near Ilantz (See Ilantz.) It is eleven leagues long, and contains many lateral vallies. From Ilantz to the central point where the valley divides, is three leagues. To the south-west of this point stretches the valley of Urin, and to the south-east that of St Petersthal. The greater part of the inhabitants are Catholics. See Lugnetz.

The road from Dissentis to Coire, along the banks of the Rhine, is extremely interesting. The Benedictine abbey of Dissentis is situated above the town of the same name, on the northern face of the mountain Vakaraka, whose great forests protect both it and the town. It enjoys a splendid view of the Rhine as far down as Coire. It was founded in 614, by Sigebert, a Scottish Benedictine, who came to preach Christianity to the Rhetians. Placide Toparcha of Trons gave him the ground for this purpose, and became himself a monk. The convent and a part of the town were burned by the French in May 1799, and the inhabitants were put to the sword, in consequence of the women having massacred a company of soldiers without arms in a general insurrection. A collection of books and precious manuscripts, and the mineralogical collections and journals of R. P. Placide a Specha fell a prey to the flames. The convent has been rebuilt, and the Catholic school of the canton has been established here since 1804. The town is the chief place of the district of Dissentis, which is one of the most ancient and populous of the Grey league. From Dissentis to Trons is a distance of 3 leagues. The best wheat in the Grisons grows about Sumvix. The mountains are all primitive to Trons, but to Ilantz they are composed of beds of calcareous stone and schistus. To the north of Trons (See Trons) opens the wild valley of Puntajlas, indented with glaciers, from which issue the torrent of Ferrara. From Trons to Ilantz, by Tavenas and Rauvis, is a distance of four leagues, through a very narrow valley The great road recrosses the Rhine below Tavenas, and passes by Rauvis, Schlowis, Sagens, Lax, Flims, Trins, and Tamins to Reichenau. At Rauvis, a league below Ilantz, is a mine of galæna, containing silver. The galæna is in masses of gneiss. At Obersax, a village on the other side of the Rhine, there is a mine of pale red copper, containing much silver. There is also here abundance of borax. These two mines have been wrought since 1806. The road through Scholwis, Sagens, and Lax, traverses thick forests of Pines, and a wild country, diversified with grain and pastures. At Flims, which is situated on beautiful hills, in a pleasant place, and also at Tamins, the houses stand in separate clusters. Flims is remarkable for the beauty of its inhabitants, and for the excellence of its springs of water. The torrent Blaun sometimes commits dreadful ravages. From Flims to Elm, in the canton of Glaris, is $7\frac{1}{2}$ hours by the Hunter's road. Reichenau is the key of the anterior Rhine, and is situated at the confluence of the posterior and anterior Rhine. The former has an ash-grey colour, and the latter is a limpid green. See Reichenau.

The road from Reichenau to Coire or Chur by Ems, is a distance of 2 leagues. Between Reichenau and Ems, are 15 or 20 conical hills, covered with oak, and adorned in the most picturesque manner by chapels and ruins. From Ems to Coire is a fine rich valley, bounded on the right by the mountains of Malix, and on the left by the Galanda. This mountain is 6598 feet high, and rises like an enormous pyramid. It is ascended most easily on the side of Coire. It is composed of calcareous rocks, and of calcareous schistus, containing much argil. The strata are inclined to the south. Coire is situated on the left bank of the Rhine, in a rich plain between 2 or 3 miles wide. The town lies partly in the plain, and partly on the steep side of a rock. It is encircled with ancient brick walls, strengthened with round towers. The streets are narrow and dirty. The bishop's palace and the cathedral, built in the 8th century, stand in the highest part of the town. The convent of St Lucius is situated above the palace. The library of the town, an institution for the poor, the cantonal school, are the other principal establishments. In 1806, about 200 copper medals of the Roman emperors were found near the anterior gate. The plain around Coire is diversified with corn and pasture, and the sloping hills are covered with vines, which yield a pleasant but not a strong wine. The population of the town is 3000. Rafts, carrying from 20 to 50 quintals, descend the Rhine from the bridge over the Albula to the Lake of Constance.

Below Coire, the road passes through the fine villages of Masans, Trimmis, Zitzen, and Ighis, to the chateau of Marschlen, where the Messrs Salis have a fine library, and a superb cabinet of natural history. The Economical Society of the Grisons was established at Zitzen in 1778, and had published nine fasciculi in 1803. The road now crosses the Lanquhart by the bridge of Zollbrucks, where there is a pontage, and passes through Malantz, Jennins, and Mayenfield. Malantz is a small handsome town on the side of a hill. Its red and white wines are reckoned the best in the Grisons. There are beds of gypsum near Jennins, and much blue marl in the neighbourhood. Jennins is half a league from Mayenfield, and three quarters of a league from the defile of Luciensteg. The fine valley of Mayenfield is a league wide, and is surrounded with lofty calcareous mountains. The defile of Luciensteg is situated near the northern frontier of the Grisons, on the side of Suabia, between the Gouscher Alp, 5573 feet high, and the Flesch, 3114 feet high. A wall 100 toises long, and a rampart of the same length, defends on that side the entrance to the Grisons. The frontier passes near Balzeres, situated on that defile. At the village of Gouscha near Luciensteg, the mothers are accustomed to tie their children to a rope of a certain length, when they are obliged to leave them at home, lest they should fall over the precipices.

3. The valley of the Inn, or the Engadin, is one of the finest in Switzerland. It has 28 lateral vallies, several of which have two or three ramifications. It stretches from the south-west to the north-east, and is 18 leagues long from the Maloggia to the bridge of St Martin. It is divided into the higher and the lower Engadin. The former is seven leagues long, from the mountain Maloggia to that of Cassanna, and the latter is 11 leagues long, from Brail to the bridge of St Martin. It is subject to frequent earthquakes. A full account of this interesting district will be found in our article Inn.

4. The valley of the Albula comprehends the valleys of Davos and of Oberhalbstein. The principal valley of Davos is five leagues long, and is watered by the Landwasser, which falls into the Albula near Filisour, the end of the valley, where the river runs through a defile 1200 feet deep. The lateral vallies of Davos are those of Flula, Dischma, and the fine valley of Sertig, which is divided into two, and has a sulphureous spring, and another mineral water of a purgative quality. Each of these three vallies is four leagues long. Opposite the gorge of Zughen is the valley of Montstein, which has two branches, each a league in length. The district of Davos contains six lakes; the greatest of these, which is half a league long and a quarter wide, contains great quantities of fish. This district possesses several mines of galæna, copper, lead, and iron. The river Albula issues from a small lake in a mountain of the same name, over which there is a road to the Engadin. It descends into the valley across a dreadful gorge, called the rock of Bergun or Bergunerstein, and meets the Landwasser at Filisour. Though the smallest of the two, the united stream is called the Albula. It receives the Rhin-d'Oberhalbstein at Tiefenkasten, and is then lost in the posterior Rhine at Furstenau.

The valley of Oberhalbstein lies on the northern face of the mountains Septimer and Julier. It is 8 leagues long, and its river rises in a small lake on Mount Septimer. Savognin is the chief place in the valley. About Tintzen the valley grows very narrow, and the road ascends at the side of a torrent, bounded by horrible rocks. At the end of three-fourths of an hour it enters the meadows of Rofna. Near Molins, the castle of Splondatsch appears at the bottom of a frightful gorge. On the road to Marmels, the ruins of the castle of the ancient lords of Marmels rise on the right, upon the summit of lofty rocks. There is a mine of silver and of tin near Ziteil; and the remains of a copper mine between Ochsenberg and Tintzen.

5. The valley of the Lanquhart, or the Prettigau, is 8 leagues long and 4 wide, and has 9 or 10 lateral vallies. An account of it will be given under Prettigau. For still farther topographical information respecting the Grisons, see Misox, and the other articles already referred to.

The Grisons are divided into three leagues. 1. The League of God's House; 2. The Grey League; and, 3. The league of the Ten Jurisdictions.

The League of God's House is divided into 11 districts, and 21 communes, and sends 22 deputies to the general diet. Coire is the capital. The jurisdictions are,

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| 1. Coire. | 7. Obervats. |
| 2. Pregalia. | 8 Oberhalbstein. |
| 3. Upper Engadin. | 9. Puschiavo. |
| 4. Lower Engadin. | 10. Munster. |
| 5. Bivio or Stalla. | 11. Villages of Zitzen, Ighis, Trimmis, and Unter Vatz. |
| 6. Ortenstein. | |

The Grey League is divided into 8 high jurisdictions and 27 communes, and sends 32 members to the general diet. The following are the jurisdictions:

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| 1. Dissentis. | 5. Flims. |
| 2. Valley of Lugnetz. | 6. Rhinwald and Schams. |
| 3. Grub. | 7. Henzenberg and Tousis. |
| 4. Waltensburg. | 8. Misox. |

The League of Ten Jurisdictions is composed of 11 communities, and sends 14 members to the diet. It comprehends the rest of the Grisons, viz. the vallies of Davos, Prettigau, Mayenfield, &c.

These three leagues are connected by an annual diet of the congress and of the three chiefs. The diet consists of 63 deputies, who are chosen in the several communities by every male above a certain age. The diet meets about the beginning of September at Ilantz, Coire, and Davos, in rotation, and sits three weeks or a month. The chief of the league, in whose district the diet is held, is president, and has a casting vote. In all affairs of importance, the deputies act according to the instructions of their constituents. A majority of votes decides every thing; but they vote in the following manner: When the communities send instructions, the secretary reads them aloud, and the votes are taken from these instructions. In all resolutions, respecting which instructions are not received, the deputies may vote as they please; but these resolutions are subject to the revisal of the communities. For this purpose, a congress is held in February or March at Coire, consisting of the three chiefs and three deputies from each league, for the purpose of receiving the votes of the different communities relative to the questions referred to them at the preceding diet. The three chiefs, and the other members of congress, receive 54 florins, about 4*l*, to defray their expences. The deputies to the general diet receive a salary, which never exceeds five shillings a day.

The three chiefs meet three times in the year at Coire, and send information to the different communities respecting the subjects of discussion at the general diet.

The Roman law, modified by municipal customs, prevails in the three leagues. It appears from the concurring testimony of several travellers, that the administration of justice, both in the civil and criminal courts, is very imperfect. The judges are capable of being bribed; and confessions are obtained by torture.

The public chamber of justice, called the *Strattgericht*, is a court composed of ten judges out of every league, and twenty advocates. It is assembled by a demand made by the peasants to the general diet, and is paramount to all law. There is no appeal from the decisions of this inquisitorial tribunal. The worst effects resulted from the meeting of this court, but fortunately it is now gone into disuse.

The Catholic and Protestant religions both prevail in the Grisons. The Protestants form about two-thirds of the population. There are 135 Protestant parishes, viz. 53 in the League of God's House, 46 in the Grey League, and 36 in the League of Ten Jurisdictions. The livings are from 6*l*. to 25*l*. per annum. The clergy are here obliged to increase their income by traffic; and their poverty is rendered more oppressive from their dependence, as they are generally chosen by the people. Several of the ministers are, however, very respectable, and well informed. The Protestants are educated at Zurich and Basle; and the Catholics at Milan, Pavia, or Vienna. A Latin school was established at Coire for the children of the burghers; and another in 1763, for those intended for the church.

The expenditure of the government consists merely in the salaries of the deputies, and in the expences incurred at the sitting of the diet. The revenues are drawn from the duties upon merchandise, which passes through the canton of the dependent states, and was farmed at 17,000 florins, or 1259*l*.: from fines upon delinquents; from a tribute of 500 Philips, or 125*l*. from the Valteline; and 100 Philips, or 25*l*. from Chiavenna; and from the interest of a small sum, the principal part of which, viz. 4000*l*. was vested in the British funds.

The commerce of the Grisons is very limited. Its principal exports are cheese and cattle, and some planks, stones, and coal, to Milan. The care of the cattle is the principal employment of the peasantry. The canton possesses 8000 head of great cattle, about 30,000 cows, from 60,000 to 70.000 goats, and nearly 100,000 sheep, which come annually from Italy to feed upon the fine pastures of the Grisons. The cattle of the Prettigau are the finest breed. Vines are cultivated in the vallies on the northern and southern frontiers.

The imports of the Grisons are grain, rice, salt, and silk stuffs from Milan; grain from Suabia and the Tyrol; salt from the Tyrol and Bavaria; fine linens and muslins from Switzerland; and English, French, and Silesian fine cloth through Germany. The only manufactory in the country, is that of cotton at Coire. The trade of the Grisons, and the subject provinces, is carried on with Milan across the Lake of Como, by its branch the lake of Lecco, by the river Adda, and by the canals of the Adda and the Trezzo.

The Italian, German, and Romansh languages, prevail in the Grison territory. The inhabitants of Pregalia and Puschiavo, and of the vallies of Misox and Calanca, speak the Milanese dialect of the Italian tongue. The inhabitants of the Ten Jurisdictions, with the exception of a few villages; those of the League of God's House, at Avers, Coire, and the four villages; those of the Grey League, at Splugen, Cepina, and other villages of the Rhinwald; at Valts, in the valley of St Pedro; at Tousis, Reichenau, Feldsperg, Tamins, Meyerhof, Versam, and Valendros.

The Romansh, or Rhetian language, is the vernacular tongue throughout the greater portion of the Grison territory. It was formerly spoken at Coire, and the adjacent districts, and as far as Inspruck in the Tyrol. It is divided into two principal dialects; the one called Cialover, spoken in the Grey League; and the other Ladin, in that of God's House. These dialects vary both in pronunciation and orthography, and they have a great affinity to the Latin, and other languages derived from the Latin. Planta seems to have proved, that the Romansh of the Grisons is the same with the ancient Romansh, called *Lingua Romana*, the mother of the French tongue. It was the earliest language derived from the colloquial Latin, and was understood in Italy, in the Morea, and at Constantinople, having been universally diffused throughout the south of Europe in the 11th and 12th centuries.

The antiquities in the Grisons are very numerous. There are no fewer than 180 castles and ruins of the middle ages.

Mr Coxe reckons the population of the Grisons at 98,000.

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| The Grey League contains - - | 54,000 souls. |
| League of God's House - - - | 29,000 |
| League of Ten Jurisdictions - - | 15,000 |
| | 98,000 |

In the year 1806, the population was 73,862, viz.

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| Protestants - - - - - - - | 44,982 |
| Catholics - - - - - - - - - | 28,880 |
| | 73,862 |

Or they may be divided into

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|---|---|
| Germans - - - - - - - - - | 28,000 |
| Those who speak the ancient Rhetian language - - - - | 36,065 |
| Italians - - - - - - - - - | 9,797 |
| Total population | 73,862 |

This number is exclusive of the provinces formerly subject to the Grisons. Se Coxe's *Travels in Switzerland*, vol. iii.; Ebel's *Manuel d'un Voyageur en Suisse*, passim; and Planta's *Account of the Romansh Language*, in the Philosophical Transactions for 1776, vol. lxvi. p. 129.

GRODNO, is a town of Poland, in Lithuania, and, with the exception of Wilna the capital, is the most important place in that province. It is now a frontier town on the Russian division of Poland. It is built upon an eminence which overlooks the river Niemen, which is here a broad, clear, and shallow stream. Grodno is a large and straggling place, and has the appearance of a town in decay. The few houses that are in good repair form a singular contrast with the wretched habitations, the falling houses, the ruined palaces, and the magnificent gateways, which are everywhere to be seen. Some remains of the old palace, in which the kings formerly resided during the diets, are still to be seen upon a hill of sand, rising abruptly from the river, and forming a part of the bank. The new palace is opposite to this hill. It was built, but never inhabited, by Augustus III. and became the temporary residence of Stanislaus Augustus after his abdication. It contains the apartments for the meeting of the diets. The late king of Poland established at Grodno a royal academy of physic for Lithuania, in which ten students are instructed in medicine, and twenty in surgery, and are lodged, boarded, and taught, at the royal expence. The physic garden contained 1500 exotic plants, when Mr Cox passed through the town in 1778. The principal manufactures here are cloth and camlets, linens and cottons, silk stuffs, embroidery, silk stockings, hats, lace, fire-arms, needles, cards, bleaching wax, and carriages. They were chiefly established by the king in 1776, and in 1778 they were carrying on in wooden sheds, built by Augustus III. for stables, which were converted into temporary working looms, and dwelling houses for the workmen. The establishment was subsequently removed to Lossona, a village near Grodno, where convenient buildings were erected at the public expence. The country furnishes a sufficient supply of wool, flax, hemp, beaver's hair, and wax, for the manufactories that require these articles; but the silk, cotton, iron, colours, gold and silver, for the embroidery, and the fine thread from Brussels, are all articles of import. Three thousand persons are employed in these manufactories, including those in the neighbouring villages who spin linen and worsted. Seventy foreigners direct the different branches, and the rest are natives. Grodno contains nine Catholic churches, and two Greek churches. The population consists of 3000 Christians, exclusive of those engaged in manufactures, and 1000 Jews. See Cox's *Travels in Poland, &c.* vol. 1. p. 220, 223.

GROINS. In our article CARPENTRY, we have already treated the subject of groins at some length. We proposed, under the present head, to have investigated the subject of *Domes*, from which we have made a reference; but we have found it necessary to include this subject under that of ROOFS, to which the reader is referred.

In the article CARPENTRY, we have mentioned the great improvement in the construction of brick groins, rising from rectangular piers, as made by Mr George Tapper. The following account of this improvement has been drawn up for our work by Mr John Narien.

If a square or rectangular area be covered with two vaults, penetrating each other at right angles, and forming two ridges which cross the area diagonally, and intersect each other at the common summit of the vaults, the arch thus formed is called a groined vault: the penetrating vaults may be either semicircular, or semi-elliptical, or one of them may be semicircular and the other semi-elliptical. The intersections of the circular or elliptical vaults, forming the ridges or groin angles, will be ellipses, because every oblique section of a cylinder or elliptical prism produces an elliptic curve, and the case will be the same when one of the vaults is circular, and the other elliptical; for if horizontal lines were drawn from points in the diameter or chord of the circular vault perpendicularly to that diameter, and cutting in different points a line drawn diagonally across the area, the ordinates drawn up to the ridge or groin angle from these points, will be respectively equal to the ordinates at the corresponding points under the circular vault, and consequently their ends will be in the periphery of an ellipse.

The four vaults or arches forming the groined vault, spring from the angles of four square abutment piers, and if the intended vault is to be built of stone, the courses in each arch respectively are laid upon the centering, in lines parallel to the axis of the arch they compose, in such a manner that the voussoirs of each arch meet the voussoirs of its adjacent arch at the groin angle, where the faces of the angular voussoir in each course are wrought in such a manner as to form the curve of the groin, which springs from the angle of the pier on which the arches stand. The upper surfaces of these angular voussoirs are also wrought, so that on both faces they may coincide with the other stones of the same course, by which means these surfaces meet in a ridge which is always perpendicular to the curve of the groin angle. When the intended vault is to be built of brick, the internal faces of the brick voussoirs in each course are cut away at the groin angle, to receive the wedge-like end of a brick in the adjacent arch in the same course, in order to bind the arches together more firmly: (See Plate CCLXXXIV. Fig. 1.) But as bricks have not, like wrought stones, the form of a frustrum of a wedge by which they may sustain themselves when arranged in the shape of an arch, their stability must depend upon the strength of the cement placed between them, which, uniting them into one mass, renders a structure of this kind a sort of vault hewn out of a rock.

From a consideration of the above mentioned mode of constructing groined vaults, it will be evident that the pressures, both vertical and lateral, of all the arches of which they are composed, are resisted and sustained by the mutual intersections of the courses of masonry at the groin angles; these intersections may be considered as squares upon the corners of the piers from which they spring, the side of the square being equal to the thickness of the course of voussoirs, so that the diagonal ribs of the vault form as it were two arches, which are kept in a state of equilibration, by the weight of the spandrils immediately over them, and serve as bases upon which the side arches with their spandrils, and all the superincumbent loading, ultimately rest; hence it will be evident that, if the weight of the arches, with their loading over them, were in a constant ratio to the weight necessary for keeping the ribs in a state of equilibration, the whole vault will be in equilibrio in all its parts. This, however, cannot be attained in practice, because the distances between the ribs at any part are never in proportion to the height of the spandrils over the ribs at those parts, and therefore the groined vaulting will always in some degree be defective in its equilibration; besides the disadvantage arising from the whole of the weight falling entirely upon the ribs, which receive no support from the voussoirs of the contiguous side arches, whose joints are all oblique to the directions of the ribs.

But as groined vaults are absolutely necessary in warehouses, and many other buildings, for the purpose of giving communication throughout the same in every direction, which cannot be obtained where waggon-head vaults are used and as there is a great saving of materials, resulting from the arches bearing on piers only, instead of parallel walls, it follows, that an improvement in their construction, which tends to bring them nearer to an equality in strength with the waggon-head vaulting, must be a great acquisition. This improvement has been lately made by Mr George Tappen, an architect of London, who, instead of the square piers hitherto used, has adopted octangular ones, (by which a considerable saving of room is made,) and has thrown stout ribs diagonally over the vault, whose breadths are equal to the sides of the octagons on which they stand. The side arches, which in brick-work are set four inches back from the face of the ribs, in order to save the trouble and expence of cutting the groin angles, are worked into, and rest upon these ribs. By this improved construction, the ribs form a much stronger support for the weight of the incumbent vault, and the loading above, than by the old method, as the following comparison will shew.

Since the force of the superincumbent weight has been found by experience to act chiefly in the direction of the groins, they require the greatest strength that can be given them; at the same time, the side arches should be made to throw as little weight as possible upon them, particularly about the summit of the vault, that their tendency to fracture towards the crown may be diminished as much as the nature of the case will admit. In the groined vaults hitherto constructed, where the groins spring from the extreme corners of the square piers, their section, taken perpendicular to their length, forms a square, (see *a*, Plate CCLXXXIV. Fig. 2.) having one of its angles turned towards the centre of the curve, and its side equal to the thickness of the arches; whereas in the new vault, the section taken in the same manner, forms a rectangle equal in breadth to the side of an octagon inscribed in the square pier, and of a depth which may exceed that of the old groin in any proportion, (see *b*, Fig. 2.) Now, the strength of an arch, in its different points, is measured by the greatest weight which it is able to carry on those points without breaking; that is, it is in a ratio compounded of the triplicate ratio of the secant of the angle of the curve's inclination to the horizon, in its various points, and the reciprocal simple ratio of the radius of curvature in the same points. But since the relative strength of arches is to be determined by comparing them in their weakest parts, (namely the crown,) the strength of any arch at the crown will be reciprocally as the radius of curvature at that point, since the angle of the curve's inclination to the horizon at that point is always 0° 0′; or reciprocally as the span of the arches, when the rise of them is the same, their thickness being supposed equal. From this it will be evident, that the strength of the diagonal ribs and groins will be directly as the areas of their sections and distances of the centres of gravity from the place where the fracture would end, and reciprocally as the spans of the arches: that is, if A represent the area of the section, G the distance of its centre of gravity, and S the span of the arch; then the strength of one arch to that of another will be as $\frac{A \cdot G}{S}$.

Let the side of the square pier be $= a$; then the thickness necessary for the side arches will be $= \frac{a}{4}$, which, consequently, will be the side of the square section of the groins in the old arch; its area, therefore, will be $= \frac{a^2}{16} = A$, and its half diagonal $= \frac{1}{2}\sqrt{\frac{a^2}{8}} = G$. The distance of the piers being $4.5\,a$, the span of the diagonal groins will be $= \sqrt{2 \times (4.5\,a)^2} = 6.364\,a = S$; we have therefore $\frac{A \cdot G}{S}$ $= \frac{\frac{a}{32}\sqrt{\frac{a^2}{8}}}{6.364}$ for the strength of the old groin.

The side of the square pier remaining still $= a$ in the new arch, the breadth of the rib $= \sqrt{2\,a^2} - a$, which is the side of an octagon inscribed within the pier, the thickness proper for the rib will be $= \frac{a}{3}$: then will $A = \frac{a^2\sqrt{2} - a^2}{3}$; $G = \frac{a}{6}$; and $S = 5.364\,a + \sqrt{2\,a^2}$; consequently $\frac{A \cdot G}{S} = \frac{a^2\sqrt{2} - a^2}{122.004}$, the strength of the new rib.

If we assume $a = 4$ feet 8 inches, (the dimensions assigned by Mr Alexander to the piers of the groined vaults at the London dock tobacco warehouses.) the strength of the old groins will be to that of the new ribs as 5.44 to 10 64, which is nearly 2 to 1 in favour of the new construction; and this will be the case while the same proportions are preserved, whatever may be the extent of the arch.

If the side arches, with their spandrils, and the loading on the floor above, be cut by parallel vertical planes, (as at S, Fig. 2) the sections will be to each other as their chords *c d* nearly; which being less in the new vault than in the old, on account of the greater breadth of the ribs, the weight incumbent on those ribs (which always tends to destroy their equilibrium) is just so much less in the former than in the latter, and consequently their tendency to fracture is diminished in the same proportion.

It may not be improper to observe, that Dr Hutton recommends the stones of the wall, or spandril over the extrados of the voussoirs of an arch, to be bonded into the stones of the pier, and with one another; because the pier will then carry part of their weight, and thereby oppose a greater power of resistance to the thrust of the arch. For the same reason, it would be equally advisable, in the new method of building groined vaults, to carry up at the same time the diagonal ribs, side arches, and spandrils, well bonding the whole together into one solid mass; which will render vaults built in this manner a valuable acquisition in warehouses and other large buildings, where the greatest weights are to be sustained.

GRONINGEN, a town in Holland, and capital of the province of the same name. It is intersected by the river Hunes, which passes through it in a northerly direction to the sea. The town is large, rich, strong, and populous, and is adorned with many excellent buildings. It is nearly round, and is surrounded with good ramparts, a wall, and ditches, and has a citadel. Its university was founded in 1614, and endowed with the revenues of several monasteries. The harbour can contain many vessels, which enter it by a canal about nine miles from the sea. It carries on a considerable trade in butter, horses, and horned cattle. There are some breweries in the town.

GROSE, Francis, a celebrated antiquarian, was born in 1731, and was the son of a jeweller at Richmond, who died in the year 1769, and left his son an independent fortune. He entered into the Surrey militia, and was appointed adjutant and paymaster; and such was his love of dissipation, that he soon squandered away the fortune which his father had accumulated. The distress to which he was now reduced, compelled him to have recourse to his talents; and having a fine taste for drawing, he began to collect materials for his *Views of Antiquities in England and Wales*, a work which he began to publish in numbers in 1773, and which was completed in 1776. Other two volumes, including Guernsey and Jersey, were completed in 1787. The success of this work induced him to embark more deeply as an author. In the summer of 1789, he made a tour through Scotland; and in 1790, he began to publish in numbers, his *Antiquities of Scotland*, which were completed in two volumes 4to. In the year 1791, Mr Grose set out for Ireland, with the view of collecting materials for an account of the antiquities of that country; but soon after his arrival at Dublin, he was seized with an apoplectic fit, of which he died, on the 6th of May 1791, about the 60th year of his age. Mr Grose was remarkable for his good humour, conviviality, and friendship. He was extremely corpulent, and altogether singular in his external appearance. A likeness of him, at full length, is given in his Olio, published after his death.

The following is a list of his works: 1. The Antiquities of England and Wales, 8 vols. 4to. and 8vo. 2. The Antiquities of Scotland, 2 vols. 4to. and 8vo. 3. The Antiquities of Ireland, 2 vols. 4to. and 8vo. 4. A Treatise on Ancient Armour and Weapons, 4to, 1785. 5. A Classical Dictionary of the Vulgar Tongue, 8 vols. 1785. 6. Military Antiquities; being a History of the English Army from the Conquest to the present time, 2 vols. 4to, 1786, 1788. 7. The History of Dover Castle, by the Rev. William Daniell, 4to, 1786. 8. A Provincial Glossary, with a Collection of local Proverbs and popular Superstitions, 8vo, 1788. 9. Rules for drawing Caricatures, 8vo, 1788. 10. Supplement to the Treatise on Ancient Armour and Weapons, 4to, 1789. 11. A Guide to Health, Beauty, Honour, and Riches; being a collection of humorous Advertisements, pointing out the means to obtain those blessings; with a suitable introductory Preface, 8vo. 12. The Olio; being a Collection of Essays, in 8vo, 1793.

GROTIUS, Hugo, one of the most profound and enlightened scholars, and one of the most remarkable men of his age, was born at Delft in the United Netherlands, on the 10th of April 1583. The name in Dutch is *De Groot*, or *the Great*; and as it had for many ages been the patronymick of one branch of his ancestors, the circumstances which led to its adoption are unknown. But few families have better merited such a distinction, if greatness be estimated not by external rank and honour, but by those intellectual and moral endowments which far surpass in value all the gifts of fortune. The family of Grotius had been illustrious at Delft for four centuries, and he himself in the estimation of his own age and of posterity, pre-eminently merited the surname of *Great* among the *great*. He did not descend, however, in the uninterrupted male line from that family; for it is related, that about the year 1430, Dederic de Groot, burgomaster of Delft, and a highly distinguished member of the family, had an only child, a daughter named Eremgard, whom he left a wealthy heiress. This young lady was sought in marriage by Cornelius Cornetz, who sprung from that branch of the noble family of Cornetz, which, under the Dukes of Burgundy, had emigrated from France into Holland. The lady favoured his addresses, but, under this stipulation, that should there be any children of the marriage, they should take the name of her and her ancestors, *De Groot*. The first who, in conformity to this agreement, bore her name, was Hugh, grandson of Dederic, and grandfather of the subject of this article. One of the sons of this Hugh was Cornelius de Groot, born in Delft in 1544. After acquiring much learning at his native place, he prosecuted his studies, literary and mathematical, with great ardour at Louvain and Paris. He delighted in the philosophy of Plato. He then applied himself to the civil law at Orleans, and on his return to Delft, betook himself to the bar, and afterwards filled several important offices. In 1575 he was appointed professor of philosophy in the university of Leyden, which dates its origin from about that time, and which has since been so celebrated in the republic of letters. He afterwards taught the civil law in that seminary, and evinced his preference for the quiet pursuits of learning, by refusing a seat in the great council of the States, though that appointment was repeatedly pressed on his acceptance. He died without issue in 1601. Hugh De Groot had another son, John, who also studied law. He was appointed burgomaster of Delft, and afterwards curator of the university of Leyden. He was an elegant scholar and a poet. But his chief claim to the remembrance of posterity is, that he was the father of our Hugo Grotius, to whom it is now proper to direct our attention.

This illustrious man was born, as we already stated, at Delft, in 1583. His mother's name was Alide Overschie, and the family to which she belonged was of some note. Endued by nature with admirable talents, he enjoyed from his infancy the advantage of an excellent education. When he was only seven years of age, he was placed under the tuition of masters, with whom he made such extraordinary progress, that before he had completed his ninth year he composed verses which obtained the approbation of the learned. At twelve he was so great a proficient in the knowledge of the classics, and of *belles lettres*, that he was qualified to pursue his studies at the university. He was accordingly sent in 1595 from Delft to Leyden, where he spent three years in the study of mathematics, philosophy, theology, and law, and excelled in the knowledge of each of these sciences. He was only fifteen years old when he wrote a commentary on a very difficult Latin poet, Marcianus Capella. The celebrated statesman, John Barnevelt, attorney-general of the republic of Holland, having been, in 1598, appointed ambassador to France, the young Grotius accompanied him thither. Henry IV. who then reigned in France, gave him most gratifying marks of his esteem. The monarch presented him with a gold chain, and a portrait of himself; and it is said that he was so highly pleased with such attention, that he caused his own portrait to be engraved, adorned with these tokens of royal favour. While he remained in France, he obtained the degree of Doctor of Law at the early age of sixteen.

On his return to Holland, Grotius, in compliance with his father's desire, entered on the profession of law; and at the age of seventeen, he began to plead with distinguished ability and success. He retained his fondness, however, for classical and literary pursuits, and continued to prosecute his general studies with ardour in those intervals of leisure which his laborious profession allowed, and which supplied the place of recreation, chiefly by affording a change of employment. When he was in his 24th year, he was appointed attorney-general of Holland, Zealand, and West Friezland, and filled his high office with such talents and integrity, that the salary attached to it was augmented.

In 1613 he removed to Rotterdam, to engage in the duty of pensionary, or chief magistrate of that city, as successor of the recently deceased Elias Barnevelt, brother of John, his early patron and friend. At this time, religious controversy ran high in the United Provinces between the Calvinists, or Gomarists as they have been called, from Francis Gomar of Bruges, and the Armenians, especially with respect to grace and predestination. Grotius, amidst the heat of the contending parties, conducted himself with such prudence and moderation, as to retain for a considerable time the respect of both. He was also admitted into the assembly of the states of Holland; and as he had written in defence of the right of the Dutch to trade with India, he was sent to England, to adjust the differences which had arisen between the merchants of the two countries. He succeeded in the object of his mission, and received marks of regard from James I. At his return home, he found the United Provinces divided and distracted by quarrels about religion; and while he had the affliction to see that true patriot and able politician, John Barnevelt, sacrificed to a faction, under the pretence of treason and heresy, to gratify its own ambitious projects, Grotius himself most narrowly escaped sharing his melancholy fate. Barnevelt was tried by twenty-six commissioners deputed from the Seven Provinces, and, in terms of the sentence of this cruel tribunal, was beheaded in 1619. Grotius, who had been warmly attached to him, and who was suspected, by the bigots of the day, of favouring the Armenians, was involved in his disgrace. He was arrested in August 1618, and in May following was condemned to perpetual imprisonment, and to have all his property confiscated. He was strictly confined in the castle of Louvestein, near Gorcum. "Here he remained," says Dumourier, "without any other consolation than the company of his wife, and of books which his friends were permitted to send to him. A large trunk was usually sent filled with books, which he returned after having devoured them, (*après les* *avoir devorés*,) and it was during this imprisonment that he translated Stobœus. But his confinement lasted only about two years, as he was happily delivered from it by the address of his wife, Mary Reygelsberg.* She, having remarked that his guards (tired with frequently searching the great chest filled with linen or books, that passed between the prison and Gorcum) allowed it at length to be transmitted without opening it, advised her husband to place himself in it, after having made holes with a wimble in the part of it over his face, to allow him to breathe. He entered into the scheme, and was thus carried to the house of one of his friends at Gorcum, whence he went to Antwerp by the ordinary conveyance, after having passed through the market-place at Gorcum, disguised as a mason with a rule in his hand. His wife, who had so dexterously managed the affair, pretended that her husband was much indisposed, in order to afford time for his escape; but when she supposed him to be in a place of safety, she told the guards that the bird was flown. It was at first intended to prosecute her, with a view of having her confined in her husband's stead; but she was liberated by a majority of votes, and she was universally praised for having restored her husband to freedom. This took place in March 1621." Dumourier *Memoires de Hollande*. Grotius, thus happily delivered, secretly left Antwerp in the following month, and repaired to France, where he experienced powerful protection, and was introduced to Louis XIII. who bestowed on him a pension of 3000 livres, which he enjoyed for about ten years. Prince Maurice, the enemy of Barnevelt, and persecutor of Grotius, died in 1625; and it is a circumstance highly honourable to Grotius, that in his History of the Netherlands, from the departure of Philip II. till 1608, which was not published till after the author's death, he relates the splendid achievements of this prince with the utmost fidelity, and without alluding to the harsh treatment which he had suffered from him. The brother of Maurice, Prince Henry Frederic, entertained the most friendly disposition towards Grotius, and would gladly have recalled him, but was deterred by the jealousy of his political opponents, which still existed with unabated force.

Many attempts were in the mean time made, but, happily for the best interests of learning and humanity, without success, to excite prejudice against him in the breast of his powerful protector Louis. That prince was not to be influenced by such unworthy efforts; but, on the contrary, his respect for Grotius increased, by observing the unabated love which the illustrious exile bore towards his ungrateful country. He employed much of his time while in France in reading and composition, and increased the resentment of his enemies who then prevailed in Holland, by his admirable defence of the deposed magistrates.

In 1631, his pension from the French court was withdrawn, whether from motives of public economy, or from ministerial pique, or from what other cause, cannot be ascertained. He soon after ventured to return to Holland, confiding in the friendship of Prince Henry Frederic. But, through the malice of his enemies, he was condemned anew to perpetual exile. Finding himself cruelly compelled to leave his native land, which he still fondly loved, he repaired to Hamburgh, where he received the most gratifying offers of protection from the kings of Denmark, Poland, and Spain, accompanied with solicitations from each, that he would attach himself to his court. He preferred, however, the patronage of Gustavus Adolphus, king of Sweden, whose death, in 1632, obliged him for some time to remain unemployed in Hamburgh. Queen Christina fulfilled the wishes and intentions of her predecessor; and in 1634, appointed Grotius one of her counsellors. She soon after nominated him to be her ambassador at the court of France. This new diplomatic appointment displeased Cardinal Richelieu, then prime minister of Louis XIII. and he used his influence with Oxenstern, the chancellor of Sweden, to have him recalled. Grotius, who had remained in retirement at St Denis till the ulterior pleasure of the Swedish court should be known, made his formal entry into Paris as Swedish ambassador in March 1635. After having spent eleven years in France, he was, in consequence of his own request, recalled, and having occasion to pass through Holland in his way to Sweden, he was received at Amsterdam with every mark of respect and honour; for many of his enemies had retired, or were dead, and several of his friends were restored to offices of public trust. The account which he gave to the Queen of Sweden of the affairs connected with his embassy, proved highly satisfactory; and anxious as he was to retire from public life, she would have gladly retained him in her councils; but the jealousies of her courtiers inducing him to persist in his desire, she at length consented. She made him, when on the eve of his departure, a present of twelve thousand rix-dollars. Stress of weather driving the vessel in which he embarked for Holland upon the coast of Pomerania, he was put ashore in a bad state of health, intending to finish his journey by land. He was unable to proceed farther than Rostock. Calumnies, with regard to the soundness of the religious principles of Grotius, and the state of his mind at his death, were officiously published by his enemies; but they are satisfactorily confuted by John Questorpius, professor of theology, and minister of Rostock. This learned and pious man wrote a letter, which is still extant, giving a pleasing account of the chearful resignation and Christian piety by which the close of his valuable life was characterized. He expired at Rostock, on the 28th of August 1645, in the 63d year of his age. The remains of this great and good man were embalmed, and removed to Delft, where they were committed to the sepulchre of his ancestors. His wife appears to have survived him. He left three sons and a daughter. The eldest son Cornelius, who wrote elegant Latin verses, was for some time employed by Oxenstern in Sweden. The second, Dederic, was aide-de-camp to Duke Bernard of Weimar, and was assassinated in a tavern by his valet. The youngest, Peter, was appointed by the Elector Palatine to be his resident with the states general; and, by the favour of the De Wits, he was made pensionary of Amsterdam. After having been employed in different political embassies for Holland, he was tried for alleged offences against the state, and was acquitted. He died in retirement at the age of seventy. Cornelia, the daughter of Grotius, was married to M. de Mouthas, who served with eclat in Holland; but being involved in the fall of the De Wits, he quitted that country in 1672.

The multitude of works which Grotius left behind him on various subjects, prove him to have been an universal and profound scholar, and a man of the most indefatigable industry. It is not without astonishment that we contemplate the literary labours of one, whose private misfortunes and public duties might have been supposed to leave him little inclination, and less leisure, for the calm pursuits of philosophy and science. His mind was amply stored with the treasures of ancient and modern learning, and his excellent memory enabled him to retain and employ, as occasion might require, the knowledge which he derived

* Dumourier writes her name Reygelsberg, as in the text; but in a marginal note in Bayle's Dictionary, she is called Reygersbergen.

from his books. It is indeed related of him by Borreman, in proof of his wonderful memory, though we must be permitted to doubt the accuracy of the anecdote, that Grotius having been present at the review of a regiment, recollected the name of every individual belonging to it.

It would be tedious to give a catalogue of the works which are known to have proceeded from his pen, most of which were published during the life of the author, as they amount to seventy-four or seventy-five. As his writings, however, exercised a powerful influence, not only over his contemporaries, but have continued, and still continue, to influence the policy of nations, and the opinions of scholars and philosophers throughout the civilized world, we shall mention the names of some of the most remarkable, and add a few occasional reflections on their value. Considering him, then, as an author, we may, for the sake of arrangement, notice some of those compositions which exhibit him respectively as a scholar and poet, a patriot, a philosopher, a philanthropist, and a theologian. It is to be premised, that his works were generally written in the Latin language, which in his time, and for ages after, formed the chief medium of communication among the learned of all the countries of Europe.

In viewing Grotius as a scholar and a poet, we may mention the following works:

1. *Poemata nonnulla, seu Characteris Pontificis Romani*, &c. &c. 4to, 1599.

2. *Marciani, M. F. Capellæ Satyricon, seu de Nuptiis Philologiæ et Mercurii, libri duo emendati et notis illustrati*, 8vo, 1600. This learned publication, from so young an author as Grotius, was among the first things that brought him into notice, and gave a most auspicious promise of his future greatness.

3. *Mirabilium anni* 1600, *quæ Belgas spectant*, &c.; a poem in 4to.

4. *Adamus Exul*, tragædia, 8vo, 1601. This work was printed when the author was only eighteen, and about seven years before the birth of Milton. Whether or not this tragedy may have suggested the idea of *Paradise Lost*, or how far he, Milton, may have availed himself of it, we have not at present the means of ascertaining. But the choice of this subject by two such eminent contemporaries, is an interesting coincidence in the history of literature.

5. *Christus patiens*, tragædia, 8vo, 1608. This tragedy was translated into English by George Sandys, with notes, in 1640. A German writer used it as a model for the illustration of the rules of tragedy; and Curpzovius, Professor of Poetry at Wittemberg, made it the theme of some of his lectures.

6. *Commendatio Annuli*, (a poem) 4to, 1609. 7. *Lucani Pharsalia*, cum notis, 4to, 1614. 8. *Exerpta ex Tragædiis et Comœdiis Græcis*, &c.

In the biographical sketch, we have had occasion to mention the ardent love of country which characterized Grotius, amidst all the sufferings and varieties of his life; and we noticed two of his works relating to his native land, the one of a historical, the other of a commercial nature. The title of the latter of these, and of the answer to it, are curious, and particularly when we consider them in connection with the political events and speculations which have marked the close of the eighteenth, and the opening of the nineteenth century, both on this and the other side of the Atlantic. It is called *Mare Liberum, seu de jure quod Batavis competit, aut Indica commercia*, 8vo, 1609. It was at first printed anonymously, was then translated into Dutch, and passed through many editions. After the lapse of some years it was answered by John Seldon, in a composition entitled *Mare clausum, seu de dominio maris*, Lond. 1635. To this attack, Grotius, in so far as we have been able to discover, made no reply. Grotius published in 4to, A. D. 1610, his work *De Antiquitate Reipublicæ Bataviæ*. Also, a Discourse pronounced in the Senate of Amsterdam, upon the views of the States of Holland respecting the Reformed Religion. In the Dutch language, 4to, 1616.

But it behoves us now to speak of the great work upon which the fame of Grotius chiefly rests, which exhibits him as a citizen of the world, and which forms the beginning of a great era in the history of political philosophy. The work to which we allude was written in France, at the instigation of his friend Peireskius, and printed at Paris, in 4to, in 1625, entitled *De Jure Belli et Pacis*. The President Jean Jacques de Mesmes gave him the use of his country house Balagni, that he might have leisure and retirement for the composition of this work. The author dedicated it to Louis XIII. and he quickly attained by it a splendid height of popularity and fame. It was revised and improved by Grotius, and translated into many languages. Under this title he has attempted to give a complete system of natural law, and to evolve from the mass of precedents and particular statutes, which constituted the chief study of the lawyers of his time, many of those general maxims which should enter into the principles of legislation, and regulate inter-national transactions, as well as to point out their foundation and sanctions in the nature of man, and in the constitution of human society. His work partakes, in some respects, of the prejudices of the age in which it was written, and, particularly, of an overstrained reverence for the institutions of the Roman law. It is also overloaded with quotations and authorities from classical writers, from the Mosaic law, from other parts of scripture, and from various writers sacred and profane, by which the mind of the reader is often perplexed rather than enlightened; and the diffuseness of the notes forms a curious contrast to the brevity and obscurity of the text. Puffendorff, for whom a professorship was formed at Heidelberg, for the express purpose of extending the knowledge of the doctrines of Grotius, is deemed the most eminent of his disciples and commentators. These doctrines have been since taught almost to our own day, in the most celebrated universities of Europe, and, in the opinion of respectable judges, form the foundation of the ethical and political philosophy of the present times. Bayle has justly remarked, that Grotius must be deemed particularly fortunate as an author; and that, fifty years after his death, this work obtained for him an honour, which was not bestowed upon the ancients till after many ages, namely, that he appeared in it *cum commentariis variorum*.

We have space only farther to mention, that, besides several treatises connected with religion and the controversies of the day, Grotius distinguished himself by a popular and a philosophical work in defence of Christianity. The first of these was entitled, Proofs of the True Religion. It was written in Dutch verse, with the benevolent designs of furnishing innocent and useful employment to the minds of his sea-faring countrymen in long and tedious voyages; and of enabling them to maintain their stedfastness in their own faith, and, as opportunities might occur, to explain and recommend it to the foreigners with whom they might have intercourse. The other work to which we have alluded, is the celebrated treatise *De Veritate Religionis Christianæ*, which was published at Paris in 1639, and dedicated to his friend Bignonius. The plan of this work is comprehensive, the style frequently obscure, and the notes unnecessarily copious and minute. Yet, as it was among the first works of the kind which were published, and as it contained much new and excellent argument and illustration, it has been translated into all the European languages, referred to in most works on the same subject, and preserves its estimation as a standard work on theology at the present day. (*l.*)

GROTTO, is a subterraneous fissure or opening in the earth, generally adorned by calcareous incrustations, which produce a brilliant effect when illuminated by torches.

Mountainous and volcanic countries, or those regions which are partitioned into many islands, more frequently exhibit grottos, caverns, or fissures, than low or level grounds. They are also common in places subject to earthquakes, and have the greatest extent and intricacy in countries where huge masses of limestone abound.

The most celebrated grotto for beauty, size and, magnificence, is that of Antiparos, an island of the Mediterranean, already described in the previous part of this work; and that which is reputed next to it is of recent discovery in the island of Skye, among the Hebrides of Scotland. It had been long known to the islanders, that the mouth of a cavern, called *Slochd Altriman*, or the *Nursling Cave*, opened among the cliffs overhanging the sea on the south-west shore, and that a particular tradition was annexed to its history. But none ventured to explore its recesses, until, in the year 1808, the masculine intrepidity of a lady, Mrs Gillespie, exposed to more timid adventurers what has been called one of the most remarkable phenomena, which exists in the structure of the earth.

This cave comes under the particular description of a grotto; for, it may be observed, that a cave and a cavern, between which some authors even make a distinction, properly implies a subterraneous vacuity without incrustations. The land above *Slochd Altriman* is of moderate height; but, from the shore consisting entirely of perpendicular rocks, the entrance can be reached on foot only at low water, and then with particular difficulty. When the tide is up, however, a boat can easily approach it, unless the wind should render such an attempt dangerous from sunken rocks, and dislocations of stony masses from the cliffs. The grand access to the cave is formed by two immense walls of free stone, separated thirty feet asunder, rising above 100 feet in perpendicular height, and stretching out in a straight line from the shore. Here the tide flows in about 400 feet; but, at low water, the bottom is rough, and covered with slippery weeds. These obstructions being surmounted, a magnificent rugged arch, of a Gothic form, is presented to the spectator, and on one side an inferior cave with many lateral crevices. This great aperture is embellished with innumerable dark green stalactites of various sizes; some descending to the ground, and forming pillars overgrown with moss, which, with the intermixture of vivid foliage, brown heath, and wild flowers, produces an interesting combination. Close to the entrance of this grotto, there is, as it were cut out of the stone, a small fountain of pure water, surrounded by rocky pillars, and the water collected in the cistern is derived from the exudation of the rock above. A passage about nine feet broad, and from fifteen to twenty in height, conducts the visitor almost on a perfect level for twenty yards, when a steep ascent for 55 feet leads up a bank of earth, sand, and small broken whinstone; another acclivity now commences, more difficult to overcome, of irregular surface, resembling a solid cascade, or frozen snow, and sparkling with crystallizations. Advancing a few yards, the principal entrance to the interior grotto is gained, eight feet broad, and twelve in height, universally white as marble, and variously decorated with beautiful incrustations. Thousands of icicles of pure white spar are suspended from the roof like the festoons of a curtain, giving the whole a finished appearance. The breadth, on proceeding still farther, enlarges to ten feet, and the height to forty, while the white marble spar continues rough and uneven; and it is only after traversing thirty-five feet of this gallery, that the proper excavation, which has been denominated the *Spar Cave*, is reached. It consists of a circular vacuity about twenty feet in diameter, with a lofty roof, and a pool at the bottom, contained in a marble cistern. But the whole is said to exhibit the most brilliant spectacle which imagination can conceive. The sparry concretions are innumerable, and in every variety of form; while the lights, by which the spectator examines them, are reflected from a thousand glittering points. Many of the surrounding objects, formed by the calcareous depositions, are compared to animate and inanimate substances of various descriptions. To the right is the resemblance of a monk, as if kneeling on a cushion, with uplifted hands, and large as life. Behind it appear several semblances of busts; and at a distance are seen the images of various animals, together with an exact representation of a fleece. But among the whole, the monk excites the greatest attention. The head is bare, after the monastic fashion; the face is supposed to be distinct; the shoulders are in just proportion; and the drapery of the robe enveloping the body is alike beautiful and correct. Figures of vegetables are every where formed; and numerous columns, some apparently supported by distorted beings, seem to sustain the roof, which resembles a pure white cloud suspended in the air. Portions of it, however, descend in stalactites; which, together with the crystals in the interstices of the columns, emit fine coruscations from the lights below.

Another rugged declivity, similar to that which conducted the spectator to the cave, leads down to the pool, which is sixty-five feet in circuit, five feet deep, and of cooler temperature than the external atmosphere. It resembles a large marble bath of pellucid water, the bottom and sides being of the purest white. It occupies so much of the base of the grotto, that a person cannot walk round it. On its margin the spectator finds himself standing in a magnificent apartment, wholly consisting of the most brilliant spar glittering on all sides, and emitting myriads of rays, which are reflected from the bottom of the pool. In some grottos and caverns of other countries, there is a constant supply of water, which is generally discharged by a stream running towards the entrance; but here there is no visible outlet, and the quantity of water in this reservoir is not observed to decrease. Crossing the pool on a plank, a gallery of great height, but only three feet wide, is found, which leads to farther passages imperfectly explored. Its entrance is formed by two large columns of pure spar: that on the left of rustic conformation, six feet in circumference, and sixteen high; but that on the right rather resembles a work of art. It is of more surprising structure, and more elegant appearance, than any of the figures which the spar of this grotto has assumed. The shaft is twenty feet in length, nearly cylindrical, and its thickness in general about two feet and a half. It stands on a regular circular base rising from the floor, and projecting about twelve inches round its circumference. A series of sections seems to constitute the whole column, each twenty-two inches in length, and divisible into two distinct portions; the upper one being a crystallized mass of stalactites, while, in its general aspect, the under part resembles the foliated carvings of the Corinthian or Composite capital inverted. On more minute inspection, this division is found to display the most methodical arrangement of structure, in the formation and insertion of the foliage of sparry concretion; and the interstices of the leaves are of such dimensions, as to admit of complete inspection of the interior of the column, which proves a combination of the same foliated incrustations as the exterior. Passing by these pillars, the width of the gallery is somewhat enlarged, the sides still exposing elegant and numberless crystals, emitting a dazzling lustre. The floor also is of white marble, but of more singular conformation than in any other part of the cavity. Part of it rising from the rest resembles a piece of lace, and consists of many concretions on one side, while the other is quite smooth, and entirely covered with shining crystallizations, the waved interstices of which are full of water. These beautiful productions abruptly cease at the distance of about 250 feet from the mouth of the cave, and the bare black rock is exposed. Although farther recesses exist, they have not yet been explored.

Several singularities regarding this remarkable grotto being peculiarly interesting, ought not to be overlooked. Its formation is concluded to have resulted from the separation of immense dykes of whinstone, while freestone constitutes both the floor and the roof. Although no considerable stratum of limestone is seen in the neighbourhood, there is a prodigious accumulation of spar entirely calcareous within. The crystallizations are of the most complete kind, free from every imperfection, and white and beautiful. Water is constantly exuding from the whole roof; and it is likewise universally suffused over the incrusted surface of the spar, which is always moist to the touch. But this humidity augments the brilliancy of the coruscations, and is the source of the water contained in the marble cistern. The endless variety in which the sparry incrustations appear, is one of the greatest ornaments of the grotto; and the infinite combinations and modifications of it are alike brilliant and interesting. Sometimes it is disposed in foliage or flowers; sometimes in busts or columns; and the interior, of tubulated stalactites, is studded with innumerable crystals converging towards the centre. It may seem idle to speak of traditions of the ninth century, but we shall only observe in illustration of the name *Slochd Altriman* or the *Nursling Cave*, that it is said to have afforded refuge to a youthful female, who had become the victim of a feud which estranged the parents of her and her lover, the young chief of Colonsay. Separated from him, she was delivered of a son, who was carried to *Slochd Altriman*, whither his mother retired to nurse his infancy; and thence the name of Nursling Cave.

On the 17th of March 1775, the Rev. Mr Newnham, a young clergyman of Bristol cathedral, accompanied by a gentleman and two ladies, went to visit a chasm in the ground called Penpark Hole, about three miles from that city. Wishing to sound its depth with a line, he advanced a short way into the upper part of the opening declivity, which is not steep, in order to give it a freer cast, and, for greater security, held by the twig of a tree, spreading across the chasm. Unhappily, in accomplishing this, his feet slipped, owing to the humidity of the earth, and he was precipitated headlong into a frightful abyss before the eyes of his terrified companions. An accident so distressing, gave birth to many speculations respecting the caverns where it had happened, particularly as the body of the sufferer was long the object of a fruitless search; but at last some hardy adventurers having resolved on descending, discovered a great accumulation of water at the bottom, and a stone thrown down being interrupted in its fall, disclosed the spot where the body still floated, 39 days after the catastrophe. It is difficult to explain the figure of this, or indeed of any other cavern, without drawings; therefore we shall briefly observe, that the access to Penpark Hole is by two separate chasms in the ground, leading by a declivity to the interior. After passing different lateral vacuities, one of which has a spacious vaulted roof, the adventurer reaches the most extensive recess, branching into an oblong irregular space, 225 feet long, by 123 in width. Below it are other recesses, and the bottom of the whole, which, if we rightly understand the description, is more than 200 feet from the surface of the earth, is covered with water, varying in depth from 6 to 50 feet, but clear, and good, and free from any peculiarities. All the cavities are of extremely irregular formation, in general presenting a rocky surface or sparry incrustations, and the floor is described as in some places to consist of "a kind of white stone, enamelled with lead ore." The subterraneous communication between the external mouths is extremely narrow, and was first explored by Mr White, a land-surveyor, who, with much hazard and difficulty, forced his way through, by crawling on his belly. But even now, should a stone be displaced in the undertaking, the adventurer would inevitably be buried alive. Penpark Hole was visited in 1669 by Captain Sturmey, and in 1682 by Captain Collins. The former was accompanied by a miner, who, penetrating one of the galleries to a considerable distance, exclaimed that he had found a rich mine; but his joy was suddenly converted to astonishment, for he returned affrighted by the sight, as he said, of an evil spirit. No inducement could prevail on him to revisit the place, and Captain Sturmey himself sickened four days after and died. In consequence of the accident above related, it was more particularly examined by several individuals; but more minutely by Mr Catcott and Mr White, the latter of whom has drawn a section of it.

Great Britain abounds with caverns, and especially the county of Derby. Here there are no less than 28 of some celebrity, and some of lesser note. Several have already been alluded to in our notice of that county, as that stupendous recess, now converted from a rude and coarse appellation, to the Devil's Cave, or Peak Cavern, Elden Hole, and Pool's Hole, whence we shall restrict our observations to an abstract of Sir Richard Sullivans's adventure in the Three Mile Cavern. This is an immense vacuity that has partly been effected by art, and which receives its name from its supposed extent. The descent is accomplished with much difficulty for 420 feet, and introduces the spectator to two or three lofty caverns, beautifully enamelled with spar. "Penetrating still farther," Sir Richard says, "we forced our way with infinite struggles, through a narrow space between two rocks, and thence getting on our hands and knees, were, for the full distance of a mile, obliged to crawl, without ever daring to lift up our heads, the passage being both low and craggy; and as it was likewise filled with mud, dirt, and a multitude of bits of rock, our progress was painful indeed; we still, however, hoped for something better. On we accordingly proceeded, till a dreadful noise rumbling along the horrible crevices of the cave, gave us to understand we were near a river. To this then we hurried; but description is inadequate to any thing like a representation of the scene; a vast ocean seemed roaring in upon us; in some places bursting with inconceivable impetuosity; and at others falling through dreadful chasms, burst into shaggy forms to give it vent." It appears that this subterraneous stream is deep, and has a long course; but whether it is absorbed in the earth, or finds a passage to the surface, is not explained. After having underwent many dangers and difficulties, not unattended with personal injury, the author concludes his narrative in these words: "Altogether, the depth we had descended was about 140 fathoms, or 980 feet, and the length about three miles, according to the miners' calculation. Neither at this distance were we at the end; a passage still continued; but so filled with water, and so full of peril, that the miners themselves were averse to further trial." Possibly the number and size of British grottos and caverns, exceed those within the same bounds of any other country with which we are acquainted; nor are we aware that any spacious recess, (with the exception of the cave in Kentucky,) opening directly from the earth, has been penetrated 2250 feet, as the Devil's Cave of Derbyshire.

In the limestone country of Virginia in North America, are several caverns of some extent, among which the most celebrated is Madison's cave, on the north side of the Blue Ridge. Its entrance is about two-thirds high in a moderately elevated hill, into which it extends about 300 feet, branching out into subordinate caverns, sometimes ascending a little, but more generally descending, and at length terminates at different places in two basins of water of unknown dimensions, that are never turbid. The vault of this cave is of solid limestone, from 20 to 40 or 50 feet high, through which water perpetually percolates; and trickling down its sides, has encrusted them with elegant drapery, or dripping from the top, generates conical stalactites both above and below.

Another cave, about 8 or 9 miles long, and with many branches, has lately been discovered in Kentucky. It is covered with stalactites: and a very remarkable mummy was found within it at a considerable distance from its mouth. See Kentucky, where we propose to give a full account of this interesting cavern.

Besides those curious excavations on the western coast of the Indian peninsula, some interesting caverns occur in that great range of mountains, which traversing Cochin China, penetrates the neighbouring countries. The inhabitants retreat thither, or conceal their effects in them during the time of war, and they are also kept concealed to avoid the expensive visits of the great men of the country. A naturalist, the late historian of these regions, affirms, would here find ample scope for observation: the caverns are full of petrifactions and crystallizations of various colours: immense halls are formed, wherein may be seen the resemblance of altars or thrones; and quantities of fruits appear ready to drop from their trees. One most remarkable grotto traverses a mountain throughout: its entrance and its exit being terminated by two fertile plains. The bottom is covered with water, which may be navigated by vessels; and the roof, which is very lofty in some places, decreases elsewhere to 8 or 10 feet. There is another in the same chain of mountains of vast extent, but abounding in deleterious exhalations; and the water of a canal covering its bottom is dangerous to be drank. No one has hitherto ventured to explore its most distant extremities.

In various parts of Italy, we find several famous grottos, though less celebrated for their extent than from some other peculiarities; and although known by the name of grottos, no crystallizations are seen in some of them. In Naples there is a spacious cavity, called *Grotto dei Funaioli*, or the Rope Makers' Grotto, because its entrance has long been devoted to this useful purpose. The roof exhibits a rent, said to be the effects of lightning, and in other respects presents a menacing but imposing aspect, though the inhabitants carry on their operations in the most perfect confidence.

The grotto of Pausilippo near Naples, is a great excavation, partly artificial, penetrating the mountain of that name 2316 feet. It is 89 feet high in the most lofty part, 24 where lowest, and about 22 in breadth, traversing volcanic tufa. The date of its formation is unknown; but in modern times, Don John of Arragon, Viceroy of Naples, and Peter of Toledo, under Charles V. brought it to its present state, and now it serves for an ordinary, though disagreeable road from the city, with a glimmering light from two apertures above.

In the side of a hill, beside the lake Agnano, in Italy, there is an artificial excavation, unskilfully executed, called the *Grotto del Cane*. It is of limited dimensions, being only twelve feet deep, four broad, and nine in height at the entrance, but always decreasing as it recedes. The celebrity of this grotto, which had long been known, is owing to pestilential exhalations arising from the earth; and it receives its name from the animal which is usually selected to demonstrate their presence. If a dog be brought within the sphere of the deleterious vapour, which remains within eighteen inches of the surface, its respiration immediately becomes affected—the abdomen contracts—the eyes are fixed—and the tongue, now of a livid hue, hangs out during the first minute, while, in the next, the animal is totally deprived of motion. Death would inevitably follow, but, on being speedily withdrawn, the lungs resume their play, and the creature gradually recovers its wonted strength and vigour; nevertheless a severe shock is sustained, as the same dog cannot support the experiment above twelve or fifteen times without destruction; in which event it dies in convulsions. The Abbe Nollet, on stooping to inhale the vapour, felt as if he had swallowed boiling water on the first inspiration, yet producing no painful sensations. On lowering his face, a kind of suffocation was experienced; and probably, had the experiment been continued longer, dangerous consequences would have ensued. The vapour is whitish, and possesses some degree of heat. It never rises above eighteen inches from the earth; and a torch immersed in it is extinguished, while the black smoke rolls over its surface without penetrating deeper. See Macleay, *Description of the Spar. Cave in Skye.* Catcott, *Account of a Descent into Penpark Hole.* Lloyd's *Account of Elden Hole*, Phil. Trans. vol. lxi. Leigh's *History of Lancashire.* Pilkington's *View of Derbyshire.* Farey's *Survey of Derbyshire.* Rudder's *History of Gloucestershire.* Hamilton, *Campi, Phlagrei. Voyage Pittoresque d'Italie*, tom. ii. *Decouvertes des Savans Voyageurs*, tom. i. p. 133. (*c*)

GROUSE. See Ornithology *Index.*

GRUYERES, is the name of a small town of Switzerland, in the canton of Friburg. It is situated at the foot of the mountains of this canton. The territory of Gruyeres, is 8 or 10 leagues long and 4 broad; and it is principally celebrated for the excellence of its cheese, which is esteemed the best in Switzerland. The best is made in the pastures of Molesson, and in the mountains of the vallies of Bellegarde and Charmey. It sells at 2½ louis per quintal; and the merchants of the country sell it at 6 batz, or 18 French sous per pound. There are large magazines of this cheese at Bulle, a town about a league from Gruyeres. The view from the summit of the Molesson, which is near the town, is very grand. It may be ascended in three or four hours.

GRYLLUS. See Entomology.

GUADALAXARA, an intendancy of New Spain, and part of the kingdom of New Gallicia, is situated between 19° and 23° North Latitude. Its greatest breadth from the port of San Blas to the town of Lagos, is 100 leagues; and its greatest length from south to north 118 leagues. It is traversed from east to west by the Rio de Santiago, a considerable river, which communicates with the lake of Chapala. It contains two cities, six villas, and 322 villages. The principal city Guadalaxara, the residence of the intendant, the bishop, and the high court of justice, is situated on the left bank of the Rio de Santiago, and contains about 20,000 inhabitants. San Blas, a sea port, and the residence of the marine department, is situated at the mouth of the Santiago, and is a very unhealthy place. The eastern part of the province is the Table Land, and western declivity of the Cordilleras of Anahuac. The maritime district, especially towards the great bay of Bayonne, is covered with forests, and supplies excellent timber for ship-building. The interior of the country enjoys a temperate and salubrious climate. The Volcan de Colima, in the northern extremity of the province, is the most western of the volcanos of New Spain, which are placed in one parallel on the same line. It is estimated to be 10,000 feet in height, but is rarely covered with snow. The lake of Chapala, in the vicinity of Guadalaxara, is nearly 160 square leagues in extent. The superficial extent of the province is 9612 square leagues; and the population in 1803 was 630,500, which gives 66 inhabitants to the square league. The value of its agricultural produce in 1802, consisting in maize, wheat, cochineal, &c. amounted to 568,531*l.* sterling; and the value of its manufacturing industry, composed chiefly of woollen and cotton stuffs, tanned hides, and soap, was estimated at 722,351*l.* The revenues of the bishop are 90,000 double piastres. This province abounds in silver mines, and affords excellent pastures. On the coast, in 21° 28′ North Latitude, are the three Marias islands, the most northern of which is about 13 miles in length, and 9 in breadth, surrounded by white rocky cliffs; and another, about 24 miles in circuit, separated from the last by a strait six miles broad, and which Dampean called Prince George's island, abounds in vegetable productions, but is deficient in fresh water. See Humboldt's *Political Essay on the Kingdom of New Spain*, vol. ii. and *Mod Univ. Hist.* vol. xxxix. (*q*)

GUADALOUPE, the largest and one of the most valuable of the Caribbee islands, lies between Antigua and Martinique. Its length is between 60 and 70 British miles, and its greatest breadth about 25. The middle of the island is situated in about 16° 20′ North Latitude, and 62° West Longitude. Guadaloupe has somewhat of the form of a crescent, and may be considered rather as consisting of two islands than of one; for it is divided into two parts by a narrow strait called Salt River. For a short distance on each side of this strait, the breadth of the island is not more than four miles. By this remarkable channel, the sea on the north-west communicates with the sea on the south-east. Its breadth varies from about thirty to eighty yards; and it is navigable for vessels not exceeding fifty tons burden. The north-west of the island is divided into Basseterre and Cabesterre; the eastern division of it is named Grandeterre. That portion of the island from which the whole takes its name, is, towards the middle, full of high and rugged rocks, where the climate is so cold and the soil so barren, that little vegetation is to been seen. Over the summit of these rocks, the mountain called La Souffriere, or the brimstone mountain, rises to a great height. This mountain of sulphur continually sends forth, through various apertures, a thick black smoke, frequently mingled with sparks of fire. It is of a singular form, being divided into two parts by a remarkable channel, navigable by boats. There are many marks of volcanos in other parts of the island. On a part of the western shore, the sea is so hot at a small distance from the beach, as to boil eggs; and the sand on being stirred, emits a strong sulphureous odour. The island contains a boiling fountain, and a hot marsh, which is very deceitful, and dangerous to strangers. The islands, of which Guadaloupe is the chief, were discovered by Columbus in his second voyage, when he visited Dominica, Guadaloupe, and Antigua. But they were at that time neglected by the Spaniards, in their eager lust of dominion and gold on the larger islands, and on the American continent, the unexplored treasures of which were then opening to their ambition.

No European nation had taken possession of Guadaloupe, when an expedition of five or six hundred Frenchmen, under two adventurous leaders, arrived from Dieppe in June 1635. The new settlers soon commenced a war with the native Caribs, for the purpose of supplying themselves with provisions, of which their own exertions could not yet produce a sufficient quantity for their subsistence. Many of these poor, simple and undisciplined people, unable to maintain a regular struggle with their more skilful invaders, retired to some of the other islands. Others of them concealed themselves in the natural strongholds and recesses of their own, and having previously destroyed their plantations and stores, their superior knowledge of the country enabled them to sally out unexpectedly, and to inflict vengeance on such straggling parties of their oppressors as fell in their way. After a struggle, which was kept up with various success, and which at length produced a terrible famine, a peace was patched up between the contending parties in 1640; and the remnant of Europeans, who had escaped the calamities which they had drawn on themselves, were joined by some discontented sailors and colonists from St Christophers. The superior advantages of Martinique as a sea-port, induced many adventurers to leave Guadaloupe, and pass over to that island; and from this time the French administration bestowed for some years almost exclusive attention on the latter, which became the seat of government of the French islands. For the first sixty years of its occupation by the French, Guadaloupe made little progress; but in the course of the ensuing fifty-five, its improvement was as rapid as it had formerly been slow. In April 1759, the island was conquered by the English. In July 1763, it was restored to its former owners in a highly improved condition. The French government now began to see the value of this settlement, and an independent government was given to it. The island was taken by the British in April 1794, but was retaken by the French under Victor Hughes in February 1795.

Early in 1810, an English expedition, the naval part of which was conducted by vice-admiral Sir A. Cochrane, and the military force by lieutenant-general Sir G. Beckwith, prepared with the design of attacking Guadaloupe and St Eustatius, was ready to commence operations. It was completely successful; and thus the enemy were deprived of the last of their possessions in the Columbian islands.

Guadaloupe continued under the power of the British crown till 1813, when in a treaty, dated March 3d, between his Britannic Majesty and the King of Sweden, it was agreed, that this valuable colony should be ceded to the latter, in consideration of an engagement on his part to furnish a force of 30,000 men, in aid of the allied powers against France. Swedish commissioners were accordingly sent, to make arrangements for taking possession of the island; but in consequence of certain political causes not yet fully explained, it was restored to its old possessors the French, at the restoration of Louis XVIII. in terms of the general treaty of peace, signed May 30th 1814. On the return of Bonaparte from Elba in 1815, General Boyer, the governor, hoisted the three-coloured flag. After the second restoration of the Bourbons, he was condemned to death, but the sentence has been commuted into twenty years imprisonment. The sum of one million sterling was the compensation given to Sweden, for our non-fulfilment of the stipulation by which it was to be delivered into her hands. The general astonishment and indignation of the people of Great Britain and Ireland, on finding, that by one of the articles in the treaty with Louis, the slave trade was to be permitted to be carried on by the French for five years, in this island and Martinique, which British generosity had restored, are not easily described. Petitions poured in upon both Houses of Parliament, and addresses to the Prince Regent from every part of the united kingdom. In consequence of these petitions, Lord Castlereagh, the British negociator, was employing all his influence and skill in order to undo what he had done, and to induce the government of Louis to receive these islands under the express condition, that the odious traffic should instantly be definitively and for ever abolished by France. The consideration of this subject was taken up by the congress assembled at Vienna. But there appeared every reason to believe that our benevolent endeavours would have failed of success, when the irruption of the exiled usurper into France once more transferred this island to the sovereignty of Napoleon Bonaparte. By a stroke of policy, intended at once to show his power, and to conciliate the people of England, he issued a decree as soon as he felt himself replaced on his trembling throne, by which he declared the slave trade to be abolished in the French islands. In doing so, indeed, he made no kind of allusion as to the immorality and wickedness of the traffic with Africa. Besides, he knew that while the war should continue, and England ride triumphant on the sea, he could carry on little foreign trade of any kind, and that these islands would probably fall speedily into our hands; so that the sacrifice he appeared to make of interest to duty, was in fact only a nominal one, and as his decree was expressed just as coldly as if he had been prohibiting the importation of flax or grain, he could easily, he well knew, and without any appearance of gross inconsistency, by another of his imperial decrees, restore the trade, on the ground of alleged expediency, whenever he might be able to derive any advantage from the renewal. This decree of Bonaparte, however, though no one could be deceived as to its motive, had a happy effect on the great cause; for when Louis was a second time restored to his throne in the summer 1815, and when these islands, once more in the power of England, were to be delivered up to France, the example of Bonaparte himself could be quoted, to shame the new government into accordance with our wishes. Indeed England had now the means and the right to enforce compliance with her request. Accordingly Louis, soon after his return, by a royal decree, declared the French slave trade to be definitively and absolutely abolished.

The unsettled state of this island, may probably have prevented any very accurate estimate either of its trade or population since the French revolution. In the year 1700, the population amounted only to about 382 indigenous inhabitants or Caribs; 325 free negroes; and 6725 slaves.

In 1755, there were

| | |
|---|---|
| Whites | 9643 |
| Slaves | 41,140 |
| Sugar houses | 334 |
| Banana trees | 2,028,520 |
| Ditches of manioc | 32,577,950 |
| Horses | 4946 |
| Mules | 2924 |
| Asses | 125 |
| Beeves | 13,916 |
| Sheep and goats | 11,162 |
| Swine | 2444 |

In 1767, France received from Guadaloupe,

| | |
|---|---|
| Fine sugar | 140,418 quintals. |
| Raw sugar | 23,603 quintals. |
| Coffee | 34,205 |
| Cotton | 11,955 |
| Cacao | 456 |
| Ginger | 1884 |
| Campeachy wood | 2529 |
| Confections | 24 boxes. |
| Liqueurs | 165 boxes. |
| Potassia | 34 casks. |
| Skins | 1202 No. |

These articles were sold in the colony for 7,103,838 livres, while the articles imported from France cost 4,523,884 livres, leaving a balance in favour of the colony of 2,579,954 livres.

In 1767, Guadaloupe contained

| | |
|---|---|
| Whites | 12,700 |
| Blacks, or free Negroes | 1350 |
| Slaves | 100,000 |
| Horses and mules | 9220 |
| Horned cattle | 15,740 |
| Sheep, swine, and goats, | 25,400 |

It possessed at the same time,

| | |
|---|---|
| Feet of cacao | 449,622 |
| Feet of cotton | 11,974,046 |
| Feet of coffee | 18,799,680 |
| Sugar houses | 388 |

In the year 1775, eighty-one vessels returned to France loaded with the following produce:

| | | Value in Europe. |
|---|---|---|
| Raw sugar | 188,384 quintals. | 7,137,930 livres. |
| Coffee | 63,029 | 2,993,860 |
| Indigo | 1438 | 1,222,529 |
| Cacao | 1023 | 71,651 |
| Cotton | 5193 | 1,298,437 |
| Skins | 727 | 6973 |

and some other articles of minor importance.

The value of the imports and exports was, in

| | | Imports. | Exports. |
|---|---|---|---|
| 1767 | livres | 4,523,884 | 7,103,838 |
| 1788 | | 5,362,000 | 15,053,000 |

Several productions of Guadaloupe were formerly sent to Martinique; and America received some of its liqueurs, and other commodities, and sent in return, wood, cattle, flour, and cod fish.

In 1789, the population of all descriptions was about 104,000. The island is well stored with horned cattle, sheep, horses, &c. and produces a vast abundance of sugar, coffee, rum, ginger, cocoa, logwood, &c.

GUIACUM. See Chemistry.

GUAM, or Guahon, as it is called by the natives, is an island in the eastern seas, forming one of the group denominated Ladrones, or Marianne Islands. According to the computation of the Spaniards, it is about 120 miles in circuit, apparently flat and even from a distance, but the east coast, on nearer approach, is found to be high and shelving, fenced with steep rocks which oppose the perpetual beating of the sea. Here there is no anchorage, but the west side is divided into small low and sandy bays, one of which, called Umata, constitutes a good harbour for a few vessels, and is defended by a battery of twenty guns. The surface of the island gradually rises from the shore to nearly the middle. The rocks are chiefly granitic; and the centre of the pebbles found on the beach, contains various coloured crystals. Several vallies are interposed between the shore and the inland parts, where vegetation becomes profuse. They appear to have been the bed of so many currents; and their soil consists of sandy earth, mixed with decaying madrepores, from which the sea seems to have withdrawn. The interior, however, is of extreme fertility, abounding with all that can be desired for the use of man. Numerous fountains spring from the rocks, and in their course form transparent pools, shaded by trees, always preserving an agreeable freshness amidst the heats of the climate. But there are no rivers of importance; the other waters being either torrents from among the hills, or inlets of the sea.

No portion of the globe is more copiously supplied with vegetables than Guam; and here our celebrated circumnavigator Dampier first discovered the bread-fruit, an invaluable plant, which affords subsistence to so many thousand islanders of the South Pacific Ocean. The forests are full of guavas, bananas, cocoas, oranges, and limes. Capers are produced in abundance from a shrub, indigenous to the soil, of beautiful appearance, flourishing throughout the year, and exhaling a delightful odour. From hence it has been transplanted to the Philippine islands. Two species of banana are thought peculiar to Guam; one of dwarfish size, only three feet in height, but producing a fruit so much superior to all the rest, that its cultivation has been recommended in the European tropical colonies; the other is the wild banana, a large tree, the fruit of which is not eatable. Of the cocoa tree there are three kinds: *first*, the common species, disseminated throughout India, bearing a nut, which is a great article of subsistence; *secondly*, a middle-sized tree, which is lower, the nut having a tender shell, and a kernel tasting like an artichoke bottom; *thirdly*, the black cocoa tree, rising at most to eight or ten feet in height, with a nut perfectly round, about three inches in diameter, and very delicate. This last affords oil more abundantly than the others, as also coire for cordage, and the leaves of all the three are equally suitable for thatching huts and making mats.

Fish is plentiful on the shores of the island, though frequently of a poisonous quality, originating, it has been conjectured, either from their feeding on the polypi of madrepores and coral, or other marine animals. It is affirmed, that the very taste of the coral is imparted to them. Turtle are large and numerous; besides which the streams of Guam afford abundance of aquatic tribes peculiar to themselves. But the facility with which subsistence of a different description is obtained, renders that which may be derived from the waters quite of secondary consideration, and it is little sought after.

It has never been explained, what are the birds and quadrupeds which are indigenous to the island. A few cattle, that were carried thither long ago, have multiplied exceedingly, and run wild in the uninhabited districts. They are large, and well fed, and exhibit one remarkable feature common to those resuming their original state, in almost all being white, with black ears. It is known, that in Great Britain the few which remain unmixed from distant ages, and have preserved their pristine ferocity, retain along with it the same peculiarity, which is of much interest to the zoologist. Some years ago, the Spaniards transported a large species of deer from the Philippines to Guam, which undergoes so great a change along with the season as scarcely to be recognizable as the same animal. From December to May, its winter coat is long, thick, and of a grey colour; but from the month of May, the hair is brown, or almost yellow, smooth, and shining, having three black streaks on the back, interspersed with white. It multiplies in the woods, which are also well stocked with wild hogs.

Dampier describes the natives of this island as "strong bodied, large limbed, and well shaped. They are copper coloured like other Indians; their hair is black and long; their eyes meanly proportioned; they have pretty high noses; their lips are pretty full; and their teeth indifferent white. They are long visaged, and stern of countenance; yet we found them to be affable and courteous." These people have a great tendency to corpulency, and are very subject to leprosy, or a kind of cutaneous disease, especially in the wet season, or between June and October. They are particularly characterised by mildness and hospitality, which have enabled their invaders to make deeper encroachments on their liberty, than if they had displayed a more repulsive disposition. They are indolent, prone to intoxication, and fond of music, dancing, and cock-fighting. The Spaniards have rendered them acquainted with agriculture; and, to facilitate their labours, they tame the wild cattle, which are trained to carry loads throughout the island. Several are kept for this purpose by most families, becoming perfectly tractable, and as quiet as horses. They are guided by a halter penetrating the septum of the nose, to which they grow accustomed in a fortnight. No part of the industry of the natives of Guam appears to have existed anterior to their conquest; they have either been explicitly taught, or acquired what they practise from example. Some of the mechanical arts are practised by them in carpentry, smith-work, brick-making; and they fabricate cloth, cordage, and even cables, for the Acapulco galleons from the wild banana, which are reputed of superior strength to those manufactured of the best European hemp. But there is one branch of the arts in which they have remained stationary since the discovery of their island, namely, the construction of their canoes; and this has arisen less from want of skill to make the alteration, than from their having already adopted the best possible form of which their local situation admitted. Celebrated navigators have repeatedly expressed their admiration of these vessels, which are equally calculated to keep the sea, and to take advantage of the prevalent winds. Some of their canoes are forty feet long, hollowed out of the trunk of a single tree, and very narrow. A piece two inches deep is sewed on as a washing board to raise it higher; "but what is very singular, one side of the boat is made perpendicular like a wall, while the other side is round, and made just as other vessels are, with a pretty full belly." The ends are sharp, each serves for a prow; and the neighbouring islands frequented by the natives lying chiefly north and south, and the wind being almost constantly east, the rounded side is found on the lee. But there is besides an outrigger projecting from the side, necessary to steady so narrow a vessel, and at the extremity is a log of wood, in shape resembling another canoe, though much smaller. A single mast stands in the middle, with a triangular sail, which, when taken in, is rolled around a yard at the bottom. No canoes are better adapted for sailing. A French navigator assures us, that, with a fair wind, they go at the rate of nine miles an hour, a distance said to be augmented to fifteen under the most favourable circumstances. Dampier observes, "I did here, for my own satisfaction, try the swiftness of one of them. Sailing by our log, we had 12 knots on our reel, and she run it all out before the half minute glass was half out, which, if it had been no more, is after the rate of 12 miles an hour; but I do believe she would have run 24 miles an hour." He was told of one of them having been sent express to Manilla, and performing the voyage, which is about 400 leagues, in the space of four days. However, it is understood, that, although the best sailers known, the canoes of Guam are not safe at sea; but should an accident happen, the natives are so expert at swimming, they are capable of repairing it in the water. The companions of M. Marion observe, that "the form of these embarcations is such, as would do honour to a ship-builder among people who have made the greatest progress in the knowledge of navigation. This form has been imitated from no model, because it differs from all those which men, inhabiting different parts of the world, have given to their vessels."

The inhabitants of Guam are dispersed in twenty-one native establishments, chiefly on the coast, and the town of Agana, situated about twelve miles north-east of the harbour. All the Indian families are agricultural, and each has a small portion of land subdivided into fields or gardens; but the interior of the island is still in a state of nature, covered with thick woods, affording excellent timber for the construction of houses or vessels. The town stands on the shore, at the base of some hills of moderate elevation, in a fine district full of springs, and watered by a small rivulet. Its streets are laid out in a straight line; and the houses, built for the most part of wood, stand on posts about three feet above the ground, and are roofed with tiles or palm leaves. But all the public edifices are constructed of brick. There is a fine church here decorated after the Spanish fashion; and two or three convents or colleges occupied by monks, one of which was established for the education of Indians. The religious establishment of Guam was formerly vested in the Jesuits, who, on the suppression of their order, were supplanted by the Augustines; and besides Agana, there are two or three other cures in different parts of the island. The government house is spacious. There is a royal magazine tolerably well stored, and barracks for 500 men. This being the only Spanish colony in the Ladrones, was preserved with considerable care; however, its chief and most important improvements were derived from the governor Tobias, who was at its head about forty years ago. He taught the natives the proper means of cultivating the land; he planted rice, maize, indigo, sugar canes, and cotton, all of which succeeded admirably, and the maize in particular produced an incredible return. To give them a proper example, this paternal governor formed gardens and plantations, where all necessary vegetables were cultivated, along with the most delicious fruits. He established a kind of cotton manufacture, and caused salt pits to be dug. Further, he instituted a school for the gratuitous education of the native children of both sexes, where they were instructed in reading, writing, and arithmetic, as also vocal and instrumental music; whence strangers have been agreeably surprized, in finding practised musicians assisting the celebration of divine worship in a place so remote from the civilized world. Finding it necessary to provide the island with a sufficient force to protect itself, he formed a militia of 200 Indians, among whom were four Spanish captains, while the remainder of the officers were chiefly Mestees, or the mixed race of Spaniards and natives from the Philippines. But to preserve these troops from the hazard of idleness, and to procure them ample subsistence, they were occupied in cultivating a tract called the Royal Domain, separate from all other property. By such humane and prudent measures, while the natives are reclaimed to habits of industry, their principles and morals, aided by an innate placid disposition, undergo an absolute alteration; yet this patriotic individual was afterwards persecuted by the clergy of Manilla.

The history of Guam is marked by some singular and interesting features. It was discovered in the year 1521, by Magellan, who ascertained that it belonged to a cluster of nine principal islands, and a number of smaller islets, which he first called *De Velas*, from the sails of the canoes, but afterwards *Ladrones*, from the propensity of the natives to theft. Guam appeared to enjoy a delightful climate; it was covered with fruits, and afforded the means of supporting a colony; therefore the Spaniards, having already established themselves in the Eastern Seas, resolved upon making a settlement here. The inhabitants were a wild and savage race; but equally savage with themselves, the Europeans, in usurping their territories, carried fire and sword along with them. In violating the religion of their fathers, they endeavoured to inculcate the principles of Christianity; but, instead of adhering to its mild and benevolent doctrines, they practised the most horrible cruelties to enforce belief. While their rude opponents might have been gained by conciliation, a war of extermination was unrelentingly prosecuted, because their demands, alike ungenerous and unjust, were resisted. At this early period, the nine islands of the group were calculated to contain 60,000 inhabitants, of whom 20,000 belonged to Guam. But they gradually fell under the barbarity of their invaders, too well skilled in warfare. After a long interval of suffering, a measure was at length adopted by the natives, which is scarcely to be paralleled in history: They resolved to allow their race to be extinguished in themselves, that posterity might not be able in their misery to reproach them with existence. Thus the women drank deleterious potions to procure abortion at the moment, and to prevent their having any future offspring; and this outrage against nature was so obstinately persisted in, that about 60 years ago, the total population of the group had decreased to 800 or 900 persons. The Spaniards, however, had awakened from their error, and learning the benefit of conciliation, found means to collect the whole in the island of Guam. There it continued to augment during twenty years, to about 1500, since which time we have no further accounts of it; but most probably it is much more considerable, or part may have colonized the neighbouring islands. During these convulsions the invaders did not escape with impunity, and on one occasion when the natives rose upon them, all the missionaries were massacred; but on another, when their numbers were small, they proved unsuccessful, and all except 100 evacuated the island, leaving the Spaniards in peaceable possession of it. Afterwards they became accustomed to the yoke, and a quiet, peaceable, and inoffensive race has now sprung up to promote, instead of resist, the objects of the settlers.

Guam is of importance as a Spanish establishment from its position and great fertility: the galleons from Acapulco to Manilla, so much the object of capture to hostile nations, were wont to put in here for refreshments, besides which, a vessel came annually from the Philippines. It is said that the natives of the neighbouring islands have become more warlike of late, and seem disposed to make conquests of other territories; but whether they disturb the European colonies is not explained. In concluding these observations, we may cite the words of a French navigator, who made a short residence in Guam, which will satisfactorily illustrate its properties. "In traversing this island, we discovered how lavish nature has been of picturesque and agreeable places. Enchanting spots were met with in our excursions, where she had bestowed every thing, and where the hand of man had made no arrangements. Ennui was banished: here all was united for the enjoyment of solitude: verdure, shade, coolness, and the perfume of flowers: crystalline fountains were seen springing from the rocks: the song of innumerable birds was heard: and groves appeared of cocoas, bread-fruit, oranges, citrons, and an infinity of fruits interspersed among the foliage of trees, all cultivated by the operation of nature alone. Here, too, they presented a pleasing disorder, which art has never been able to imitate. I could not quit this delightful abode without regret, where life might be passed in satisfaction."

It seems doubtful whether the actual position of Guam is completely ascertained. Dampier, after a very long run, lays it down in Latitude 13° 21′ North, Longitude 125° 11′ West: later navigators place it in 13° 25′ North Latitude, and 155° 10′ East Longitude; and La Perouse, probably from observation, fixes the harbour of Umata in 13° 10′ North Latitude. (*c*)

GUAMANCA, Guamanga, or Huamanga, is the name of a city and province in Peru. The city was originally founded by Pizarro in 1539, as a middle station for the trade between Lima and Cusco. It was built at first on the site of an Indian village of the same name; but, in memory of a victory gained over the Ynca, was called by the Spaniards San Juan de la Vittoria. It was situated in the vicinity of the Andes, in a barren district; but, after the subjugation of the Peruvians, was removed to its present site, in 13° South Lat. in a more fertile territory, about sixty leagues east-south-east from Lima. It stands upon the declivity of a mountainous ridge, not remarkable for its height; but still so far above the rivers, as to be scantily supplied with water. About twenty noble families reside in the centre of the town, in spacious houses of a considerable height, built partly of stone, and covered with tiles, and surrounded with extensive gardens. It is skirted with suburbs of Indian habitations, which are chiefly built of stone, and, though low in the walls, as is generally the case in the inland towns of South America, yet add considerably to the appearance of the city. It contains a splendid cathedral, and a seminary for the service of the church, under the title of St Christopher; a university, with professors of philosophy, divinity, and law, and endowed with privileges equal to that of Lima; and also several chapels and convents, a hospital, and a college of Jesuits. It is governed by a corregidor, assisted by the principal nobility, who form a corporate body, out of which are chosen the alcaldes, to superintend the several departments of the police of the city, and the jurisdiction of the province.

The province or diocese lying eastward of Lima, is of very considerable extent, and is divided into the following districts:—Guamanga, which contains the capital of the province, is very fertile and populous. Its climate is temperate, and it abounds in various kinds of grain, fruit, and cattle. It contains several mines, but few of them are worked; and its agricultural wealth is fortunately the principal object of attention to the inhabitants. A principal part of its commerce consists in bend leather, for the soles of shoes; and great quantities also of conserves and sweetmeats are prepared for exportation.—Guanta, about four leagues north-west of the city of Guamanga, and about thirty leagues in length, is likewise a temperate and fruitful district. It is diversified by numerous heights, woodlands, and broken glens, rich in fruits and pastures. Its silver mines, which were formerly very rich, are now almost exhausted; but there are still many of lead; and this metal, together with salt and provisions, are its principal articles of trade.—Vilcas Guaman, about seven leagues south-east of Guamanga, is celebrated for its esculent vegetables and fine pastures, and breeds vast quantities of cattle. The natives are employed in various manufactures, particularly woollen stuffs, which are carried to Cusco and other provinces. There is still remaining in this district one of the old Indian fortifications.—Andaguaylas, to the south of Guamanga, extends about twenty miles eastward, between two branches of the Cordillera, and is watered by a number of small rivers descending from the hills. This extensive valley produces all kinds of fruit and grain, particularly maize and sugar cane. It is one of the most populous districts in the country; and in it many of the wealthier inhabitants of Guamanga have large sugar plantations. Guanca Velica, or Huanca Belica, commencing about thirty leagues north of Guamanga, is a bleak, hilly, and barren district. It produces little fruit or grain, and its inhabitants are supplied with provisions from the neighbouring countries. It is chiefly celebrated for an immense and apparently inexhaustible mine of quicksilver, to the working of which the inhabitants owe their chief subsistence. In the mountains are many shells and marine substances, and in a river near the principal town such large petrifactions are formed, that they are frequently used in building houses and other works.—Angares, about twenty leagues west-north-west from Guamanga, and about twenty leagues in extent, is tolerably temperate and fruitful, and yields vast herds of all kinds of cattle.—Castro Virreyna, south-west of Guamanga, is of very various temperature, but in its bleakest parts its greatest wealth is found. This consists in the wool of a species of sheep, called Vicunna, which had been improvidently hunted down for the sake of its fleece, and which is now to be found only in the coldest heathy spots.—Parina-Cocha, about twenty leagues south of Guamanga, is fertile in grain, and rich in pastures; and its mountains contain several mines of gold and silver, which yield these metals in great abundance, and supply its principal article of commerce.—Lucanus, about thirty leagues south-south-west of Guamanga, is of a cold temperature, but its vegetable productions are abundant, and its herds of cattle numerous. It abounds in rich mines of silver, and is the centre of a very considerable commerce. See Ulloa's *Voyage to South America*, vol. ii.; and Playfair's *Geography*, vol. vi. (*q*)

GUANAXUATO, an intendancy of New Spain, lies between the 20° 55′ and the 21° 30′ North Lat. and is wholly situated on the ridge of the Cordillera of Anahuac. Its length, from the lake of Chapala to the north-east of San Felipe, is fifty-two leagues, and its breadth, from the Villa de Leon to Celaya, is thirty-one. Its principal cities are, Guanaxuato, or as it is also called Santa Fe de Gounajoato, in 21° 0′ 9″ North Lat. built by the Spaniards in 1554, surrounded with mines, and containing 70,600 inhabitants; Salamanca, a neat little town, situated in a plain; Celaya, in which are several splendid buildings, and particularly a magnificent church of the Carmelites; Villa de Leon, in the midst of a highly fruitful district; and San Miguel el Grande, celebrated for its industrious inhabitants, who are employed in cotton manufactures. The province, which is part of the old kingdom of Mechoacan, was first cultivated by the Europeans in the sixteenth century, who expelled the Indian tribes of hunters and shepherds, and supplied their place with colonies of Mexican or Aztec Indians. During a considerable period agriculture made greater progress than mining, and during the seventeenth and eighteenth centuries, most of the mines were entirely abandoned. But, during the last forty years, the mines of Guanaxuato have yielded a greater metallic produce than Potosi, or any other mine in the two continents; and it is now the first mining district in America. Of the situation and products of its mines, a minute description is given by M. Humboldt, both in the historical account of his travels, and in his *Political Essay on New Spain*, vol. iii. p. 169. One of these mines alone, that of Valentiana, which has been known only for forty years, has sometimes furnished, in one year, as much silver as the whole kingdom of Peru. This fine province also is, relatively, the most populous in New Spain. Its superficial extent is only 911 square leagues, and it contains 517,300 inhabitants, which gives 586 to every square league. The principal natural curiosity in this province, are the hot wells of San Jose de Comangillas, which issue from a basaltic opening, and of which the temperature was found to be 205°.3 of Fahrenheit. See Humboldt's *Political Essay on New Spain*. (*q*)

GUATIMALA, one of the three audiences or kingdoms into which Mexico or New Spain was formerly divided, lies between $7\frac{1}{2}$° and 22° North Lat. extending upwards of 300 leagues along the south coast, and in no place exceeding 160 in breadth. It is in some parts extremely narrow, and on the north coast is deeply indented by the Bay of Honduras. It has been divided into thirteen provinces, according to some accounts, and according to others into eight. The latter of these is here adopted, because it best corresponds with the map given in this work, and also because the limits of the thirteen departments have not hitherto been accurately ascertained.* Veragua, the most southern province, and bordering on Panama, is about fifty leagues from west to east, and from nine to twenty-seven in breadth. It was discovered by Columbus in 1502, and was granted to him and his posterity as a reward of his services. Its coasts are low, and full of brushwood; but the interior parts are hilly, covered with forests, very imperfectly explored, but known to abound in rich silver mines. Its principal river Veragua is remarkable for the verdant hue of its waters; and from this circumstance its discoverer gave it the name of Verdes Aquas. Its principal towns are, Conception, considered as the capital of the province, a small place, situated near a river of the same name; Santiago al Angel, built in 1521, but frequently destroyed and restored; Santa Fé, a small town and bishop's see in the middle of the province; and Pueblo Nuevo, or New Town, situated in an unhealthy spot at the mouth of a river, about twenty-three leagues south-west of Santa Fé. There are besides upwards of thirteen villages, inhabited by Indians. Costa Rica, or Rich Coast, north-west of Veragua, is from fifty to sixty leagues in length, and forty in breadth. It consists chiefly of mountainous and woody deserts, and is thinly inhabited and little cultivated. Its mines were formerly productive, but have been abandoned on account of the difficulty of working them; and its chief articles of trade are hides, honey, and wax. Its principal town is Cartago, a small place and Bishop's see in the interior of the province, where the governor resides. Nicaragua, in 12° North Latitude, is about 80 leagues in length, and 50 in breadth, running from north-west to south-east, between Costa Rica and Honduras. It consists for the most part of high woody mountains, in which are some volcanos, but no mines. There is a large lake, 200 miles in circumference, in the south-west, which communicates with the Atlantic ocean by the river St Juan. Its vallies are well watered, and its principal products are timber of great size, cotton, sugar, honey, wax, cochineal, and fruits. Its chief towns are Leon de Nicaragua, a place of considerable trade, on the north-west border of the lake, several leagues from the south coast; and Granada, a populous and trading town on the west border of the lake, near a rugged volcanic mountain. The eastern coast is surrounded with shoals, and has no proper harbour. Honduras, in 15° North Latitude, extends 180 leagues along the south border of the gulf of that name, and from 25 to 50 from north to south. It is well watered by many streams which run northward into the gulf, and which, overflowing their banks in the rainy season, render the soil extremely fertile. Its bay, which includes a compass of 500 miles, is of dangerous navigation; but celebrated for the excellent logwood, which abounds on its flat and marshy shores. There are several islands along the coast of this bay; one of which particularly, Rattan, about 10 leagues in length, was long the resort of pirates, till the British established a colony upon it, for the protection of the trading vessels. The chief towns of the province are, Valladolid, a bishop's see, a small inland town in a pleasant valley; St Jago, 100 miles east of Valladolid; Truxillo, 125 north-east; and Puerto de Cavallos, about 90 north-west; all formerly places of considerable trade, but now greatly deserted. The British established a settlement in 1730 on the Black river, 26 leagues east of Cape Honduras, and another on a navigable river near Cape Gracias da Dios, where there is a secure and spacious road for ships. Guatimala, in 14° North Latitude, bordered on the south and west by the Pacific Ocean, is a province of considerable importance. Its surface is mountainous, and it is extremely subject to earthquakes; but its vallies are remarkably fruitful, abounding in grain, sugar, cotton, various dyeing drugs, especially indigo of a superior quality, and the richest pastures, stocked with incredible multitudes of cattle. Its capital, St Jago, or Guatimala, a bishop's see and the seat of a university, is a considerable trading town. It formerly stood in a delightful valley, not far from the west coast, but was repeatedly destroyed by tremendous earthquakes and volcanic eruptions; and was at length removed to a beautiful plain about 8 leagues from its former site. Nearly 30 leagues to the south-east is Sansonata, or Trinidad, which is the nearest proper harbour for ships from Panama and Peru, trading with St Jago. Verapaz, or Coban, in 16° North Latitude, at the bottom of the bay of Honduras, and north of Guatimala, is about 35 leagues in length, and 30 in breadth. It is a mountainous country, covered with forests; but a few cultivated tracts yield plentiful crops of maize. Cotton, wool, cocoa, honey, wax, and gums, are its chief articles of trade. It contains no towns of any importance; and Vera-paz, the governor's residence on the bank of a river running south-east to Golfo Dolce, Acarabatlan, a small place to the westward, esteemed for its musk melons, and Robinal, a trading village in the pleasant valley of St Nicolas, are scarcely worthy of being noticed. Chiapa, north-west of Vera-paz, in $16\frac{1}{2}$° North Latitude, is of a triangular form, and each of its sides extends about 65 leagues. It abounds in hills covered with forests, and has two rivers, the Chiapa, running eastward to the bay of Campeachy; and the Samasinta, which traverses the eastern part from south to north. It has no mines of gold or silver; and its riches consist in grain, fruits, and pastures. Its principal town, Cividad Real, a bishop's see, is situated in a valley surrounded by mountains, about 90 leagues north-north-west of Guatimala, and trades in cotton, cocoa, and cochineal. There are several Indian towns in this province, of which the most populous is Chiapa dos Indos, about 12 leagues westward of Cividad Real, situated in a valley watered by the river Tabasco. The natives of this diocese obtained, through the mediation of the Bishop Cacas, exemption from slavery, with other signal privileges. Soconusco lies between Chiapa and the Pacific Ocean, and is about 35 leagues in length and 30 in breadth. It is a mountainous country, but has no mines. It is covered with forests, and its vallies produce indigo, cocoa-nuts, fruits, and pastures. The only settlement worthy of notice is Guevitlan, or Soconusco, which is the residence of the Spanish go-

* The celebrated traveller M. Humboldt has furnished a complete description of the modern division of New Spain into Intendencies; but he has not touched upon the portion comprehended in Guatimala, for which he mentions that he had no data, and which we can therefore describe only under its ancient divisions.

vernor, and is situated near the coast of the South Sea, about 40 leagues south of Chiapa. See *Modern Universal History*, vol. xxxix; and Playfair's *Geography*, vol. vi. (*q*)

GUAXACA, or more properly OAXACA, is the name of a city and intendancy in Mexico, or New Spain. The city, which is the ancient Mexican Huaxyacac, was called Antiquera at the time of the conquest. It is situated in an extensive and populous valley, about 80 leagues south-east of Mexico. It carries on a considerable trade, and is particularly celebrated for its excellent chocolate. It is handsomely built, and contains a very fine cathedral, but is open and unfortified. It is a bishop's see, and in 1792 contained 24,000 inhabitants. The province of Guaxaca lies in 17° North Latitude, reaching from sea to sea, extending about 90 leagues along the south coast, 30 along the Mexican Gulf, and from 30 to 70 in breadth. Its climate presents a perpetual spring, and it is one of the most delightful countries in that quarter of the globe. Its mountainous districts, composed of granite and gneiss, are rich in mines of gold, silver, and lead. Its plains are highly fertile, and yield abundance of sugar, cochineal, fruits, grain, and various useful productions. Its relative population is equal to that of European Russia, and it has been long advancing in civilization. Throughout the whole province, vegetation is extremely vigorous, especially half-way down the declivity, in the temperate region, where the rains are very copious from May to October; and, at a small village, about three leagues from the capital, is an enormous trunk of *Cupressus disticha*, which measures 118 feet in circumference; but upon a narrow inspection is evidently composed of three united stems. Many remains of ancient Mexican structures are to be seen in the province, especially at San Antonio de los Cues, a populous place on the road from Orizaba to Guaxaca, and at a village named Mitla. In this last mentioned place, which was formerly called Miguitlan, a word signifying, in the Mexican language, a place of sadness, are the ruins of an extensive palace, constructed over the tombs of the kings, and to which the sovereign used to retire for some time on the death of a son, a wife, or a mother. This palace, or rather sepulchre, consists of three edifices, placed symmetrically in a very romantic situation. The principal structure, which is in the best preservation, is nearly 131 feet in length, and the distribution of the apartments bears a strong analogy to what has been remarked by the French *savans*, in the monuments of Upper Egypt. A stair, formed in a pit, leads down to a subterraneous apartment, which is 88 feet by 26, and which, as well as the exterior walls of the edifice, is covered with those ornaments, generally called *grecques*, such as meanders, labyrinths, &c. some of which are in Mosaic, of small porphyry stones. Several curious paintings have been found in these ruins, representing warlike trophies and sacrifices; but the most striking object is a vast hall, of which the ceiling is supported by six porphyry columns, about 16 feet in height. These columns, the only ones found in the new continent, bear strong marks of the infancy of the art, having neither base nor capital, but simply a contraction of the upper part. Besides the capital, there are several other towns in the province, the principal of which is Tecoantepec, about 40 leagues south of Guaxaca, at the bottom of a bay on the coast of the Pacific Ocean. It is a small town, with a good fishing harbour, and an open road for ships; but the port is impeded by a dangerous bar. It is likely, however, to become a place of greater importance, by the increase of the indigo trade from Guatimala. The family of Hernan Cortez bears the title of Marquis of the valley of Oaxaca, a property containing 4 villas, 49 villages, and 17,700 inhabitants. There are 306 secular ecclesiastics in the province, and 342 regulars. The revenues of the bishop amount to 18 000 double piastres. See Humboldt's *Political Essay on the Kingdom of New Spain*. (*q*)

GAUYAQUIL, a city and province in the kingdom of Quito. The city is the second of Spanish origin in the empire of Peru; and was first built about the year 1535, near the gulf of Charapoto, but, in 1693, it was removed to its present situation, on the west bank of the river Guayaquil, in 2° 11′ 21″ South Latitude, about 63 miles from Quito, and 188 from Lima. It extends along the side of the river nearly half a league, and is divided into an old and new town, both of which contain about 2000 houses, which are built of brick or wood, covered with tiles or thatch, but, on account of the numerous conflagrations by which it has suffered, the latter covering is now prohibited. The ground on which the new town stands, is composed of a spongy chalk, and is every where so level, that, in the rainy season, it becomes utterly impassable either on foot or on horseback, and the communication of the inhabitants is effected chiefly by means of large planks, which soon becoming slippery, afford a very inconvenient path. The place is defended by three forts, two on the river close by the town, and a third behind it, guarding the entrance of a ravine. All the churches and convents are built of wood, on account of the softness of the soil, except the church of St Domingo in the old town, which is of stone; and the country supplies timber well adapted for these purposes, being extremely hard, and capable of retaining its solidity either in the mud, or under the water. The city and its jurisdiction are under a corregidor, who is subordinate to the president and audience of Quito, and holds his office during five years; the police is conducted by ordinary Alcaldes; and the ecclesiastical government is lodged in the Bishop of Quito's vicar, who is generally also the priest of the town. It contains a small college of Jesuits, and an hospital without any endowments. The inhabitants of Guayaquil, including the strangers who are drawn thither by commerce, are computed at 20,000; and many of the principal people are Europeans, who have married and settled in the place. All who are capable of bearing arms are enrolled in companies of militia, according to their rank or cast. Though the heat of the climate is equal to that of Panama or Carthagena, yet it is a remarkable circumstance, that the Spanish inhabitants are extremely fresh coloured, and their children universally fair, having light hair and eye-brows. They are accounted the handsomest people in all Peru, and are said to be equally distinguished by the elegance and politeness of their manners. As the river is brackish near the city, good water is extremely scarce, especially during summer, and is brought from a distance of four or five leagues, by means of boats resembling rafts. The fish also in its immediate vicinity is neither good nor plentiful; but great quantities of the most excellent kinds, particularly shell-fish, are brought from the neighbouring coasts, and constitute a principal part of the food of the inhabitants. As wheat is scarce and the bread from it also badly made, different kinds of roots have been employed as substitutes, particularly unripe plantains cut into slices and roasted. The inhabitants affect great splendour in their formal entertainments; and their dishes are a succession of high-seasoned ragouts and sweetmeats, always beginning with the latter. Their liquors, on these occasions, are grape-brandy, cordials, and wine. Weak acid punch is much used by both sexes, in the forenoon and evening, as a refreshing and wholesome drink, and as a necessary mode of correcting the disagreeable qualities of the water. Melons and water melons are brought in great abundance to the city during the summer season. From the month of May to December, the air is remarkably serene and delightful; and the cool breezes, which blow from the mountains from mid-day till five or six o'clock next morning, tend greatly to refresh the earth and the atmosphere. But during the other half of the year, the climate is intolerable to strangers, the heat greater than at Carthagena, the rains continual, the country overflowed, the insects and other vermin extremely numerous, and even venomous. They are said to be so abundant in the city, that it is impossible to keep a candle burning except in a lantern, as it would otherwise be extinguished in a few minutes by the multitudes flying around it. Tertian fevers prevail much at this season, which the inhabitants, from a prejudice against the use of the bark, (though originally discovered in the province,) suffer to prey upon their constitutions, till they often become incurable. They are very subject also to cataracts and other distempers of the eyes, which often terminate in total blindness, and which some have ascribed to the aqueous exhalations during winter from the chalky soil. The city carries on a considerable trade, and exports native produce, of which the chief article is cocoa, to the value of 550,000 piastres annually; while the amount of imports is 1,200,000 piastres. The province of Guayaquil extends about 60 leagues from north to south, and about 45 from east to west; and is divided into seven departments or lieutenancies, for each of which the corregidor appoints a deputy governor, but whose authority must be confirmed by the audience of Quito. These are Puerto Viejo, a poor and thinly inhabited district, abounding in wood, producing a little cotton, and formerly noted for a considerable pearl fishery in the bay of Manta.—Punta de Santa Elena, a low fertile country, full of salt works, but chiefly remarkable for possessing the purple dye so highly esteemed among the ancients, and which is simply the blood of a species of shell fish growing on the rocks. The threads, after being drawn through this liquor, are tinged at first with a milky hue, which changes into green, and then into a vivid purple, which does not fade by wearing, and is rather improved by washing.—Puna, a low flat island in the mouth of Guayaquil river, about seven leagues square, covered with thickets of mangrove trees.—Yaguache, around the mouth of a river of the same name, which falls into the Guayaquil, has no towns of note, but the country is populous, and produces much excellent wood.—Babahoyo, is a large district, subject to great inundations during winter, but productive in cotton, rice, Guinea pepper, and other fruits, especially in plantations of cocoa. Large droves of horses, mules, and black cattle, which are kept in the mountains during the wet season, are brought down when the land is dry, and fattened on the plant called gamalotte, which, resembling barley in its blade, grows in such luxuriance as entirely to cover the plains, even to the height of 7 or 8 feet.—Baba, a very extensive district, reaching to the skirts of the Cordillera, abounds chiefly in the cocoa tree, which delights in a watery soil, and which here grows frequently to the height of 20 feet. The gathering of its fruit and drying of its seed forms the principal trade of the inhabitants. Daule has many large orchards, and extensive corn fields, plantations of cocoa, cotton, and sugar cane, but is chiefly distinguished by the excellence of its tobacco. Throughout the whole province of Guayaquil numbers of cattle are reared, especially where there are mountainous tracts to afford a retreat during the season of the inundations. The woody parts are much infested with insects and noxious animals. The river of Guayaquil, which is the principal channel of the commerce of the country, is navigable for the space of 24 leagues, from the isle of Puna at its mouth to the town of Babahoyo, where all the goods intended for the Cordillera, or proceeding thence, must be entered. This river is frequently swelled by torrents from the mountains; and, as these floods are continually shifting the sand banks, its navigation is uncertain, and requires constant sounding. It is navigated principally by *balzas*, or rafts, which are made of a soft, light wood, and which are of various sizes, but frequently carry 400 or 500 quintals. (See BALZA.) The principal articles of the cargoes exported from the province are cocoa, timber, salt, and cattle, tobacco, wax, Guinea-pepper, drugs, and ceibo-wool. This last is the product of a high and tufted tree, and bears a greater resemblance to silk than either to cotton or wool. It is chiefly used to fill mattresses, and has this remarkable property, that when compressed by dampness, yet, if laid in the sun, it swells again, and often with such force as to stretch the covering of the mattress. The imports are, wine, brandy, oil, and dried fruits from Peru; bays, flour, papas, bacon, hams, cheese, and similar articles, from Quito; iron and cordage from New Spain; and European goods from Panama. But the principal profits of the Guayaquil traders arise from the commercial exchanges between Lima and Quito, which pass in the course of its river, especially in the summer season, when the goods can be conveyed between the mountainous districts and the shipping. The banks of the river are covered with habitations, and the inhabitants thus enjoy the advantages both of fishing and of agriculture. These houses, like the greater part of what are built in the province, are chiefly of timber, and raised upon posts 12 or 15 feet from the ground, on account of the general inundations during winter. In that season, the inhabitants of the level districts pass from house to house by means of canoes, which even the children are able to manage with extraordinary dexterity. The river of Guayaquil supplies the numerous inhabitants of its borders with abundance of fish; and the Indians after harvest set sail in their balzas with their families, and employ several weeks in fishing; moving from one creek to another, according to their success. Besides using harpoons and nets, they employ in the smoother creeks a certain herb called *barbasco*, which they chew, mix with bait, and scatter on the water. The juice of this herb is so powerful, that it often kills the smaller fish when they eat of it; and so stupifies the larger, that they float on the surface, and are taken up without any trouble. The increase of the fish is greatly hindered by the multitudes of alligators which frequent the river and the adjacent plains; and some of which are fifteen feet in length. They are not ferocious, and uniformly flee at the approach of a man; but they often devour the calves, colts, and even the children when wandering near the river in the dusk; and it is said, that after once tasting human flesh, they become more ravenous, sometimes watching an opportunity to drag the boatmen, while asleep, into the water. The gallinazo, a bird about the size of a pea-hen, and very common in the hot climates of South America, furnishes a useful check to the increase of the alligators, by its activity in destroying their eggs. Concealed among the branches of a tree, it silently watches the female alligator till she has laid and covered her eggs in the sand. As soon as she is gone, the bird darts upon the spot, and, assisted by a multitude of its tribe, who readily join the fortunate discoverer, uncovers the nest, and devours the eggs. See Ulloa's *Voyage to South America*, vol. i. (*q*)

GUAYRA. See CARACCAS.

GUERCINO. The original name of this celebrated artist was *Giovanni Francisco Barbieri*. Malvasia relates, that in his infancy he lost the sight of his right eye, and that from this accident he acquired the name by which he is now generally known. He was born at the village of Cento, in the territory of Ferrara; and little doubt remains that he never received any regular instructions in painting but what he derived from two very obscure artists in his own country, namely, Gio. Batista Cremonini, and Benedetto

Gennari. It has been affirmed, indeed, that he was taught in the school of the Carracci; but this supposition is rendered improbable by a variety of circumstances, and by none more than the peculiarities of his different styles, all of which are at variance with the principles of that school. It is more than likely, however, that he derived much advantage from studying the magnificent picture of Lodovico Carracci at the Capuchins at Cento; but for the great proficiency which he attained, he must be considered as chiefly indebted to the strength of his own genius, and to the careful study of nature. The tendency of his mind began to shew itself at an early age; and it is recorded of him, that when only ten years old, he painted a picture of the Virgin, in the façade of his father's house, which would not have disgraced a more mature age, and a more practised hand. When premature talent is found to ripen into great excellence, we too readily give credit to the stories which blind admiration delights to record of childhood already atchieving what belongs to experience and age. And when his biographers relate that this picture of Guercino, at the age of ten, with such a subject as the Virgin, was actually a picture of *extraordinary excellence*, we may safely class it among those innumerable instances of a like nature, in which exaggeration sets not only what is probable, but what is possible also, at defiance.

In the course of his practice, Guercino adopted three different styles, which he followed at different periods. The first is not distinguished either by accuracy or grace of design; and in respect of colouring and effect, is violent, inharmonious, and harsh. It is a bad imitation of Michael Angelo Caravaggio, whose works at that time were held in high estimation. Dissatisfied with his attainments, he visited the celebrated schools of art at Rome, at Venice, and Bologna, and by great study and observation, he changed and improved his manner; and his second style is free from many of the faults which are observable in his previous works. He still retained that vivid contrast of light and shade which distinguishes the productions of Caravaggio; and, like him, his outlines are generally lost, and blended in the *fondo*, but he now far surpassed him in grandeur of composition, and in dignity of character. His females are remarkable for elegant and fascinating beauty. His men, however, are not always free (even in this his best and most valued manner) from a degree of vulgarity and individuality, which probably arose from too strict an adherence to the mode from which he painted. Among the great performances which he executed at this period, we may reckon the picture of St Petronilla, formerly in St Peter's, and lately removed from the gallery of the Louvre; the Aurora, in the Villa Ludovisi; his St Philip of Neri; his St Glena; and his fine picture of the Resurrection. In a similar style of bold design, and magically forcible effect, both of colouring and of light and shade, he executed his grand undertaking of the Dome at St Piacenza, in which he has carried fresco painting to a high degree of perfection. The late Mr Barry, in a letter dated at Bologna, to Sir Joshua Reynolds, speaks in terms of the highest praise of the pictures by Guercino, at that time in the church of St Gregorio. Speaking of the solemn colouring in the works of Ludovico Carracci, "Guercino," says he, "has much of this manner in his fine pictures at St Gregorio, with this difference, that I observe in Guercino more mellowing and *fuoco* in the colouring;" and he regrets that this great artist should ever have departed from the grave majestic tone which he then practised. Like the great painter to whom he is thus compared, one great excellence of Guercino is the clearness of his deepest shadows. In his best works, he admitted a very large proportion of shadow; yet, notwithstanding their breadth and deep repose, every object which it envelopes is as distinctly seen as it would be in nature. Nothing is lost, nothing is left ambiguous.

From this style, however, he was at an advanced period of his life tempted to deviate. The manner of colouring which Guido had adopted, remarkable for sweetness, openness, and delicacy, was become the subject of great admiration; and Guercino, in attempting to rival the peculiarities of style so widely different from his own, lost all that stamped him an original genius, and fell into a manner of comparative imbecility. In this last manner, were his pictures of the Annunciation at Forli, the Prodigal in the royal palace at Turin, and the Marriage of the Virgin in St Paterniano, at Faro.

This laborious artist left an incredible number of works. In the list given by Malvasia, he enumerates 106 altarpieces for the churches, 144 large historical pictures, besides his great fresco works, and his numerous portraits and landscapes in private collections. He left also a vast number of drawings, which are held in great estimation. The etchings which he executed, nine in number, are very spirited. He died in 1666, aged 76 (*t*)

GUERICKE, Otto. See Pneumatics, *History of*.

GUERNSEY, the *Sarnia* of the ancients, is an island belonging to Great Britain. It is one of the Channel islands, lying within the bay of St Michael, and about seven leagues from the coast of Normandy. This island is of a triangular shape. Its extreme length is about $7\frac{1}{2}$ miles, and its greatest breadth about 4 miles. It is about 21 miles in circuit. According to the recent account of it given by Dr Macculloch, it is elevated to the south, and shelves towards the north. The southern coast is bounded by high cliffs, stretching along part of the eastern coast. The rest of the eastern coast, and the northern coast, consists of a number of flat bays, separated by ridges of lofty rocks. Dr Macculloch conceives the island to be divided by an imaginary line, drawn from the town of St Peter's Port to Pezeries. A level tract, broken only by cairns and rocky hillocks, lies to the north of this line. This tract comprehends an inundation of more than 60 years standing, which covers three hundred acres. It was formerly quite dry before the time of low water, but has lately been embanked and drained. Towards the south of the imaginary line, the country forms a higher stratum, everywhere intersected by deep glens and narrow vallies of various directions. With the exception of two or three narrow caves, which form the mouths of small vallies intersecting the high land, the lofty cliffs which bound the southern tract are continuous. There are here few detached rocks, but the northern coast is covered with them. Dr Macculloch observed, that the island is entirely of granitic formation; that the southern division consists wholly of gneiss; and that the rocks which form the northern point, exhibit various kinds of granite, or granitel. At the foot of a rocky steep, near Prevolet Point, is a curious cave, called *La Cave Mahie*. It is about 200 feet in depth; and from an entrance 9 or 10 feet wide and 6 high, it extends from 50 to 60 feet in height and breadth, ending in granite points.

The soil of Guernsey, which is decomposed gneiss, is very fertile, and is well watered by springs and rivulets. Agriculture is carried on with great care. The lands are inclosed with stone fences. The seats of the gentry, and the farm-houses and cottages, which are very handsome, are agreeably situated among orchards and gardens. The ordinary food of the inhabitants, is a soup made of cabbage, pease, flour, and a few slices of green bacon. Their beverage is cyder. The produce of the island is nearly the same as that of the west of England. The fruits are very fine. Pigs are fed in winter on parsnips; and the butter, pork, and veal, are in the highest perfection. Red and grey mullets, mackarel, congor eels, and lobsters, are caught in great abundance round the island. Coals are imported; but the principal fuel of the poorer inhabitants is sea-weed, the ashes of which are used as manure by the farmers.

The climate of Guernsey is mild and temperate, and is not subject to excessive heats or colds. The winters and springs are moist, and high winds often prevail.

Guernsey is divided into ten parishes, each of which is divided into several vintons, for the better management of affairs. The island is in the diocese of Winchester, and province of Canterbury. The convention of the state, consists of the governor, a bailiff, 12 jurats appointed by the king, who administer the laws, which are quite different from ours. These officers hold their places during pleasure; and they judge in all civil and criminal cases excepting high treason. The governor receives tythes of all kinds of grain. He has under him a lieutenant-governor, who is called the constable of the castle. The prevailing religion is that of the church of England, though the followers of Wesley are numerous. The Catholics are very few in number.

The only town in the island is St Peter's Port. It originally consisted of a narrow street of high houses, but the buildings have been extended across a ravine over the surrounding heights. The lower streets are narrow, dirty, and irregular. The principal church, built in 1312, is of granite. It has Gothic mouldings, though no pointed arches. Its exterior is handsome. Its porch is remarkable for the depth and extent of its mouldings; and its tower is a great ornament from the pier and road. It contains some good modern monuments. The new court-house is handsomely built of granite, and fitted up with suitable offices for the preservation of a few records. The new prison, built after the model of the debtors' gaol at Manchester, is very spacious and commodious. The work-house, or hospital, is supported by an endowment, and by an assessment on lands and houses. The harbour affords sufficient shelter and security to shipping. The keys and the piers are immense masses of rough masonry, formed of granite, and extending out into the harbour. These walls are paved, and have parapets, and they inclose a space of several acres. The harbour and the road are exposed to the south-east. Harbours for vessels of light tonnage occur on the north and west sides of the island, at the creeks of Bazon, L'Accousse, Ferminer, St Sampson, and the west passage. The market-house for meat and vegetables, is a large building, erected in an open square. Two large and handsome rooms have been fitted up above the market-house, for the public assemblies and entertainments, which are held monthly during the gay season. There is also a small theatre here. An ascent of about 100 steps, leads from the level of the market-place up the side of a ravine to the new town, where there are many good and open streets, one of which, called George Row, contains several elegant houses. The government house, the public walks at L'Hivreur, and the college founded by Queen Elizabeth, are the only other objects of interest.

There were formerly four castles in the island, viz. Castle Cornet, the Castle in the Marshes, Vale Castle, and the Castle of Notre Dame. Castle Cornet is situated on a rock of gneiss often approaching to granite, and intersected by veins of quartz, trap, and felspar, curved and mixed in various ways. This rock is about a quarter of a mile from the shore, and near Port St Peter's. It is scarcely accessible but on one side. It is surrounded with an outer wall of great thickness, flanked by several machicolated towers, and the keep has been converted into casemates. Elizabeth enlarged it with a lower line of curtain and bastions; and barracks and accommodation for a numerous garrison have since been formed. It is now defended by a considerable quantity of heavy artillery.

The Castle in the Marshes appears to be very ancient. It is encircled with a double wall of granite, and has an outer and inner ditch, and a keep in the Norman form.

The Vale Castle, which is also ancient, stands upon a commanding eminence, near St Sampson's harbour. It was once reckoned to be strong, but it has now only a surrounding wall, with flanking towers, and a portal. There are barracks for a garrison; and several pieces of cannon on the ramparts, command a passage called the Russel. The castle of Notre Dame, and that of Rocquane, no longer exist.

The inhabitants are chiefly employed in agriculture, and in the cultivation of their gardens and orchards, from which great quantities of excellent cyder are made. The only manufacture is that of woollen goods. They are allowed to import 1000 tons of wool annually from England, which is made into stockings, waistcoats and breeches. Lobsters are the only fish which is exported. Guernsey was, before the establishment of the London Docks, the grand depot of all the foreign wines and brandies. Towards the bay of St Sampson's there is a fine rock of grey or black granite, which is exported in large quantities to London and Portsmouth. It is called the Guernsey or St Sampson's stone, and being hard and tough, it is admirably adapted for building and paving, as it easily breaks into square masses before the hammer. Dr Macculloch could not obtain any physical or historical evidence that emery was a production of this island, as has been generally stated. Every part of the coast of Guernsey is fortified with strong batteries and breast works. The number of houses in St Peter's is about 800, and the population of the island about 15,000.

See Dicey's *History of Guernsey*; Grose's *Antiquities of England and Wales*; and Macculloch's *Account of Guernsey* in the *Transactions of the Geological Society*, vol. i. p. 7.

GUIANA, an extensive country in South America, is bounded by the river Orinoco on the north, by the river of the Amazons on the south, by the Atlantic Ocean on the east and north-east, and by New Granada on the west. It is nearly of a triangular form, and is computed to contain 250,000 square miles. It extends along the coast from the mouth of the Orinoco to that of the Maranon or Amazons river, about 700 miles; and stretches inland from east to west about 1200. The Orinoco is known to communicate by several branch-streams with the Maranon; and one of these, called the Yupura, is considered as the western verge of Guiana. It is therefore completely an insulated tract, and is probably capable of being circumnavigated.

The discovery of Guiana has been attributed by some to Columbus in the year 1498, and by others to the Spanish navigator Vasco Nunes, who, after ascertaining Cuba to be an island, landed in 1504 on the continent of South America; and, having traced the coast from the Orinoco to the Maranon, comprehended the whole tract in that extensive country, to which, in contradistinction to Cuba and the adjacent islands, he gave the general name of Terra Firma. But, though originally seen by the Spaniards, Guiana was little known, till it was visited by Sir Walter Raleigh in the year 1595; who not only explored the coast, but also sailed up the river Orinoco about 600 miles, in quest of the imaginary El Dorado. Several English buccaneers next resorted to the coast; and, in 1634, about sixty persons, partly English and partly French, under the command of a Captain Marshall, were found in Surinam cultivating tobacco, and making trading voyages to the neighbouring coasts. In 1650, this voluntary settlement was taken under the protection of Great Britain, and Lord Willoughby of Parkham was appointed governor; but, in 1667, it was taken by the Dutch, and finally ceded to them by the treaty of Wesminster in 1674, in exchange for the province of New York. Similar settlements were gradually made by other powers, on different parts of the coast; and the country of Guiana has thus been distributed by geographers into four distinct divisions; viz. Spanish Guiana, Dutch Guiana, French Guiana, and Portuguese Guiana. Spanish Guiana extends along the coast about thirty leagues, from the mouth of the Orinoco to Cape Nassau, and runs inland about 150 leagues on the south of the Orinoco; Dutch Guiana lies between Cape Nassau and the river Maroni; French Guiana between the Maroni and the river Carapana; and Portuguese Guiana, between the Carapana and the river of the Amazons. The more inland part of the country, behind these settlements, may be considered as a fifth division, and called Indian Guiana. Of these, Spanish Guiana is by far the most extensive and valuable possession. Its breadth, indeed, for the space of 80 leagues eastward, does not exceed 30 leagues; but it afterwards widens to more than 150 leagues, running along the back of the Dutch and French possessions, till it reaches the equinoctial line, which separates it from the Portuguese territories. It is divided into Upper and Lower Guiana, of which the river Caroni may be considered as the separating boundary. Lower Guiana is intersected in all directions by numerous rivers, which from time immemorial have contributed to increase the vegetable mould on its surface, so that in point of fertility it is not surpassed by any other portion of territory in the American continent. But, for the space of 30 leagues from the coast, it is completely occupied by the Caribs, the most ferocious of the Indian tribes, who have hitherto massacred every Spanish missionary or settler, who ventured to approach their habitations; and whose hostility to the Spaniards, the Dutch have been accused of fomenting, for the purpose of extending their commerce along the coast of Spanish Guiana. The city of Saint Thomas, the capital of Spanish Guiana, is situated on the right bank of the Orinoco, about 90 leagues from the mouth of the river; and is the residence of a governor and a bishop. Its streets are regularly built and well paved; and its climate pure and healthy; but its port is incommodious, and its distance from the coast unfavourable to its commercial prosperity. From this port of Guiana were exported, from 1791 to 1794, 10,380 oxen, and 3140 mules, all either bred in the province or brought from Varinas; and, in return, were imported 200 negroes, and 349,448 piastres in specie. From 1791 to 1795 the silver exported to Europe amounted to 25,203 piastres, and the commodities to 363,397 piastres. But this commerce is said to have greatly diminished. The population of Spanish Guiana, exclusive of the portion occupied by the Caribs near the coast, is estimated only at 34,000, of which 19,425 Indians are under the jurisdiction of the missionaries, 6575 reside in the capital, and the remaining 8000 are scattered through the different villages. Farther particulars respecting the political and ecclesiastical state of this province will be found under the articles Caraccas and Orinoco; and for an account of the other European settlements on the coast of Guiana, we refer to the articles Berbice, Cayenne, Demerary, Surinam, &c. In the present article we confine ourselves to such topics as may be considered common to them all, especially to the natural history of Guiana, comprising its soil, climate, native productions, original inhabitants, &c.

Guiana was originally called by some navigators the wild coast; and its shores, accessible only by the mouths of its rivers, are every where covered by dangerous banks, quicksands, rocks, and impenetrable thickets. Its appearance from the sea is wild and uncultivated; and it is so low and flat, that, even where there are plantations along the coast, there is nothing visible at first but a continued forest, standing close to the beach; so that the country appears as a cluster of trees growing out of the water. The European settlers, particularly the Dutch, attempted at first to cultivate the banks of the rivers, at a considerable distance from the coast; but, by the example of the British, were persuaded to extend their plantations along the shore, where the soil is remarkably fertile, and adapted for every variety of tropical production. The ground, for a considerable way up the country, is every where level; and so low, that, during the rainy season, it is usually covered with water nearly two feet in height. This renders the soil so rich, that, on the surface, for 12 feet in depth, it is a stratum of perfect manure, and has been actually carried to Barbadoes for that purpose. In some places, 30 crops of rice can be raised in succession; whereas, in the West India islands, not more than two is ever expected from the richest lands. The whole country is intersected by deep swamps or marshes, numerous rivers, and extensive savannahs. The interior has been little explored; but, in proceeding inland, it becomes more hilly, and the soil poorer, sometimes rocky, and often sandy. It is covered with immense forests, rocks, and mountains; and, in some of the latter, a variety of mineral substances are found. The most prominent objects are, a lake called Parima, whose extent varies with the seasons; and a chain of mountains called Mei, nearly parallel with the form of the coast. From these mountains, rivers flow in every direction; some, like the Essequebo, falling into the Atlantic; some, like the Caroni, joining the Orinoco; and others, like the Rio Blanco, uniting with the river of the Amazons.

The climate of Guiana is the mildest and most salubrious of any tropical country hitherto inhabited by Europeans. This has been ascribed principally to the regular blowing of the trade-wind over the surface of a vast tract of ocean, which thus carries a perpetual stream of cool air over Guiana from east to west; while, on the opposite coast of Africa, the same equatorial wind, coming over land, is heated with the sultry vapours of sandy deserts. Besides this general flow of the whole atmosphere in a westerly direction, there is a daily lateral fluctuation, termed the sea-breeze and the land-breeze; the former, which is the cooler of the two, blowing from the north-east during the day, temperating the ardour of noon; and the latter, which is the warmer of the two, blowing from the south-east during the night, preventing too rapid a chillness. The range of the thermometer on the coast, during the whole year, is from 72 to 87; and, between two or three hundred miles up the country, it is from 65½ to 84. Instead of the cold and the warm seasons of Europe, the year is divided by the rainy and the dry seasons, which may be termed the winter and summer of the country. But, in Guiana, there may be said to be annually two winters or wet seasons, and two summers or dry seasons, which are distinguished from each other by the appellation of the *greater* and the *smaller*, referring not to the intensity of the heat, or the violence of the rains in the one more than the other, but to their duration. The long wet season begins about the middle of April, declines in August, and ceases in September; when the short dry season commences, and continues till the middle of November. Then comes on the short wet season, which lasts till the middle of January, when the long dry season appears, which does not terminate till the middle of April. During this last period, especially in the month of March, the weather is most pleasant, the atmosphere clear and pure, the climate genial and cool. There are frequent variations in these stated periods; and the changes are generally accompanied with tremendous storms of thunder and lightning, which sometimes prove fatal both to the inhabitants and the cattle of the country. In the wet season, though the rain falls in torrents, yet it is generally in the afternoon; and in the dry season, there is rarely a drought, but showers occasionally come during the night. The earth is thus, during the whole year, adorned with perpetual verdure, the trees loaded at the same time with blossoms and ripe fruit; and the whole presenting to the view a delightful union of spring and of summer. There are no hurricanes to destroy the crops of the planter; and rarely are any earthquakes felt in the level districts.

There are few contagious disorders in Guiana; and by temperate living, together with proper care to avoid the mid-day heat and evening dews, Europeans have been able to preserve a state of excellent health in the country. The principal disease is fever, in a variety of forms and degrees, from the simple intermittent to the dreaded yellow fever. A prickly heat, or scarlet eruption, is frequently experienced, which causes extreme itching, but is considered rather as friendly to health. The stings of the musquitoes or gnats are often succeeded by large pimples, which are apt to be converted by scratching into troublesome ulcers. The ring-worm consists of long scarlet spots, chiefly about the face and neck, and is prevented from spreading by the immediate application of lime-juice mixed with gun-powder. The chigoe, or jigger, is a kind of sand-flea, which lodges under the toe-nails, between the skin and the flesh, and, unless extracted as soon as the itching which they occasion is felt, are apt to produce very deep and fretting ulcers. The yaws, a dreadful disorder resembling the small-pox, and covering the body with large ulcers, is extremely infectious, but seems peculiar to the negro race. Dry gripes, bloody flux, and dropsy, are also frequent.

The vegetable productions of Guiana are exceedingly numerous, and many of them particularly worthy of notice, both as objects of curiosity and as articles of utility. The trees in the forests grow to an immense size, many of their trunks rising to the height of 100 feet, and throwing out at the lower extremity a number of flattened projections, which surround the stem like supporting buttresses, and form deep recesses, capable sometimes of affording shelter to 10 or 12 persons. The mountain cabbage, unrivalled in the vegetable world, has a straight tapering trunk 100 feet in height, and 7 or 8 feet in circumference, branches 20 feet in length, diverging in a horizontal direction, palmated narrow leaves above 2 feet long, a green husky pod 20 inches in length at the clefts of the lower branches, full of nuts, which are the seeds of the plant; and, on the summit of the trunk, the cabbage, consisting of thin white strata, and resembling an almond in taste. The silk cotton tree, generally growing to the height of 100 feet, with a trunk 12 feet in circumference, and free of branches for the space of 70 feet, bears a pod full of silky filaments. The red mangrove tree, growing in marshy places, rises from a number of roots, which appear several feet above ground, before they are joined together to form the main trunk, which is generally tall and large, hard, and good for building; and numerous ligneous shoots, without leaves or branches, descend from the stem and the lateral boughs towards the ground, where they take root, and like props or pillars, afford support to the tree in its watery soil. The cocoa nut tree, growing to the height of 60 or 80 feet, but seldom perfectly straight, bears fruit at the age of six or eight years. The pipeira tree, about 70 feet high, and 9 in circumference, affords a weighty durable timber, and bears a small round fruit of a farinaceous nature, which is sometimes used by the Indians as food. Among a variety of other valuable forest trees, growing to the height of 50 feet, may be mentioned the iron-wood tree, so called from its hard and heavy wood, which is used for clubs, wind-mills, and similar purposes; the bullet-tree, which has a dark coloured wood, spotted with small white specks, very durable, and so weighty as to sink in salt water; the launa tree, which bears a fruit like an apple, yielding a purple coloured juice, employed by the Indians in painting their bodies; the mahogany tree, resembling the cedar, and preferring a rocky soil; the tonquin bean tree, which bears the sweet-smelling pulse of that name, and some of which sometimes grow to the height of 70 or 80 feet; the cassia fistula, covered with a light brown bark, and bearing pods 18 inches long, containing a sweet pulp resembling treacle. Of a smaller size are the bourracoura, or letter wood tree, which contains a heart of a deep red colour, marked with black spots, hard, ponderous, capable of the finest polish, and highly valued for its beauty; the hiarree tree, which grows near rivers, and generally at a distance from other trees, esteemed a strong poison, even the smoke of the wood when burning proving fatal to animal life; the cocoa tree, which bears a pod of the size and shape of a melon, containing rows of nuts in its longitudinal cavities.

The most valuable fruit trees are, the guava, which bears a round fruit of a light yellow colour, the internal part of which is a red pulp generally made into jellies, and the external part resembling the substance of an apple, employed in tarts, &c.; the tamarind tree, which grows to a considerable size, and produces its fruit in a large pod; the aviato or avogato pear tree, resembling a walnut tree, and bearing a delicious fruit like a large pear, of a pale green colour, and yellow pulp, similar in taste and flavour to the finest peach; the female poppau, which produces an oval-shaped fruit, about six inches in length; plantains, bananas, pine apples, &c. Among the useful shrubs, we can only particularize the cotton bush, which produces two crops annually; the coffee bush, which also bears two crops, each tree yielding about a pound and a half at a crop; the palma christi, or castor bush, which bears nuts of a triangular form, covered with a thin brown fur, the kernels of which yield by expression the well known castor oil; the cassava shrub, of which the roots are ground into meal, and formed into an excellent bread; but the bitter cassava, though it becomes a wholesome food when boiled or baked, is in its raw state a fatal poison. Of many curious plants may be mentioned the aloe, of which there are various kinds; the caruna shrub, bearing a nut, of which the kernel is used by the Indians as a slow poison; the curretta, or silk-grass plant, a species of aloe, the leaves of which contain a saponaceous pulp, used in washing, mixed with fine and strong white filaments, which, when properly cleaned, can scarcely be distinguished from threads of silk, and are employed in making nets, cords, &c.; the siliqua hirsuta, a slender creeping plant like the vine, bearing pods resembling the common pea, covered with fine stiff pointed hairs, which, upon being applied to the skin, produce an intolerable sensation of itching; troolies, or leaves of an enormous size, from 20 to 30 feet in length, and about 2 or 3 in breadth, growing from a short root close to the ground, and used as a thatch for houses, which they protect from the heaviest rains, and last for many years; nibbees, a kind of ligneous rope, without any foliage, growing to an immense length, and from 3 to 18 inches in circumference, sometimes entwining themselves together to the thickness of a ship's cable, and at other times interweaving themselves like nets, so as to intercept the game in their course, frequently climbing to the tops of the loftiest trees, and again descending to take root in the earth, often coiling themselves so closely around the trunks of the trees, as completely to check their growth, and so extremely tough as to be used by the natives for fastening the posts and thatch of their huts. The roots most deserving of notice, are the ipecacuanha, the ginger, and the Indian yam, which last is about eight inches in length, and six in circumference, of a reddish purple colour, and affords an agreeable farinaceous food..

The native animals of Guiana are not yet fully ascertained; and its unexplored forests contain, in all probability, many animated beings, which are but very imperfectly known to the zoologist. Many of the domestic animals, the bull, the cow, the ass, the hog, the sheep, &c. have been imported from the old continent; and some of these, having escaped into the woods, have run wild and multiplied rapidly. Most of them, however, have greatly degenerated both in size and in flesh, in consequence, it is conjectured, of the perpetual perspiration to which they are exposed, and the coarseness of the grass on which they feed. The sheep, particularly, are remarkably diminutive, and their wool converted into straight hair. The hogs, on the contrary, are large and fat, and superior to those of Europe. The goats are large and beautiful animals, common in all parts of the country; often kept on the plantations, where they breed quickly, and yield much milk. The poultry are as plentiful and excellent as in any part of the world. A smaller species of domestic hen, with rumpled or inverted feathers, is reared by the natives in the inland parts of the country, and is considered as natural to Guiana.

The beasts of prey, which abound in the forests of this country, though numerous, are not remarkably formidable to the human race. The most powerful is the tiger, of which there are several kinds; the jaguar, which resembles the African species, and sometimes measures six feet from the nose to the root of the tail, is very strong and ferocious, frequently attacking the cows, horses, and young negroes on the plantations; the couquar, or red tiger, resembling a grey hound in shape, but larger in size, and equally fierce as the last mentioned; and the tiger cat, a beautiful creature, not much larger than the domestic cat of Europe, but destructive and untameable like the rest of its kind. This is a ferocious little creature, called the crabbo-dago, not much larger than a common cat, and supposed to be the same with what Buffon calls the grison or grey weasel, which is never glutted with blood, but murders whatever comes in its way, whether quadrupeds, fowls or reptiles, if it is able to vanquish them. There are various kinds of monkeys, but no apes in Guiana. The natives affirm, that the ouran-outang, five feet in height, is found in the woods, but no European has ever seen any of these animals in the country. Of the others, the most remarkable are, the quato, which has a naked face, a nose like that of a negro, deeply sunken eyes, large ears, and, excepting its long tail, beais a great resemblance to the human form; the howling baboon, which is about the size of a small bull dog, has a long black beard, and is chiefly remarkable for assembling in large crowds, and uttering a most disagreeable howl or yell, which is continued for a long time, and which is said to be a sure sign of approaching rain; and the saccawinkee, or schacomingky, sometimes called the lion monkey, a small and delicate creature, only about five or six ounces in weight, which perches like a bird upon the forefinger, and is frequently brought down to the plantations by the natives for sale, has a small head, round smooth ears, oval face covered with fine white hair, a tail much longer than its body, long bushy black hair, especially around its neck, like the mane of a lion, is extremely susceptible of cold, and though frequently tamed, seldom lives longer than a few months. The coatimondi or Brasilian weasel, shaped like a dog, often as large as a fox, and resembling that animal in cunning, is a great destroyer of the poultry: and, equalling the monkies in the faculty of climbing trees, commits great ravages among bird nests. One of the most extraordinary animals in Guiana is the great ant-bear, which often weighs from 150 to 200 lbs. and measures not less than eight feet from the snout to the tip of the tail. It has a small head, covered with hair as soft as velvet, and a tail immensely large, flat, and covered with long hair like that of a horse, and as strong as the bristles of a hog, with which, during a shower, or when attacked, or when asleep, he protects his whole body. His feet are armed with long claws, with which he can defend himself against any dog, and even against the tiger, and never quits his hold while he has life. He has a long slender tongue, resembling a worm, sometimes almost two feet in length, and moistened with saliva of a sweetish taste, which he thrusts into the ants' nests, who settle upon it in crowds, when he draws it into his mouth, renewing the operation till no more are to be found. There are found in Guiana the porcupine, the armadillo, the sloth, several kinds of opossum, wood rats, and hedge-hogs.

There are two kinds of deer, the largest of which, called bajew, are about the size of an English buck, and feed in great numbers, in the savannahs; the smaller species, called wirrebocerra, are remarkably nimble, have no horns, and make the most delicate venison. The paccarara, or Indian coney, is common in all parts of Guiana, and greatly resembles the hare in shape and size; is very prolific, and easily taken; and its flesh, which is much like that of a rabbit, forms a principal part of the food of the natives. There are several kinds of wild hogs in the forests, particularly the pingos, or warree, resembling small English hogs, found in herds of 300 or more, running always in a line, and easily knocked on the head. A larger kind, called craspingos, are armed with strong tusks, and, when wounded or obstructed in their course, become extremely ferocious. But both these kinds are supposed to be merely the domestic hog of Africa or Europe in a wild state; and the only species indigenous in Guiana, is the piccaree, or Mexican hog, which is about 3 feet in length, without either tusks or tail, and is particularly remarkable, from having on its back, above the hind legs, a cavity about an inch deep, filled with a white fetid fluid, which, unless cut out as soon as the animal is killed, infects the whole flesh, so as to render it unfit for being used as food. They are found in large herds in the drier and mountainous parts of the country; and their flesh is greatly admired by the natives. There is a great variety of lizzards, of which the most remarkable is the guana, about three feet in length, and generally found among the shrubs and fruit trees. Its eggs, which are deposited in the sand, are reckoned excellent food; and its flesh particularly is esteemed a great delicacy, resembling in taste that of a chicken.

The amphibious animals are very abundant in Guiana; of which we can only slightly notice the tapira, resembling the hippopotamus, but not larger than an ass, with the head of a horse, and a considerable prolongation of the upper lip, excessively thick skin, bristly mane, and short tail, feeds on grass and aquatic herbs, and its flesh is accounted superior to the finest ox beef, but it is rarely procured, as the animal is extremely shy, and plunges into the water upon the least alarm; the manatee, or sea cow, about 16 feet or more in length, with a head like that of a hog, nostrils like an ox, breasts like those of a woman, and a tail like that of a whale, seldom quits the water entirely, and its flesh, which is very fat, tastes much like veal; the alligator, or cayman, found sometimes 20 feet in length, but generally harmless, and even in water seldom attacking a man, as long as he keeps himself in motion; the laubba, which seems to be the same with what others call the paca, or spotted cavey, or aquatic hare, is peculiar to this part of the world, about the size of a sucking pig or large cat, with the head of a pug dog, extremely fat, and resembles the finest pork, feeds on herbs and grain, takes refuge in the water when pursued, swimming a long time at a short distance from the surface, so that it is often shot under water with arrows; the pipa, a kind of toad or frog, sometimes as large as an ordinary duck, a creature of a hideous appearance, covered with a brown shrivelled skin, and chiefly remarkable for the uncommon loudness of its voice; but still more for the peculiar manner of its propagation, the young being hatched in watery cells on the back of the female, or, according to others, placed there by the assistance of the male after they have become tadpoles, and continuing to nestle there till the second transformation is completed.

There are many snakes in Guiana, of which the best known are the rattle-snake, whip-snake and dipsas; the papaw, or ammodytes, a harmless and beautiful creature, from three to five feet in length, which is revered by the natives as a sacred object; the oroocookoo, supposed to be the same with the small laboia, the bite of which has been known to prove fatal in a few minutes; and the aboma, an amphibious animal, delighting in low marshy places, found upwards of 20 feet in length, and said when fully grown to be from 30 to 40 feet long, and from 3 to 4 in circumference at the thickest part of the body. Its bite is not considered as venomous, and it is a sluggish unwieldy creature, but seizes its prey by surprise, and devours deer, hogs, or even the tyger, without difficulty, entangling and crushing them in its grasp, besmearing them with saliva, and swallowing their bodies entire.

The birds most commonly found in Guiana are, the vulture, eagle, owl, falcon, butcher bird; parrots of various kinds; large and beautiful mackaws, some of which are about the size of a capon, toucan, pelican, wood-pecker, green sparrow, tiger bird, a kind of heron of a reddish colour, spotted with black; flamingo, found in flocks on the banks of rivers, and so tame as frequently to mix with the poultry on the plantations; agame, or trumpeter, a kind of turkey peculiar to the country, and often domesticated; sun-bird, resembling the English partridge, and sometimes kept in the houses to destroy the ants; peacock-pheasant, or powese, resembling in size and flavour an English turkey; kishee-kishee, about the size of a sparrow, adorned with most beautiful plumage, and sometimes brought by the Indians from the interior of the country; the mocking bird, which hangs its nest, (about 14 inches in length, and 8 in circumference,) at the extremity of the twigs of the remotest branches, as a security from the monkies; and the humming bird, which is found here in great number and variety: the most common of these, of a green and crimson colour, is not bigger than a large cherry, and the smallest, of a black and green colour, with a golden tuft on its head, nearly a third less than the last mentioned, sometimes weighs little more than 50 grains. There are bats of a large size, some of which have been found to measure thirty-two inches between the tips of the extended wings, and which are known to open the veins in the feet of persons asleep, and to suck the blood till they are satisfied.

The fish caught on the coast are far from being delicate, as the water is extremely muddy for several leagues from the shore. The most remarkable of the salt water fish is the low-low, about six inches in length, and three in circumference; and the largest of the fresh water fish is the barroketa, about three feet long, and two in circumference, resembling a salmon, white, fat, and delicate. The peri, another fresh water fish, about 18 inches long, and of a flat form, has a large mouth armed with long sharp teeth, and is said to attack persons when bathing in the rivers. The frog fish is one of the greatest curiosities in Guiana, and is said to pass by regular gradations, through the form of a frog, a frog fish, and lastly a fish, but is affirmed by Stedman to proceed rather in the opposite direction, from a fish to a frog, and to be probably nothing else than a kind of tadpole, which grows to a large size before undergoing its usual transformation; in the fish state, it is about eight or ten inches long, without scales, and exceedingly fat and delicate. The galvanic eel is very common in the rivers of this country, generally about three feet in length, and 12 inches in circumference, though sometimes found of a much larger size; it comes frequently to the surface of the water, as if to inhale the air, and its flesh is esteemed delicate food by the natives. Multitudes of crabs are found in the bottoms of the muddy streams; and a large land crab, much used as food by the natives, abounds on the banks of the sea, at the mouth of the rivers.

Insects abound in Guiana in vast numbers, owing to the continued warmth of the climate, which both favours their production, and prolongs their existence; and continually flying in the faces, or crawling about the bodies of the inhabitants, are the most intolerable pest of the country, especially to new settlers from Europe. Musquitoes are inconceivably numerous during the rainy season, particularly on the coast, and on the banks of rivers; and are said to prevail most in places, which are in a state of progress from a wild to a completely cultivated condition. The juice of lemons or limes mixed with water, and applied to the skin, is at once the best remedy for their stings, and a tolerable preservative against their attacks. Cock-roaches are found from one to two inches in length, which make their way into chests and boxes, and besides destroying cloths of every description, render every kind of victuals which they attack utterly disgusting, by the nauseous smell which they leave behind. As this creature is seldom seen to fly, the best preservative against its ravages is to place the boxes or trunks upon empty wine bottles, kept free from dust, so as by their smoothness to render its ascent more difficult. Ants of many different kinds are extremely numerous, and prove very destructive to the stores, (especially of sugar,) in the plantations. Their immense nests of black earth, built on the trunks of the trees, are often so high as to resemble large black bears at a distance; and some of their hillocks on the ground have been seen as high as 15 or 20 feet, and nearly 100 feet in circumference. Some of these insects are above an inch in length, and cause great pain by their bite. A small species, called the fire-ant, which flies in great numbers, occasions a burning sensation resembling that produced by boiling water, supposed to proceed from some venomous fluid injected into the wound. There are two kinds of fire-flies, the smallest of which, seen only during night, emits sparks of fire at intervals; but the larger kind, which is more than an inch in length, affords so steady and clear a light, that two or three of them put into a glass will enable a person to read or write without difficulty. The bees of Guiana are very small, of a black colour, and armed with powerful stings; and one species, mentioned by Stedman, which builds its nest in the roofs of houses, is said to attack every stranger with the greatest fury, while it never molests the regular occupiers of the habitation in which it has taken up its abode. The grasshopper tribe is sufficiently numerous; but two kinds are peculiarly worthy of notice, one called "the walking leaf," from its wings, about three inches in length, being so folded on its back, as to give it a close resemblance to a brown leaf; the other, called in Surinam "Spaanse-juffer," has a body about seven inches in length, not thicker than a common quill; has no wings, but is mounted like a spider on six legs, nearly six inches long, and has on its head four antennæ, two of which are about five inches in length. An enormous and hideous looking spider, called the bush-spider, is found in the forests; and is of such a size, that one of them, when put into a case bottle eight inches high, actually reached the top with some of its claws, while its feet were resting on the bottom. It feeds upon all kinds of insects, and is said even to suck the blood of young birds. Its bite is so venomous, as to be supposed to prove sometimes fatal, and always at least occasions a fever. The groe-groe, or palm-tree worm, about three inches long, and thick as a man's thumb, of a light yellow colour, with a black head, breeds in the cabbage tree after it is cut down, is roasted, and eaten as a great delicacy, equal to the finest marrow; and sometimes its fat, melted and clarified, is used instead of butter. There are centipedes above six inches in length, which move with equal rapidity backwards or forwards, and whose bite is venomous. Scorpions, also, are frequently found among old trees and rubbish; but their sting, though very painful, and apt to occasion fever, is said not to be mortal.

For an account of the native human inhabitants of this country, we refer to the general description of the Amecan Indians, given under the article America; and shall only notice here, in a cursory manner, the particular tribes which occupy the interior of Guiana, but occasionally visit the European settlements on the coast. The chief of these are the Caribs, Accawaws, Arrowawcs, and Worrows. The Caribs inhabit that part of the coast which lies between the Essequebo and the Orinoco, and are by far the most numerous, warlike, and active of the natives. Their stature is taller, their complexion lighter, and their features more sprightly and agreeable than those of the other tribes. They are also more industrious, and, besides the ordinary Indian occupations of hunting and fishing, they cultivate fields of plaintains and cassava around their dwellings. They carry on constant hostilities against the Spaniards; but are considered as allies of the Dutch. They frequently go to war also with the other tribes; and, in some instances, have been known to devour their enemies slain in battle. The Accawaws inhabit the inland districts behind the Caribs, and adjacent to the sources of the Essequebo, Demerary, and Berbice. They bear a nearer resemblance in their persons to the Caribs than the other tribes; but are more grave in their aspect and manners, and remarkable for their superior cunning. They are also addicted, more than any of their neighbours, to the use of poison, both against their enemies, and those of their own people who may may have done them any injury. The Worrows occupy the coast between Demerary and Surinam, and are much darker in their colour, disagreeable in their aspect, and dirty in their habits, than any of the other tribes. They are said to be extremely pusillanimous and lazy, scarcely exerting themselves to provide any other clothing than the bark of trees, or to procure any better food than crabs and fresh water. The Arrowawcs reside behind the Worrows, at the back of the settlements of Surinam and Demerary, and are described as the most gentle in manners, lively in temper, and handsome in person, of all the Indians of Guiana. They are remarkably friendly to the Europeans, and peaceable in their intercourse with the other Indian nations. Besides these four tribes, who are most frequently seen at the settlements on the coast, other two have been mentioned, namely, the Taiiras, residing on the sea-coast between Surinam and the river Amazon, who are said to be extremely numerous, but peaceable and indolent, resembling very much the Worrow tribe; and the Piannacotaws, who live far inland, and are violent enemies to all Europeans, with whom they obstinately refuse to have any kind of intercourse. It has long been the policy of the Dutch settlements to cultivate the friendship of these native tribes; and an annual sum is expended in purchasing blue cloth, beads, hatchets, ribbons, and other ornaments and implements, as gifts to their Indian neighbours. They come down to the colonies occasionally in small parties, and make engagements to cut wood, an operation at which they are remarkably expert; but they soon become impatient of the restraint of regular industry; and sometimes take their departure suddenly, without any apparent reason. They frequently appear also as traders, bringing as their merchandize, cotton hammocks, canoes, baskets, wax, balsam of capivi, arnotto, wild nutmeg, wild cinnamon, parrots, monkeys, ebony, and other curious woods; for which they receive, in return, chequered cloth, fire-arms, gunpowder, hatchets, knives, scissars, looking-glasses, fish-hooks, combs, needles, pins, beads, &c. One of their favourite purchases is rum, which they swallow with eagerness till they become completely intoxicated; but it is generally observed, that one half of the party keep themselves sober to watch their drunken friends, who afterwards perform the office of guards in their turn. Sometimes they bring down the prisoners whom they have taken in war, and sell them as slaves; but these captives serve only for show, as they absolutely refuse to work; and, if treated harshly, particularly if beaten, they pine and languish, refusing even to take food, till they finally die of want or dejection. The native Indians have a strong dislike of the negroes, whom they regard with contempt as an inferior race, and are generally ready to render assistance to the colonists in suppressing insurrections among the slaves, or apprehending the runaways. It is strongly recommended that every inducement should be offered to encourage their intercourse with the settlements; and that fairs should be held, at certain fixed seasons, for their barter trade, which might thus be greatly increased, to the mutual advantage of both parties.

See Depon's *Travels in South America;* Pinckard's *Notes on the West Indies;* Bolingbroke's *Voyage to the river Demerary;* Stedman's *Narrative of the Expedition against the Revolted Negroes of Surinam;* Bancroft's *Natural History of Guiana;* and *Letters to Dr Pitcairn*, published in 1766. (*q*)

GUIDO. See Rheni.

GUILDFORD, a borough and market town of England, in Surrey. It is the county town, and is situated on the side of a considerable chalk hill on the east bank of the Wey. This river is crossed by a stone bridge of five arches, which was lately widened with brick, and the centre arch enlarged to allow barges to pass. The town is large and well built, and consists principally of one excellent and spacious street, which, from the declivity of its situation, is particularly striking to strangers. Guildford contains three parish churches. Trinity church is situated on the top of the hill, and on the south side of the high street. The foundation stone was laid in 1740, and it was completed in 1763. It is a handsome brick structure, 82 feet long, and 52½ broad. The tower, which is also of brick, is about 90 feet high, and contains eight bells. St Mary's church is a very rude and ancient building, consisting of chalk, flint, pebbles, and rubble stones, coarsely put together. St Nicholas's church, which stands on the west bank of the Wey, is an ancient building of chalk and stone. The other public buildings and institutions are, the hospital, the free grammar school, the town or guildhall, the theatre, and the gaol. The hospital, built in 1619, is a brick building, inclosing a quadrangular space of 66 feet broad, and 63 deep, with a noble tower gate, with four turrets, at its entrance. It was founded by George Abbot, archbishop of Canterbury, for the maintenance of a master, twelve brethren, and eight sisters. The free grammar school, built of brick and stone, was built in 1557, and is 65 feet long and 22 broad. The town or guildhall, is a spacious building, with a turret on the top. It was erected in 1683, and is 44 feet long. The hall was formerly used at the assizes; but in 1789, Lord Onslow and Lord Grantley purchased the Red Lion Inn, and on one part of the ground erected a room 40 feet long, 30 broad, and 20 high, in which the judges now sit. The theatre was built near this room a few years ago. The gaol, rebuilt of stone in 1765, is near St Mary's church. There is also here a charity school, a Roman Catholic chapel, and meeting houses for the Baptists, Presbyterians, and Quakers: a cold bath was erected at a house near the bridge, by Lord Grantley, in 1775. There is a fine circular race course about two miles east of the town. A plate of 100 guineas given by William III. and three subscription plates, exclusive of matches, are run for in Whitsun week. The castle of Guildford, one of the principal objects in the town, is situated about 300 yards southward of the high street. The keep is now the chief part that remains. It is a quadrangle, 47 feet by 45½, and 70 feet high. The walls are ten feet thick. On the west side of the keep may be seen the outer gate of the castle. The ruins occupy at present about five acres. In the chalky cliff on which the castle is situated, is a series of caverns. One of these caverns is 45 feet by 20 wide, and 9 feet high. This town formerly enjoyed a considerable share of the clothing trade; but a small part of it only remains. The trade of the place consists chiefly in sending timber and corn to London by the Wey, and in supplying the surrounding villages with their requisite merchandize. A direct communication has lately been made with Brighton and the coast of Sussex, by a turnpike road to Horsham, and a fund has been raised for joining the river Wey and the Arun, so as to form a navigable line from London to the sea at Little Hampton.

The town is supplied with water by means of an engine, which discharges it into a reservoir at the foot of Poyle hill, from which it is carried by pipes to the houses of the inhabitants.

The following is the population abstract for the borough for 1811.

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|---|---|
| Inhabited houses | 495 |
| Number of families | 596 |
| Families employed in agriculture | 46 |
| Do. in trade and manufactures | 434 |
| Males | 1382 |
| Females | 1592 |
| Total population | 2974 |
| Increase since 1801 | 340 |

See the *Beauties of England and Wales*, vol. xiv. p. 251.

GUILLOTINE, is the name of an instrument of death, invented by Dr Guillotin of Lyons, a member of the National Assembly of France, and used during all the horrors of the French revolution. M. Louis, a celebrated surgeon in Paris, is said to have been rewarded with 2000 livres for a dissertation on the advantages of the guillotine; and the inventor himself suffered death by his own instrument in the reign of Robespierre.

The hands of the sufferer being tied behind his back, he is fixed to a plank standing vertically, not reaching higher than his neck. This plank is suddenly brought by machinery into a horizontal position, and moved below the loaded axe, which descends with a slanting edge, and severs the head from the body.

An instrument of a similar kind seems to have been first used at Halifax in Yorkshire. It was introduced into Scotland, under the name of the *Maiden*, by the Regent Morton, who accidentally saw it in use when passing through Halifax; and one of these instruments is still to be seen in Edinburgh, in the Museum of the Society of the Antiquaries of Scotland.

# GUINEA.

Guinea, is a maritime district in the south-west part of Africa, to which various limits are assigned by different nations. The Dutch consider it as extending from Cape Blanco, 21° North Lat. to Cape Lopez, in 1° South Lat. making Sierra Leona, in 8½° North Lat. the boundary between North and South Guinea. The Portuguese include, under the general name, the whole of the coast from Cape Ledo or Tagrin, 8° North Lat. to Cape Negro, 16° South Lat. making Cape Lopez the division between Upper and Lower Guinea. According to the French, Guinea lies betwixt Cabo Monte, 11½° West Long. and Cape Lopez; and, by the English, the tract between the mouth of the river Gambia, 12½°, and Cape Palmas, 4° North Lat. is called North Guinea; while South Guinea reaches from Cape Palmas to Cape Lopez. By the greater part of geographers, Upper Guinea is limited to that part of the coast which runs from east to west about 500 leagues, comprehending Sierra Leona, Malaguetta, or the Grain Coast, the Ivory Coast, the Gold Coast, the Slave Coast, and the kingdom of Benin. Of Lower Guinea, in the more confined application of the name, extending from the kingdom of Benin to Cape Lopez, very little is known except the line of coast; and we have only to refer our readers to the map of Africa in this work, for the names and situations of its principal districts. The southern division, between Cape Lopez and Cape Negro, has been explored, and occupied chiefly by the Portuguese; and its different countries, Angola, Benguela, Congo *Proper*, and Loango, are described under separate articles. It is to Upper Guinea, that our attention is at present to be directed, and particularly to that portion of it which is generally denominated Guinea Proper, comprehending the Ivory, Gold, and Slave Coasts. Benin has been already noticed; and Sierra Leona will form the subject of a distinct article.

The interior of the Grain country is very little known, and its line of coast may be described in a few words. It is sometimes called the Pepper Coast, and Malaguetta, from the long pepper of that name; but generally the Grain Coast, from the grain of paradise with which it abounds. It extends about 100 leagues from Cape Mesurado to the vicinity of Cape Palmas; and is in general low, flat, covered with forests, and watered by numerous streams.

The principal places along the coast, are Rio Junco, or Rio del Punto, about 50 miles east of Cape Mesurado, a shallow stream, about 500 paces broad at its entrance, flowing through a level and delightful tract of country, which is inhabited by a peaceable and industrious people, who are principally employed in making salt and cultivating rice, and who trade in cotton cloth, sea horse teeth, skins of wild beasts, and slaves;—the country of the Foljas, or Pholeys, a powerful tribe, who are noted for the superior elegance of their speech, and whose territories are partly watered by the Junco;—Tabo-Dragon, a large and populous village on the east bank of the Tabo, or Rio Corso, where the merchants of Dieppe established a factory;—Rio Sestos, about 50 miles from Rio Junco, said to be navigable by small barks for 25 miles, has several villages at its mouth and on its banks; and the inhabitants, called Quabo-monou, are a pacific and well-proportioned race, subsisting on millet, fruits, and fish;—Sanguin, Baffa, Setuna, Batoua, Cape Sino, Sestrokrou, Wappo, Great Sestro, &c. all villages along the coast, of which the last mentioned is the most populous, and most noted for its trade in pepper and ivory, and is situated near Rio des Escravas. The Grain Coast is generally bordered with shoals; and its staple commodities are long pepper, leather, ivory, gold-dust, and slaves.

The Ivory Coast extends about 110 leagues from west to east, from Cape Palmas to Cape Apollonia, in a low strait line, with few bays or islands; but a foul bottom and high surf prevent vessels from anchoring or landing upon any part of it with safety. Cape Palmas, formed by two hills covered with palms, in 4° 25′ North Lat. and 12° East Long. has a small gulf behind it, where vessels may be sheltered from the south wind. Grova, a few miles eastward of Cape Palmas; Tabo-Duno, where there is a commodious road for shipping; Drevin Petri, a considerable village about 50 leagues east of Cape Palmas; Giron, on the border of a well watered meadow; Lahou, a populous town frequented by Europeans, and abounding in provisions, and from which, eastward to Cape Apollonia, the coast is commonly called the country of the Quaquas; Gammo, a place to which the inhabitants of the interior bring down their articles of traffic; Sueiro d'Acosta, where there is a small road for ships; Issini, where the French built a fort at the beginning of the 18th century; Assoka, about five or six miles from the sea coast, and said to contain about 1000 inhabitants; Albiani and Tabo, environed with plantations of palm trees; Akani Mina, in the vicinity of Cape Apollonia, are the principal villages on the coast, and most of them are situated on the borders of rivers. The soil of the lower and maritime tracts produces cotton, indigo, cocoa nuts, fruit, rice, and other grain. The chief articles of trade are gold, ivory, salt, cotton, palm-wine, and oil. All sorts of tame animals abound in the country; and immense numbers of elephants, tigers, panthers, serpents, &c. are found in the forests. This level coast is bounded by mountains well covered with wood, and where the vallies are generally fertile and populous.

The Gold Coast commences a few leagues westward of Cape Apollonia, and terminates at Rio Volta, an extent of about 350 miles, lying between 4° 40′, and 5° 40′ of north lat. and between the meridian and 3° west long. Cape Apollonia is low on the coast, but rises into three hills, covered with trees, and seen from a great distance at sea. The first fort on the windward part is Apollonia, about three miles eastward of the Cape, situated in a spacious plain, which is bounded towards the interior by a fine lake of fresh water, about six miles in circumference, and full of fish. In this lake a small village is erected on wooden piles, the inhabitants of which are said to have been exiles from the interior, who were not allowed to build upon the land. Along the whole coast of Apollonia, the surf is exceedingly dangerous, and there are no creeks or harbours. This territory or state extends about 100 miles along the coast, and probably not more than 20 inland. The next settlement is Axim, which belongs to the Dutch, and forms part of the extensive and fertile country of Ahantah. The fort, originally built by the Portuguese, and called Fort Anthony, stands upon a promontory, which forms the western part of Cape Three Points. The landing is here perfectly safe, and may be approached by boats in the dry season without any danger. About four leagues from Fort Anthony is Fort Fredericksburgh, first erected by the Prussians, but afterwards sold to the Dutch, and now in ruins. At three leagues distance is Accoda, another Dutch settlement; and three leagues farther is Dix Cove, belonging to the British, advantageously situated at the entrance of a small cove, which is capable of admitting vessels of 40 tons at high water. Boutry, Taccorary, and Succondee, all Dutch settlements, lie at the distance of a few miles from each other; and the last mentioned forms the extremity of the Ahanta country, which is the richest and best provided with harbours of all the Gold Coast. It stretches farther inland than Apollonia, and is bounded by the Warsaw and Dinkara states. About three leagues from Succondee is Chamah, where the Dutch have a small fort called Sebastian, supposed to have been originally built by the Portuguese. About eight miles from Chaman, is Commenda, where the British and Dutch have settlements and forts, and where the inhabitants are chiefly employed in supplying vessels with canoes and canoe-men for trading on the leeward coast. About 9 miles from Commenda, is Elmina, the most respectable fortress on the Gold Coast, and the head-quarters of the Dutch settlements. The town is large, and some of the houses built of stone. The river admits vessels of 100 tons at high water, which can unload under the walls of the castle. The inhabitants consist of traders, fishermen, and a few mulatto mechanics. The population amounts to about 15,000; and a considerable trade is carried on, particularly in gold and slaves. About 9 miles from Elmina, is Cape Coast Castle, the principal British fort and settlement on the Gold Coast. It was built by the Portuguese, who ceded it to the Dutch, from whom it was taken in 1665. It has been considerably improved and strengthened by the African Company; and the castle is capable of making a powerful resistance on the side towards the sea. The town is irregular, and the houses chiefly built of clay. The population amounts to 8000; and the trade consists chiefly in gold. The adjoining country is called Fetu, and is subject to the Fantee state. During the existence of the slave trade, the countries from Cape Coast to Acra were the great centre of that nefarious traffic, which brought a rapid accumulation of wealth to the native traders in every town and village, the result of which was a spirit of idleness, licentiousness, and turbulence, which threatened the overthrow of all order and security in the settlement. About four miles from Cape Coast, is a Dutch fort called Nassau, situated at a village named Mouree. About six miles from Mouree, is the British fort Anamaboa, the most compact and best built in the country; and the town in its former flourishing state contained at least 15,000 inhabitants. But it was destroyed in a war with the Ashantees, a powerful people in the interior; and the abolition of the slave trade, in which it formerly bore a principal share, is likely to retard its re-establishment. About three miles from Anamaboa is the town of Cormantine, where the Dutch have a fort called Amsterdam, originally built by the British, and the first that was erected on the Gold Coast. About six leagues eastward is Tantumquerry, where landing is very difficult; and, nine miles farther, is the district of Assam or Apang, where the Dutch have a small fort, and where the coast is more accessible. About 8 miles from Assam is the town of Winnebah, where there is a small fort belonging to tho British, and where the landing is generally safe. The town has been reduced, by wars and other casualties, from a population of 4000 to 2000, and was formerly a part of the Agoona country, which has recently fallen under the power of the Fantees. About three leagues from Winnebah is the Dutch fort of Berracoe; and nine leagues farther west is Acra, where there are settlements of the British, Dutch, and Danes. Acra, is an independent state, which formerly belonged to the kings of Aquamboe, but has at present most intercourse with the Ashantees. It is the most healthy situation on the Gold Coast; and the inhabitants are more civilized than most of their neighbours. About 32 miles from Acra, is a small British fort named Pram Pram; and 8 miles farther, is the Danish fort of Ningo, around which the country is level and fertile, abounding in game, and in a large breed of horned cattle. About 36 miles from Ningo is Adda, where there is a Danish fort, and is situated on the left bank of the Rio Volta, which terminates the Gold Coast. This river runs nearly north-west and south-east, separating the countries of Aquamboe and Aquapim, and is navigable for small craft to the distance of 100 miles from its mouth. See Acra, Anamaboa, and Aquamboe.

The slave coast extends from Rio Volta to Rio Sagos, which separates it from the kingdom of Benin. It reaches about 50 leagues from west to east, and contains the following districts or provinces: Koto, lying between Rio Volta and Cape Monte, which is a flat, sandy territory, little frequented. Near Cape Pucalo, is a village named Quilta, where there is a British fort; and at a little distance is Koto, the capital of the country. Popo or Papa, about 10 leagues in length, between Cape Monte and Juida, is low and sandy, in some places marshy, and generally inaccessible on the coast. At the mouth of the Tari, is a village of the same name, and a Dutch factory. Juida or Whidah, extending several leagues, is more fertile and populous than the districts already noticed; and at the mouth of one of its rivers, called Euphrates, is a port where ships may unload, though not without considerable inconvenience from the surf. Near this river, but about two leagues from the shore, is a populous town, named Sabi or Xavier, where merchants resort. At the mouth of another river, named Jaquin, are British, Portuguese, and Dutch settlements, in an island called Gregoi. Ardra extends about 15 leagues along the coast, and is a fertile but insalubrious tract. Foulaon, Assem, Jago, and Appak, are the names of its principal villages. Whidah and Ardrah have been long subject to the king of Dahomy, a powerful state in the interior. The principal trade of the slave coast consists in salt, palm-oil, and slaves. See Ardrah and Dahomy.

There are several tracts along the coast of Guinea of a sandy and sterile nature, without any other trees than the palm; but the general appearance of the country from the sea is that of an immense forest, with a few high grounds covered with lofty trees, and the thickest underwood. Many of the vallies are richly planted, and extensive plains may be seen, beautifully studded with natural clumps of trees and bushes. In the more inland parts, where the moisture is more abundant than on the coast, the woods are almost impenetrable, on account of their luxuriant growth; and the surface of the ground is completely concealed by shrubs and herbs. The rivers generally run in a very winding direction, and in some places overflow their banks during the wet season, forming large stagnant ponds.

The soil varies considerably along the coast, from a light sand or gravel, to a fine black mould and loamy clay; but it is more uniformly rich and productive towards the interior of the country. For the space of six or eight miles from the sea may be found soil of every description, suited to every kind of cultivation.

The climate is not so hot as in many other parts of Africa, nearer the tropics; and it is generally observed that the countries on the equator, from five to six degrees on either side of it, are the most temperate in the tropical regions of Africa. The temperature is found in these countries to be affected, not merely by the latitude, but by various other causes; and is always cooler where the soil is good, cultivation extensive, and the country open, with high lands in the vicinity. At Cape Coast, though accounted the hottest situation on the Gold Coast, the thermometer is usually, during the hottest months, from 85 to 90 degrees of Fahrenheit. At Winnebah and Acra, it is seldom known to exceed 87; and, during the months of June, July, August, not higher than 78 degrees.

The seasons, as in other tropical countries, may be distinguished into wet and dry; or rather into two wet and one dry period. The first wet season commences in the end of May, or beginning of June, when the rains fall with great violence, and without intermission for several days. Strong breezes commonly follow this first deluge, and the rains are seldom very heavy during the remainder of the wet season, which terminates with the month of July. Then begins the foggy season, which is extremely unhealthy, especially in low, swampy, or woody situations, and continues for two or three weeks. About the month of October, the second rainy season begins; but the rains do not fall with so much violence as the first, nor are they succeeded by mists and foggy weather. The dry season begins with November, and continues during the remainder of the year to the month of May; but, in the course of this period, the coast is visited with violent storms of wind, generally denominated tornadoes and harmattans. Tornadoes* commonly commence in March, and cease with the beginning of the first rains; but sometimes blow before or after the second rains, or preceding a harmattan. They invariably come from the eastward, and are generally experienced a day or two after the full and change of the moon. Their approach is sufficiently indicated by vivid and successive flashes of lightning in the east, attended with thunder and heavy clouds, and by the clear and bluish appearance of the horizon. Their nearer approach is announced by the darkening of the horizon, especially in the eastern hemisphere, the increase of the lightning, and, finally, as an immediate prelude to the tempest, by a solemn stillness and entire calm in the lower part of the atmosphere, while the upper regions appear in dreadful commotion. A gentle air is then perceived, which is almost instantaneously succeeded by violent gusts of wind, usually accompanied with rain, and seldom continuing above half an hour or fifty minutes. Tremendous peals of thunder, and torrents of rain, for the space of two or more hours, terminate the storm. During its continuance, the thermometer suffers a rapid depression of five degrees or more; the air is subsequently cooled, vegetation refreshed, and the human

* The name *tornadoe* is supposed to be a corruption of the Portuguese word *trevado*, a thunder storm.

constitution invigorated. A harmattan* is an easterly wind, which prevails in the months of December, January, and February, along the coast from Cape Verd and Cape Lopez. It comes on indiscriminately at any time of the day, or of the tide, or of the moon; and continues, sometimes one or two days, sometimes five or six, and sometimes even fifteen or sixteen. It is always accompanied by a fog or haze, which occasions a considerable obscurity, and renders the sun, which appears only a few hours about noon, of a mild red colour. Extreme dryness is another attendant of a harmattan, and, during its continuance, no moisture is perceived in the atmosphere, or any falling of dew on the earth. All vegetation is checked, and the more tender plants are completely destroyed. The grass becomes like hay, and the most vigorous evergreens droop under its influence. Its parching effects are severely felt on the external parts of the body, particularly the eyes, nostrils, lips, and palate, which become dry and uneasy. Drink is often required, not so much to quench thirst, as to remove a painful aridity in the fauces; and, though the air is cool, a troublesome sensation of prickly heat is felt on the skin. If the wind should continue for four or five days, the scarf-skin generally peels off from the hands and face, and even from the whole of the body. Notwithstanding these disagreeable effects, it is found, on the coast of Guinea, to be highly conducive to health, restoring persons labouring under dysenteries, fevers, or any debilitating evacuations, arresting the progress of epidemics, and apparently preventing even the artificial communication of infection.†

The principal vegetable productions of the coast of Guinea, are maize, millet, rice, yams, cassada, potatoes, pulse, plantains, guavas, bananas, chillees, &c. The sugar cane grows spontaneously, to a tolerable size; and the cotton shrub is found in a wild state. The indigo plant is common in many parts of the coast; and black pepper has been discovered in the inland districts. European cabbage and eschallots are cultivated in some places; and a mucilaginous vegetable, called *encrumah*, the same as the ockra of the West Indies, (*Helescus esculentus*,) is very plentiful in the country. Besides the ordinary tropical fruits, there is one of a very nutritious nature, called *enteraba*, which is much used, and is about the shape and size of the largest onions. The silk-cotton tree is found in every part of the coast, and grows to a majestic size, so as to furnish excellent materials for the formation of canoes. There is a great variety of useful timber in the country, but the palm-tree is the most profitable to the natives. Of the leaf they make rope, thread, nets, fishing lines, &c. From the fruit they express an oil of great delicacy, which is used in all their dishes, and, when eaten fresh, is equal to excellent butter. The kernel contains a hard pulpy substance, which is sometimes roasted and eaten by the women, as promoting corpulency. From the trunk of the tallest species, which sometimes reach 100 feet in height, they draw an intoxicating liquid, which they call palm-wine, and which is procured by inserting a reed into a hole at the top of the tree, through which the liquor flows into an earthen pot. A similar liquid, of a more agreeable flavour, and less intoxicating quality, is procured from the low-palm; but, in order to procure it, the tree is generally dug up, and the trunk heated by fire, that the juice may flow more abundantly. This wine is drunk in a state of effervescence, and will not keep above a few hours.

The mountains of Guinea, as far as they have been examined, are in general granitic and schistous, and are filled with mines of gold and iron. The latter of these metals is little known to the natives, and Europeans have not thought it their interest to instruct them in the subject; but the first has been sought from time immemorial, and is likely to become a still more extensive object of traffic, in proportion as the exportation of human beings shall cease. Gold is found in these mountains in a primitive state, between two layers of a granite, finer, more solid, and more highly coloured than the rest of the rock; but the natives, unacquainted with the art of mining, and unprovided with proper tools for the purpose, have never attempted to work it in these places. They confine their operations to digging at the base of the mountains, where the schistous beds and banks of granite are more friable, and washing the sands in the beds of rivers and water courses at the bottom of the hills, when the rain water has run off. In digging, they work downwards, as if forming a well; or sometimes make a ditch about 20 or 30 feet deep, till they become alarmed for the crumbling down of the earth. They generally begin to find the gold at the depth of three feet; and, as they advance in the work, put the lumps of the metal into pouches which are fixed round their waists. Pieces are sometimes found of a considerable size, and the king of Ashantee is said to possess a lump of native gold, so large that four men are required to lift it. The earth, which is thrown out in the course of the digging, is laid in heaps at the side of the pit, and is carried by other labourers, chiefly women and children, to the nearest river, where it is washed in bags or wooden bowls, and the particles of gold afterwards separated from the heavier parts which remain in the vessel. This ore is sometimes so rich, that a piece of it, weighing four or five ounces, has been known, when pounded and washed, to produce about four pennyweights of gold dust; and the general fertility of the mines may be estimated, from the circumstance of the slaves employed by the king of Ashantee in 1790 engaging to supply him with half an ounce a-day for each labourer. The gold-finders, who wash the sands on the banks of rivers, and the sea-shore, are less successful in their researches, and it is generally the women only who are thus employed; but this precious metal, it is sufficiently ascertained, is very abundant in the interior of the country, and the mines may be considered as still virgin mines.

The animals of Guinea are numerous, but only such as are common to the western coast of Africa. The ordinary domestic animals, dogs, cats, sheep, goats, and hogs, are plentiful in most places; and poultry, particularly is found in great abundance. There are horned cattle in some parts of the coast, especially in Apollonia, but only in the possession of the chiefs. The wild animals are buffaloes, tiger cats, leopards, hyænas, jackals, ant-bears, porcupines, monkeys, deer, hares, squirrels, musk-cats, alligators, lizards, land-crabs, chameleons, guanos, scorpions, centipedes, and a variety of snakes. The hippopotamus is occasionally seen on the banks of the river Volta. The feathered tribe in a wild state are extremely various; and the smaller birds, particularly, are remarkable for the beauty of their plumage. The lakes and rivers abound with mullet and other kinds of fish; oysters and prawns are plentiful in some places; and turtles are not uncommon. There is a variety of excellent fish on the coast, which is procured in abundance during the dry season, when the surf is least violent.

* Supposed to be a Fantee word, pronounced by the natives *harmanta*, and said by them to signify a cold dry wind.

† It appears to be the same kind of wind as the *sammiel* of Egypt, and the *sirocco* of the Mediterranean.

There are several distinct nations along the coast of Guinea; but their general customs are so extremely similar, that they may be described as one people. The most powerful tribes are found in the interior of the country, and they are, in many respects, superior to those who inhabit the maritime districts. The two most extensive of these kingdoms are Dahomy (see Dahomy) and Ashantee, both of which have made their power at times severely felt on the coast. The former is described in a preceding article; but very little was known of the latter, till its king appeared on the coast, in a war against the Fantees in 1807; when the discipline and bravery of the army, and the order and regularity of the court, evinced a considerable degree of civilization. The following account of an interview between the governor of the British fort at Annamaboe and the king may furnish some idea of this people. "The governor was obliged to visit each man of rank, before he could be received by the king; a ceremony that could not be prudently denied, and which occupied some time; for those men had their several courts, and collectively had formed an extensive circle. Every one of them was seated under a huge umbrella, surrounded by attendants and guards, with young persons employed in fanning the air, and dispersing the flies." "After the ceremony of visiting those persons was over, the governor was conducted towards the king, who was surrounded by a number of attendants, whose appearance bore evident marks of riches and authority. Chairs, stools, axes, swords, flutes, message-canes, &c. were either of solid gold, or richly adorned with that metal. Those dazzling appearances, added to damask, taffety, and other rich dresses, gave a splendour to the scene, highly interesting. When the governor approached the king, and when an interchange of compliments had passed, the air resounded with the noise of musical instruments, such as drums, horns, and flutes. After some conversation, during which much politeness was observed in the behaviour of the king, the governor wished this ceremonial visit to be returned, &c.—The king was of the middle size, well-formed, and perfectly black, with regular features, and an open and pleasing countenance. His manner indicated understanding, and was adorned with gracefulness; and in all respects he exceeded the expectations of every person. His dress was plain; it consisted of a piece of silk wrapt loosely about him; a wreath of green silk ornamented his head; his sandals were neatly made, and curiously studded with gold. He was not distinguished by any gold ornaments, as his attendants were."*

The kingdoms along the coast are considerably different in respect of government. Among some tribes, as in Apollonia and the Slave Coast, it is absolute monarchy; in others, as in the Ahanta country, a kind of aristocracy; and in others, as among the Fantees, it consists of a variety of forms, according to some of which the power is lodged in the hands of the community at large, as in a democracy; and in others, as in Acra, it is a mixture of aristocracy and democracy. In this last mentioned country, the inhabitants of different states are known to unite occasionally for general safety, under the absolute command of individuals, as in a dictatorship; and, when the danger is past, to revert to their accustomed forms of government. The laws consequently differ considerably in the form of administration, according to the nature of the government; but, during the continuance of the slave trade, the most trifling offences was every where examined with the utmost strictness, and almost every punishment was commuted into slavery. The prevailing penalties are fines, or servitude, which are almost the same punishment, as every convict, if unable to pay his fine, becomes a slave. Even murder, though by law generally punishable with death, may be compensated by the payment of seven slaves, or their value; but if the person murdered should have been of any consequence or authority, the law of retaliation is enforced, and much bloodshed ensues. In the Fantee country the laws are more rigorous than in any other part of the coast. If any person be detected in the act of committing the most trifling theft, he forfeits his freedom; and if the article stolen should be valuable, his family becomes involved in his fate. If any one, either by accident or design, should kill a hog, a goat, even a hen, or any other animal which is the property of another, he loses his liberty, unless he can soften the injured party by presents. The law against witchcraft is peculiarly severe, and extends to all under the same roof with the offender, as they are supposed to possess some portion of the evil influence; but, since the abolition of the slave traffic, few convictions of this kind have taken place, and the rigour of the laws respecting trifling offences has begun to relax. Another oppressive law, peculiar to the Fantee country, deserves to be noticed, chiefly as demonstrating the baneful effects of the same odious trade in human beings. If a person become involved in debt, and was either unable or unwilling to pay, the creditor was at liberty to "panyar," that is, to seize and confine any person or persons belonging to the family, or the town, or even the country of the debtor; and these captives, if opportunity offered, were sold as slaves, without any delay or ceremony. During the time of the slave trade, this custom was often practised, under false pretexts of debts or offences, and many innocent persons forcibly seized, and instantly sold by private individuals, without any possibility of redress.

In the monarchical state of Apollonia, the right of succession devolves on the son of the king's sister. The reigning sovereign is the sole administrator of justice; and passes sentence without the advice of any of his subjects; but, if the accused be a person of rank, he generally receives a message, requiring him to prove his innocence by the ordeal. This consists in swallowing a portion of a certain bark, accounted poisonous, which, if rejected from the stomach, is a token of innocence, but if retained, (in which case it commonly proves fatal,) it is an evidence of guilt. In the more mixed governments, as in the Fantee country, the administration of justice and of public affairs resides principally in the pynins or elders, who are elected by the public voice, and sometimes succeed by hereditary right. They are the oracles of the laws, which they commit to memory with extraordinary correctness; and, in the trial of causes, they act at once as judges and jurors. They assemble their courts in the market-place, where both parties are attentively heard, witnesses regularly examined, and sentence duly pronounced. They have a share in all fines and forfeitures, and generally receive a present of rum when any cause of importance is brought before them. If the condemned party think himself aggrieved, he may appeal to the elders of another town or district, and sometimes to the governor of the neighbouring European fort. The natives are said to plead their causes with much ability, and to accompany their words with suitable and energetic gesture. In consequence of the strictness of the laws, crimes are extremely rare; but, during the prevalence of the slave trade, when false accusations and false witnesses abounded, condemnations occurred every day. But, though the natives rarely commit thefts against the property of their countrymen, every thing belonging to a white man is considered as a fair object of plunder. In cases of slander or evil speaking, a peculiar trial, called "brandeeing," is instituted between the parties. The injured person repairs

* Meredith's account of the Gold Coast.

to the market-place with a portion of spirits, and invites his accuser to make good his assertions, who is obliged to produce an equal quantity of liquor before he can obtain a hearing. The person found guilty is required to make a pecuniary compensation to the other; and the spirits, which in the case of wealthy individuals sometimes exceed a hundred gallons, go to the elders, and the friends of the person who is acquitted.

The religion of the natives of Guinea is not easily described. They have some notion of a Supreme Being; but their worship consists in a mass of strange and unmeaning superstitions, of which they do not attempt to give any account. They do not generally engage in any external worship; and though, on certain days, they abstain from their ordinary employments, they have no reason to assign, except that it has been the custom. In some places there is an annual sacrifice of a deer to the divinity. They seem to hold the moon in greater veneration than the sun, and welcome her appearance with great rejoicings. Their system of belief, however, is little else than a constant fear of some malignant influence, and a superstitious confidence in certain charms to avert the dreaded evil. Their object of worship, whatever it be, bears the undefinable name of Fetish, a word which some suppose to be derived from the Portuguese *fetischo*, witchcraft; but which is applied with great latitude to any thing sacred, prohibited, unlucky, or unaccountable, and is considered as equivalent to the "Obi" of the West Indies, perhaps also to the "taboo" of the South Sea islands. In Acra, the principal image, or deity, is a large mass of solid gold in the form of a human head. In the Fantee capital, Abrah, their chief object of adoration, is denominated Woorah, woorah! Agah, nannah! that is, Master, master! Father of all! But every town or village has its own favourite idol, and even in every house is some object emblematic of a divinity. The Fetish-men or women, who are considered as alone possessed of any knowledge, are not only the priests, but also the lawyers and physicians of the country. They are supposed to have communications with the demon or Fetish, and to be able to instruct their votaries in every case of actual or apprehended evil. Their good offices must be procured by presents, which are often of considerable value, and are appropriated to their own use. They are usually connected with persons in power, and are frequently useful in enforcing the authority of the laws. Where there is no monarch, and the government is lodged in the community, these persons assume great consequence, and render it hazardous for any one to withstand their influence, or to be guilty of any neglect towards the Fetish.

There are innumerable languages and dialects along the whole of the west coast of Africa; but the most prevalent in Guinea is the Fantee, which is understood from Apollonia to Acra, and to a considerable distance inland. It is soft and harmonious; but has never been reduced to writing. The following specimen gives the proper names of men and women, according to the day of the week on which they were born.

| Days of the week. | Men. | Women. |
|---|---|---|
| Sunday | Quashie | Aquishervah |
| Monday | Cudjoe | Adjuah |
| Tuesday | Quabino | Abinabah |
| Wednesday | Quacoe | Eccoah |
| Thursday | Quow | Abbah |
| Friday | Couffee | Effuah |
| Saturday | Quamina | Ambah |

The natives of the coast of Guinea are in general extremely similar in their physical qualities, and in their prevailing customs; but differ considerably in their dispositions and morals. The diversity in this respect is ascribed, with sufficient probability, to their intercourse with Europeans, and especially to the degree in which they engage in the slave trade; but seems also to arise partly from the form and character of the native governments. In most of the districts they are tall, well formed, with the usual negro features, thick lips, and flat noses. On the Grain Coast, especially in the western parts, they are mild, peaceable, honest, and industrious; but on the Ivory Coast they have become deceitful and cruel. In Apollonia, they are extremely courteous, hospitable, and brave; but generally reserved in their manners, a circumstance which has been attributed more to the despotic form of their government than their natural disposition. In the Ahantah country, they are friendly in their manners, and more free in conversation than the Apollonians, but less hospitable and courteous. The people of Chamah and Commenda are very turbulent and ferocious, addicted to frequent quarrels, and much inclined to maltreat Europeans. Those of Elmina have generally been found to be civil and peaceable; but some recent instances have occurred of their ferocity when roused by provocation. The Fantees are generally an indolent, ferocious, and faithless people; and their petty chiefs are extremely avaricious and deceitful, watching every opportunity to gratify their vicious passions. The natives of the Agonna country, especially around Winnebah, have long been noted for every species of licentiousness, living entirely by plunder, and displaying a degree of ferocity unparalleled in any other part of the coast. In Acra and Adampe, the inhabitants are remarkably indolent, addicted to drunkenness, and full of deceit; but those of Acra have been considerably improved by their intercourse with the Ashantees, a powerful people in the interior, already mentioned, and who manifest a greater attention to the rules of decency and morality than any other tribe yet discovered in the country.

"Notwithstanding some years acquaintance with the natives," (says Mr Meredith, referring principally to the Gold Coast,) "I find it no easy matter to lay down their true character; for they appear to us in a variety of forms, according to the nature of our intercourse with them, and to their employment. Those persons who are indifferent to exceed a further intimacy with Europeans, than an interchange of commodities will admit of, are to be viewed in the true light of peddling traders. When there is a prospect of a good bargain to be obtained, every species of low cunning and mercenary artifice is practised to acquire it. They accommodate themselves with much ingenuity and facility to our humours and fancies; every attitude, every expression, is carefully recommended by flexibility and supplication; yet they carefully avoid (showing) too great a desire of obtaining what would turn out profitable or advantageous to them; and, when they know that their wishes are not to be gratified as easily as was expected, disappointment is carefully concealed, and a seeming indifference is preserved in their behaviour."—"They may be justly pronounced as possessing all the chicanery inseparable from their calling, and are not readily outwitted. Those who gain a livelihood by fishing, are a laborious people; and our knowledge of them extends a little further than of the trader, because they are employed frequently by us as canoe-men and labourers. When thus employed, they perform their duty with cheerfulness; and, if encouraged, will go through a vast deal of labour; but they must be treated with exactness and punctuality. When they call for any customary allowance, or for payment, they do not like to be put off, and expect that their labour should meet with its instant reward. If they be not punctually attended to, they become neglectful, and inattentive to the interest of their employer. They are much addicted to that vice (theft), which prevails in almost every part of the world, and are very expert in the practice of it, particularly as to small articles which they can easily conceal. Men who follow an agricultural life, and who chiefly inhabit the inland parts, will be found more uniform in their conduct than the traders or fishermen. To consider them in a general view, and to make allowances for the failings attached to the uncivilized part of mankind, they may be considered a well-meaning set of men. They are divested of that low cunning and deceitful artifice, known and practised by those who gain a livelihood by a more intimate connection with Europeans. They possess no small share of honesty, sincerity, and benevolence; and are strangers to the corrupt and licentious conduct plainly to be seen among the inhabitants of the water side."—"The natives of the sea coast, from a more immediate connection with Europeans, we should suppose, are more inclined to industry than those inland; but it will be found that real industry prevails more uniformly inland, and vice is less encouraged. Every person on the coast appears very diligent in acquiring the profits of his occupation; but profligacy, drunkenness, and debauchery, are practised to a pernicious extent."

Young persons of both sexes generally go naked till the age of puberty, (which takes place in males at the age of twelve, and in females at ten,) except a girdle about the loins, with a small slip of cloth affixed to it for the sake of decency. The dress of both sexes is nearly alike, and consists in a piece of cloth, about four yards long and two broad, wrapped loosely around them; but, when engaged in any occupation, part of it is folded about the loins, and the remainder hanging down, covers the lower part of the body. The more wealthy, especially when they travel, are provided with hats, and sometimes with sandals. The women generally have their breasts uncovered; and their garment is fastened round their middle by a girdle or zone called tombah, which is supported behind by folds of cloth, forming a protuberance, in proportion to the age and rank of the wearer. Women of quality have likewise a number of silver keys suspended by a ring to the front of the girdle. The women also wear bracelets and necklaces of gold and beads, and frequently oval brass rings on their ankles. Both sexes are remarkably attentive to the decoration of their heads, and cut the hair with great nicety and taste. Some of the men allow the hair to grow on the chin, and occasionally wear whiskers and mustaches. The old men shave the whole of the head, leaving only one or two locks behind, to which they commonly keep a piece of gold suspended. The Fantees are distinguished from the other natives by small scarifications on the upper part of the cheek bones, and on the back of the neck. Both the men and women among this tribe are remarkably cleanly, and generally wash their whole bodies twice a day. The Fetish men, especially in Acra, are habited in white, a colour which is held in great veneration in all parts of the country, as emblematic of purity and perfection. The principal article of food in the Fantee country is bread, which is unleavened, and made of maize or Indian corn. In all their dishes, pepper is a necessary ingredient. Their chief mess consists of fish or poultry made into soup, with fresh palm oil, pepper, salt, and eschallots; and with this high-seasoned dish they eat bread, or yams and plantains made into a pudding. The men and women generally eat separately; and seat themselves in small parties round a bowl of soup, into which they alternately dip some bread or pudding. They do not drink during their meals; but, after finishing the repast, sometimes indulge freely in the use of palm wine or spirits. The houses are commonly made of bamboo, and plastered with a strong loamy clay, with which also the floors are laid. The towns and villages are generally surrounded by a strong fence of bamboo cane, as a protection against wild beasts.

Arts and manufactures are in a very low state among the natives. They make canoes, baskets, mats, bills, hoes, fishing nets, hooks, lines, &c. and some of them work as masons and carpenters. The women, who are literally the slaves of the men, perform most of the laborious offices, such as grinding corn, procuring food and water, every thing in short except fishing and planting. In the Ahantah country, particularly, the people are much inclined to agriculture, which is in a very rude and defective state; but in many of the maritime villages, besides acting as fishermen, they used to procure their subsistence, in a great measure, by hiring themselves as canoe men to the slave ships bound to the leeward coast. Their canoes are of various sizes, requiring fron 3 to 21 oars, or rather paddles; and some of the larger have a platform in the bottom, with an awning erected over the fore part of the deck, for the shelter of the passengers. These canoes are made of the trunks of the silk cotton tree, shaped and hollowed by a very simple iron instrument like a large chisel, answering either as axe or adze, according to the form of its handle. The wood of these trees, especially when green, is soft, and easily worked; when dry, almost as light as cork; and sometimes large enough to make a canoe paddled by twenty men, and carrying four puncheons of liquor. Those who are acquainted with the management of these canoes, conduct them through the high surf on the coast with great dexterity. On coming ashore, they watch the sea when on the point of breaking, and betake themselves to steering, by keeping the flat part of the paddle parallel to the canoe, and giving it a quick motion, moving it nearly at right angles with the canoe; and, when it is on the summit of the wave which is ready to break, this quick motion is discontinued, the paddle kept firmly in a parallel position, and the canoe, steadily balanced and directed in a straight course, flies on shore with amazing velocity.

In travelling by land, Europeans make use of a large cotton hammock, which is slung from a bamboo pole about nine feet long, and covered by a cloth in such a manner, that the person carried in it may either sit up or lie down. For a distance of 25 or 30 miles, this conveyance requires six or eight bearers, two of whom carry it by turns; and, if well supplied with rum, will travel at the rate of five miles an hour. When a party of Europeans travelling in this way arrive at a town or village, they are met by the men in their war dresses, jumping and firing their muskets heavily loaded with powder almost in the faces of the visitors; a ceremony which is not without hazard, from the occasional bursting of the pieces, and which it is necessary nevertheless to requite by a present of liquor and gunpowder.

The recreations of the younger part of the people consist chiefly in dancing and singing; and they are in most places fond of music. Their instruments consist of drums of various forms and sizes; horns made of the tusks of young elephants, and sounding like a bugle; and flutes made of a large reed, about four feet in length, open at both ends, and producing a soft and plaintive note.

Polygamy prevails in every part of the coast, and every man may have as many wives as he can maintain; but the first wife has the sole management of the domestic affairs within the house, besides acting as a watch over the fidelity of the rest. Mothers have the entire disposal of their daughters in marriage, and their consent must be procured by presents. After the payment of a certain sum, which is regulated by custom, the young woman is dressed according to her rank with rich clothes, valuable beads and ornaments of gold; and conducted by the female relatives to the house of her husband, where she is formally received by his relations and friends. On the following day she receives visits, and must continue to appear in her wedding dress for a week.

The Fantees, and most of the other tribes, bury their dead within their houses; and they are very reluctant to leave the spot where their relatives are interred. If any one die in a state of insolvency, his body does not receive the rites of burial till his debts are discharged; and the corpses of persons guilty of suicide are burned, unless a considerable sum be paid to the elders for permission to commit them to the earth. In Apollonia funerals are in general solemnized by a mixture of condoling and carousing; and every friend of the deceased contributes something expressive of regard for his memory. Cloth, spirits, and gunpowder, are lavished on these occasions; and, till the body be deposited in the ground, there is a continual succession of dances, songs, volleys of guns, and lamentable exclamations. These customary revellings, however, are performed by persons hired for the purpose, and, after the interment, the habitation of the deceased exhibits sufficient tokens of real affliction. The dead body is exposed for several days to public view, decorated with ornaments and valuable articles; and, when buried, gold, rich cloths, and other things of value, are put into the grave. At the funeral of any person of eminence, some of his slaves, generally the old and infirm, are offered in sacrifice. "In the year 1800," says Mr Meredith, "when a king of Apollonia died, one or two human beings were sacrificed every Saturday, until the grand ceremony took place, which did not happen till six months after his decease. On that occasion, upwards of fifty persons were sacrificed, and two of his youngest wives were put into the grave. The lid of the coffin was covered with human blood, and gold dust sprinkled upon it, and much gold and rich clothes were deposited in the grave.

The diseases incident to the natives of Guinea are, leprosy, which is greatly dreaded, and generally considered incurable; though, in its milder form, and when early attended to, it is sometimes removed. It is in some places supposed to be contagious, and the sufferers are excluded from society. The natives employ chiefly vesicating and excoriating substances in the milder cases. Yaws, appearing in white crusted spots on the skin, not a common but a very infectious disease, and though repressed for a time, is never radically cured. Elephantiasis, an enormous hard swelling of the legs, which is also incurable. Smallpox, which causes great ravages wherever it appears, and to which the natives in general apply no remedy; but in some parts of the coast, inoculation is practised, and the puncture usually made at the wrist. Guinea-worm, peculiar to the sea coast, and supposed to be occasioned by drinking water full of animalculæ, as it is seldom experienced in places provided with good water. It is considered by others as rather produced by absorption through the pores of the skin, as persons are known to receive it by going to the pools for water, and by infection from others. The legs are the most common seat of the disease, though occasionally it has appeared in other parts of the body. The worm itself appears no bigger than a large woollen thread of a whitish colour, and rather flattened in its form; but some have been extracted above thirteen feet in length. Much pain is felt before it protrudes through the skin, and an inflammatory tumour is produced, through which the creature makes its appearance. The natives then apply a slip of wood to the sore; and when the worm comes in contact with it, they carefully turn it round, so as to wind the worm upon it, leaving it suspended in this situation, that the weight may draw it out more speedily. If the animal is broken, the part remaining in the flesh generally recedes, and may not reappear for months; and, unless properly managed, much pain and dangerous sores are often the consequence.—Enlarged scrotum, supposed to be caused by an immoderate use of palm wine.—Dysentery, which the natives treat with great success, by administering drastic purgatives, followed by stimulating astringent clysters, making use of suppositories, keeping the patient warm, and frequently imbrocating the loins and belly with a composition of pepper.—Ophthalmia, which, though not common, is troublesome at some seasons, but chiefly occasioned by excesses in living; and is treated by the natives only with topical remedies, inserting lime juice into the eye, and drawing blood from the temples.—Fevers, which are most prevalent after the periodical rains; and excepting a few external applications, such as ablutions with warm water, and rubbing the body with certain herbs, are left by the natives to the powers of nature.—Rheumatism, a common disorder, successfully removed by tepid applications and warm clothing.—Internal inflammations, pleurisies, and pulmonary diseases, are very general during the rainy season. The medical practitioners of the country are principally females, whose skill is transmitted from one generation to another, and who perform the operations of scarification and cupping with great dexterity, as well as discover considerable botanical knowledge in the selection of herbs and plants. The male physicians are generally ranked among the Fetish men, and are much greater empyrics than the women, imposing upon the credulity, or working upon the imaginations of their patients, by pretending to expel the evil influence, or extract the supposed cause of their sufferings.

The insalubrity of the climate to Europeans is understood to have been greatly exaggerated, and to be chiefly owing to their own excesses and neglect of proper precautions. The climate of Guinea is greatly superior to that of Guiana, which lies under the same parallel; and any part of the coast, if cleared and improved, would not be less healthful, it has been affirmed, than Barbadoes, the most salubrious of the West India Islands. Strangers arriving in the country are directed, by Mr Meredith, to avoid, as much as possible, the meridian sun, by keeping within doors from eight o'clock in the morning to three in the afternoon, but to take regular exercise before and after these hours; to travel during the night with heavy clothing to protect the body from the dews, or, if necessitated to go out in the day-time, to use an umbrella, and place a handkerchief or two between the head and the hat, to rub the body well with coarse cloths, and put on warm clothing after getting wet, and, if much exposed to rain, to bathe in salt water, but never to apply spirits to the surface of the body; to use cold bathing frequently, to practice early rising, to take animal food only once a day, and to wear flannel next the body; to counteract the damp air of the wet season by heavy clothing, warm apartments, and even occasional fumigation of the rooms with vinegar, sulphur, or tobacco; and, in the dry months of December and January, to be more attentive to exercise in the open air, temperance in living, and the use of cooling laxatives. Persons just arrived in the country are particularly warned to be sparing in diet, refraining from salt meat, and freely using vegetables and acid fruits; to drink also sparingly, using chiefly rum and water, wine and water, lemonade, &c.; to take the cold bath every day, and avoid the heat of the sun as much as possible; and to keep the body gently open by means of salts, cream of tartar, or similar cooling purgatives, of which a dose should be taken every week for two months, till the constitution becomes habituated to the climate.

Europeans have hitherto made no attempt to extend their commerce to the interior of the country; but, with the exception of slaves, (which must soon cease, it is hoped, to be enumerated among articles of traffic,) have confined themselves to a very limited coast-trade. The articles of which it consists are chiefly pepper, palm oil, cowries, ivory, gold; in exchange for which, they import lead, iron, firearms, gunpowder, tobacco, spirits, tobacco pipes, vessels of brass, woollens and cottons of British manufacture, and especially East India cotton goods, which are most esteemed in the country. All the ivory is procured from the interior, and, in all the inland countries, gold is found in considerable quantities. The native traders penetrate to a great distance into the interior in quest of these articles, or rather they pass through numerous hands from nation to nation, till they reach the commercial establishments on the coast; but all the people concerned in this inland traffic are extremely mysterious in their operations, and very reluctant to communicate the slightest intelligence on the subject. It is only gold-dust that they sell to the Europeans, as they generally convert into ornaments the solid pieces, and even hold them sacred, if tolerably large. The gold of this country, whether in grains or in dust, is extremely pale, though very pure; and greatly resembles the filings of yellow copper, with which it is sometimes fraudulently mixed. This alloy is easily discovered by means of aqua fortis; but it is sometimes also imperfectly cleaned from the sand, which is of a quartzose nature, and which requires a keen eye, a glass, or even the crucible, to detect its presence. The native brokers or gold-takers are extremely skilful in this commerce, and know with the utmost precision the value of what they sell; but they are often equally well versed in the arts of knavery, requiring to be trusted with great caution, and only upon good recommendation. In Apollonia, it is said, the trader is more secure, either from exactions or impositions, and his person is considered as sacred. The gold trade is understood to have diminished considerably of late, in consequence of the more powerful princes having attempted to secure a monopoly for themselves, by compelling the weaker to renounce the working of their mines. Cowries and gold form the current medium of exchange, especially the former, as being easily reduced to the smallest sums. Forty cowries make a string; fifty strings a head, which is equal to one ackey of gold; and 16 ackeys make an ounce, which is valued at four pounds sterling.* The price of gold never fluctuates; and it is commonly estimated to yield in Europe a profit of 25 per cent. Much attention has recently been directed to the improvement and civilization of this and other tracts on the western coast of Africa; and a more interesting topic could scarcely be presented to enlightened humanity, than an enquiry into the most effectual means of promoting the benevolent object. It has been suggested, in general, to extend our trade inland, by forming alliances with the princes, and placing residents in the principal towns; thus reaching the resources of the country, securing the confidence of the natives, and enlarging the demand for European manufactures;—to encourage the progress of cultivation, by protecting planters from Europe, and directing the industry of the natives to the production of new articles of export;—to annihilate absolutely every vestige of the slave trade, to establish schools for the instruction of the people, and to exercise, in the vicinity of our settlements, as much controuling power of government as possible, for introducing salutary regulations, and enforcing orderly obedience.† "There exists no country in the world," says the French mineralogist De Montfort, "so susceptible of general cultivation. We know that certain districts of Africa are fertile in corn, and grain of every kind grows there, intermixed with sugar-canes lately introduced, and which protect the grain from hail. The plants of India, Europe, America, Australasia, or the fifth portion of the globe, will flourish there in perpetual spring, and the animals of all climates can be easily naturalized. The negroes, whose respect for the whites is extreme, notwithstanding what they have suffered from them, will cheerfully give up their lands to be cultivated by us." *Philosophical Magazine*, vol. xlvi. p. 302. See Meredith's *Account of the Gold Coast*; Smith's *Voyage to Guinea*; Peuchet's *Dict. De la Geog.*; and Playfair's *Geography*. (*q*)

GUITAR, *Guitarra* Spanish, *Chitarra* Italian, from *Cithara*, is the name of a musical instrument, commonly strung with wire; but in Spain, the guitars are always strung with catgut or bowel strings, which gives them a much finer tone. The Guitar seems to have been introduced into Spain by the Moors, and has at particular times been more or less in use in almost every part of Europe.

GULF STREAM, is the name given to a constant current in the ocean, produced by the trade winds, which are constantly blowing from east to west. This current, coming from the Pacific and Indian Oceans, passes round the Cape of Good Hope, and, after going along the coast of Africa, it crosses to America towards the equator. It is there divided, and reflected southwards to the Brazils, and running along the shores of Guiana and Terra Firma, it passes through the Caribbean Sea, and coasts along the Gulf of Mexico. Issuing from the Gulf between Cape Florida and the island of Cuba, it traverses the coasts of East Florida, the United States, New Brunswick, and Nova Scotia, and advances eastward to the banks of Newfoundland, where it turns off to the south-east, and runs through the Western Islands, from which it goes to the coast of Africa, and in a southerly direction along that coast, till it supplies the place of the waters carried away to the west by the trade winds. "It is perhaps on account of these currents," says Dr Thomas Young, "that the Red Sea is found to be about 25 feet higher than the Mediterranean.‡ Their direction may possibly have been somewhat changed in the course of many ages, and with it the level of the Mediterranean also, since the floor of the cathedral at Ravenna is now several feet lower with respect to the sea than it is supposed to have been formerly; and some steps have been found in the rock of Malta, apparently intended for ascending it, which are at present under water." M. Humboldt remarks, "that the Gulf Stream is occasioned by the current of rotation, (trade winds,) which strikes against the coasts of Veragua and Honduras, and, ascending towards the Gulf of Mexico, between Cape Caloche and Cape St Antoine, issues through the canal of Bahama. It is owing to this motion, that the vegetable productions of the Antilles are carried to Norway, Ireland, and the Canaries."

The general breadth of the Gulf Stream is about 50 or 60 miles. Sir Charles Blagden, in a voyage to America in the year 1774, found that the water of the Gulf Stream was from 6° to 11° warmer than the waters of the sea

* It is said that a labouring man, during the plentiful season from September to May, can subsist abundantly on two strings, or two-pence farthing a day; and that the usual pay of a labourer is from two to three ackies per month, *i. e.* from 10s. to 15s. currency.

† For the best views of this interesting subject, the readers may be referred to the *Reports of the African Institution*; and the accounts of these publications in the *Edinburgh Review*.

‡ The observations of the French engineers make it 6 toises or 38 feet.

through which it ran. The heat at its commencement in the Gulf of Florida was about 82°, and it lost 2° for every 3° of latitude in going northwards. It continued sensible off Nantucket.

The Gulf Stream may be easily distinguished from the other waters of the ocean, by the gulf-weed with which it is every where interspersed, and by its not sparkling in the night. In high latitudes it is always covered with a thick fog. Its breadth is diminished by north-east and east winds, which also increase the rapidity of its motion, and drive it nearer the coast. A contrary effect is produced by north-west and west winds.

The Gulf Stream passes at the distance of about 75 miles from the coast of the southern states of America. This distance, however, augments as it advances northwards. Its common velocity is about three miles an hour, and it takes about 20 days to run from Cape Florida to Newfoundland.

See Franklin's *Maritime Observations*, in the Transactions of the American Philosophical Society, vol. ii. p. 314. This paper contains a chart of the Gulf Stream, principally from the observations of Captain Folger. Blagden *On the Heat of the Water in the Gulf Stream*, in the Phil. Trans. 1781, page 334. Pownall's *Hydraulic and Nautical Observations*, 4to, London, 1787. This last work also contains a chart of the Gulf Stream. Rennel, *Phil. Trans.* 1793, vol. lxxxiii. p. 8. Humboldt's *Political Essay on the Kingdom of New Spain*, vol. i. p. 53; and Humboldt's *Voyage to the Tropics*, vol. ii. chap. 1. Young's *Natural Philosophy*, vol. i. p. 587; and Morse's *Geography*. See also Physical *Geography*.

GUMS. See Chemistry, vol. vi. p. 748, 763, 769.

Gum *Amber*. See Amber, and Chemistry, p. 766.

Gum *Ammoniac*. See Chemistry, page 769. This gum should be chosen full of drops or tears, dry, brittle, easily softened by the fire, reducible to a white powder, and of a sharp taste and smell. When thrown on live coals, the drops should burn away in a flame. In 1804, the quantity imported by the East India Company was 81 cwt. and the price per cwt. 3*l.* 11*s.* 1*d.* In 1805, the quantity was 333 cwt. and the price 1*l.* 12*s.* 2*d.* In 1806, 81 cwt. were imported at the price of 1*l.* 8*s.* 2*d.* And in 1807, 59 cwt. were imported at the price of 1*l.* 15*s.*

Gum *Anime*. See Chemistry, p. 764. This gum should be chosen in large pieces, clear and transparent. When laid on a red hot iron it melts, flames, and burns quickly away, with a fragrant smell, leaving a few light coloured ashes. Small dark coloured and opaque pieces should be rejected. The quantity imported by the East India Company from 1804 to 1808, was

| | Cwt. | Average Price per Cwt. |
|---|---|---|
| 1804 | 166 | *l* 6 8 11 |
| 1805 | 452 | 7 5 8 |
| 1806 | 268 | 4 19 2 |
| 1807 | 936 | 4 6 7 |
| 1808 | 1099 | 1 15 3 |

This gum is often sold for gum copal.

Gum *Arabic*. See Chemistry, Sect. v. p. 749. In choosing this gum, great care should be taken that it is not mixed with another kind of gum, generally in larger pieces, which, instead of dissolving completely in water, only swells in it. The following quantities were imported by the East India Company from 1804 to 1808:

| | Cwt. | Average Price per Cwt. |
|---|---|---|
| 1804 | 1767 | *l.* 4 12 1 |
| 1805 | 3931 | 4 1 11 |
| 1806 | 1534 | 2 17 8 |
| 1807 | 6565 | 2 6 10 |
| 1808 | 1382 | 2 3 3 |

Gum *Assafœtida*. See Chemistry, p. 770. The use of this gum was introduced by the Arabians about 1000 years ago. It should be chosen clear, fresh, strong-scented, and of a pale reddish colour. When broken, it should have a resemblance to marble; and by exposure to the air, it should turn of a violet red colour. That which is soft, black, and foul, is adulterated. The following quantities were imported by the East India Company from 1804 to 1808:

| | Cwt. | Average Price per Cwt. |
|---|---|---|
| 1804 | 141 | *l.* 3 15 2 |
| 1805 | 157 | 5 11 2 |
| 1806 | 82 | 3 12 8 |
| 1807 | 40 | 3 12 6 |
| 1808 | 72 | 3 17 9 |

Gum *Bdellium*, is a gum which is brought from Persia and the East Indies. It has a reddish brown colour externally, but is like glue internally. The loose drops in which it is brought home are sometimes as large as hazel nuts, but often less than a pea. They are commonly of an irregular shape. It is moderately heavy and hard, and grows tough in the mouth. It readily takes fire, burns with a bright white flame, and crackles, throwing out small fragments. It dissolves completely in vinegar.

Gum from *Botany Bay*. See Chemistry, p. 765.

Gum *Caoutchouc*. See Caoutchouc, and Chemistry, Sect. xxvi. p. 768.

Gum *Cherry tree*. See Gum *Prunus Avium*.

Gum *Copal*. See Chemistry, p. 765.

Gum *Dragon's Blood*. See Gum *Sanguis Draconis*.

Gum *Dragon*. See Gum *Tragacanth*.

Gum *Elemi*. See Chemistry, p. 764. This gum is obtained from the East Indies, as well as from Canada and Spanish America. The East India elemi is semi-transparent, of a pale yellow colour inclining to green, and is brought in cakes of 2 or 3 lbs. each, wrapped up in flag leaves. That which is soft, with a strong smell and a bitterish taste, is the best. The hard and dark coloured is never good.

Gum *Euphorbium*, is the concrete resinous juice of a prickly shrub, which grows in Malabar and various parts of India. The irregularly shaped tears of which it consists, sometimes enclose thorns, twigs, &c. The best kind is dry, clear, and of a bright light yellow colour; and is so sharp to the taste, that a small piece held a short time in the mouth will inflame it.

Gum called *Frankincense*. See Gum *Olibanum*.

Gum *Galbanum*. See Chemistry, p. 769, and Galbanum.

Gum *Gamboge*, or *Gumgutt*. See Chemistry, page 770, and Gamboge.

Gum *Guiacum*. See Chemistry, Sect. xxiv. p. 766.

Gum *Juniper*, the same as Gum *Olibanum*, which see.

Gum *Labdanum*. See Chemistry, p. 765, and Labdanum.

Gum *Lac*. See Chemistry, p. 765, and Lac.

Gum *Manna*. See Chemistry, p. 748.

Gum *Mastich.* See Chemistry, page 764, and Mastich.

Gum *Myrrh.* See Chemistry, p. 770, and Myrrh.

Gum *Olibanum*, or *Frankincense.* See Chemistry, p. 770, and Olibanum.

Gum *Opium.* See Chemistry, Sect. xviii. p. 758, and Opium.

Gum *Opponax.* See Chemistry, p. 770, and Opoponax.

Gum *Prunus Avium.* See Chemistry, p. 750.

Gum *Sagapenum.* See Sagapenum.

Gum *Sandarach.* See Chemistry, p. 764.

Gum *Sanguis Draconis.* See Chemistry, page 768. Dragon's blood in drops is preferable to that which is obtained in cakes, being more pure and compact. Genuine dragon's blood readily melts and flames, but is not soluble in water. The following quantities were imported by the East India Company:

| | Cwt. | Average Price per Cwt. |
|---|---|---|
| 1804 | 53 | *l.* 11 0 0 |
| 1805 | 103 | 3 13 0 |
| 1806 | 26 | 9 19 11 |
| 1808 | 19 | 11 6 9 |

Gum *Scammony.* See Chemistry, page 770, and Scammony.

Gum *Senegal.* See Chemistry, p. 748. This gum exudes from a prickly shrub, of the same genus with that from which gum arabic is obtained. It is chiefly used by calico printers, and in other trades where gums are employed. It dries more slowly than gum arabic.

Gum *Tacamahac.* See Chemistry, p. 764.

Gum *Thus*, or *Frankincense.* See Gum *Olibanum*, and Olibanum.

Gum *Tragacanth*, or Gum *Dragon.* See Chemistry, p. 749.

There are many other gums than those which have been mentioned, but they are not of much importance as articles of commerce. Dr Francis Buchanan informs us, that gums are collected between Seringapatam and Bangalore from the following trees:

Andersonia panshmoum. (Dr Roxburgh's MSS.)
Melia azadirachta.
Chirongia glabra. (Dr Buchanan's MSS.)
Mangifera Indica.
Cassia auriculata.
Ægle marmelos.
Shorea jala. (Dr Buchanan's MSS.)
Chloroxylon dupada. (Do.)
Bomboe gossypinum.

See Buchanan's *Journey from Madras*, &c. vol. i. p. 169. See also Milburn's *Oriental Commerce*, passim.

GUN Flints, are small pieces of flint cut into regular shapes, for the purpose of setting fire, by their collision against a piece of steel, to the priming of fowling pieces, muskets, &c.

The first stones used for this purpose were a kind of compact pyrites, or marcasite, and they were long known by that name. The species of stone used in the greater part of Europe, is called by Wallerius *silex igniarius*, and by Linnæus *silex cretaceus.* In Germany it was called *flins* or *vlins*; in the Swedish and Danish *flinta*; and in English *flint.* This name is said to be of great antiquity, as the Wends had a Pagan deity which they placed on a stone called *flynstein.* From the word flint arose the names of *flintgewehr*, *flint*, or *flinte*, which the Germans have given to guns fired by that stone. Stones seem to have been first used about the middle of the 16th century.

The manufacture of gun flints has been long kept a profound secret; and we are indebted to Dolomieu for the first exposition of the method employed in France.

The masses of flint which are best fitted for this purpose, are of a convex surface, approaching to globular. The knobbed and branched flints are commonly full of imperfections. The best flint nodules are generally between 2 and 20 pounds weight. They should be unctuous, or rather shining internally, with a grain so fine as to be imperceptible to the eye. The colour should be uniform in the same nodule, and may vary from honey yellow to a blackish brown. The fracture should be smooth and equal, and the fragments slightly conchoidal; and the transparency should be such as to allow letters to be distinguished through a thickness of one-fourth of a line when laid close to the paper. When flints do not possess these properties, either naturally, or after a long exposure to the air, they are rejected by the workmen.

Four tools are necessary in the manufacture of gun flints. 1. An iron hammer with a square head, a handle seven or eight inches long, and not exceeding two pounds in weight. This instrument is shewn in Fig. 3. Plate CCLXXXIV. 2. A hammer of well-hardened steel, with two points, a handle seven inches long, and from 10 to 16 ounces in weight. The handle must pass through in such a manner that the two points may be nearer the hand of the workman than the centre of gravity of the mass. This hammer is represented in Fig. 4. 3. A disk hammer, or roller, like a solid wheel, or the section of a cylinder, two inches and four lines in diameter, and not exceeding 12 ounces in weight. It is made of steel, not hardened, and has a handle six inches long, which passes through a square hole in the centre. It is shewn in Fig. 5. 4. A chisel, tapering and bevelled at both ends. It should be made of steel, not hardened, and six, seven, or eight inches long, and two inches wide. This chisel is represented in Fig. 6. This is set on a wooden block, which is also used as a bench for the workman. A file is necessary for restoring the edge of the chisel. With these tools the flints are formed in the following manner, which we have abridged from Dolomieu's Memoir.

1. *To break the block.* The workman seated on the ground, places the nodule of flint on his left thigh, and applies slight strokes with the square hammer, to divide it into smaller pieces of about a pound and a half each, with broad surfaces, and almost even fracture.

2. *To cleave or chip the flint.* The workman holds the piece of flint in his left hand, not supported, and strikes with the pointed hammer, No. 2. on the edges of the great planes produced by the first breaking, by which means the white coating of the flint is removed in the form of small scales, and the mass of the flint itself laid bare in the manner represented, Fig. 7. After which he continues to chip off similar scaly portions from the pure mass of the flint. These scaly portions are nearly one inch and a half wide, two inches and a half long; and their thickness in the middle is of about two lines. They are slightly convex below, and consequently leave in the part of the flint from which they were separated, a space slightly concave, longitudinally bordered by two rather projecting straight lines, or ridges, Fig. 8. These ridges, produced by the separation of the first scales, must naturally constitute nearly the middle of the subsequent piece; and such scales alone as have their ridges thus placed in the middle are fit to be made into gun flints. In this manner the workman continues to split or chip the mass of flint in various directions, until the defects usually found in the interior render it impossible to make the fracture required, or until the piece is

reduced too much to receive the small blows by which the flint is divided.

3. *To shape the gun flint.* Five different parts may be distinguished in a gun flint. 1*st.* The sloping facet, or bevel part, which is impelled against the hammer of the lock of the gun. Its width should be from two to three-twelfths of an inch; if it were broader, it would be too liable to break; and if more obtuse, the scintillation would be less brisk. 2*dly*, The sides or lateral ridges, which are always rather irregular. 3*dly*, The back, or the part opposite the tapering edge: this is the thickest part of the flint. 4*thly*, The under surface, which is uninterrupted and rather convex. And, 5*thly*, The upper facet, or small square facet between the tapering edge and the back, which receives the upper claw of the cock; it is slightly concave. In order to fashion the flint, those scales are selected that have at least one of the above-mentioned longitudinal ridges: The workman fixes on one of the two tapering borders to form the striking edge; after which, the two sides of the stone that are to form the lateral edges, as well as the part which is to form the back, are successively placed on the edge of the chisel, in such a manner, that the convex surface of the flint which rests on the fore-finger of his left hand is turned towards that tool. He then with the roulette applies some slight strokes to the flint, just opposite the edge of the chisel underneath; by which means the flint breaks exactly along the edge of the chisel.

4. *To trim the flint.* The last operation is to *trim*, or give the flint a smooth and equal edge; this is done by turning the stone, and placing the edge of its tapering end on the chisel, in which situation it is completed by five or six slight strokes with the roulette. See Plate CCLXXXIV. Fig. 9.

The whole operation of making a gun flint is performed in less than one minute. A good workman is able to manufacture a thousand good chips or scales a day, (if the flint nodules be of a good quality;) and in the same manner he can fashion 500 gun flints in a day; so that, in the space of three days, he is able to cleave and finish a thousand gun flints without farther assistance.

In this manner, five or six blows with the hammer are sufficient to produce a perfection of figure which would require more than an hour's labour, if the faces were formed by grinding them against harder substances; and less than a farthing will pay for a gun flint from the hand of the workman, though fifty times that sum would be insufficient to purchase it, if it were formed in any other way.

When the gun flints are completed, they are sorted into two classes, fine and common flints, and according to their application into flints for pistols, fowling-pieces, and muskets. A good gun flint will give 50 strokes without being unfit for service. They are sold in France at from four pence halfpenny to seven pence per hundred. They cost twice as much in Italy, and, in 1745, when they were exported from the department of the Loire and Cher to Lyons, Strasburg, and St Quintin, they cost 12 francs per thousand, or one shilling per hundred.

The manufacture of gun flints in France, employed above 800 of the inhabitants in the communes of Noyers, Couffy, and Meunes, in the department of the Loire and Cher. The mine, which is four leagues square, is thirty or forty feet deep, and thirty million of flints manufactured here were stored up in 1794. They are also made in the communes of Lye, in the department of the Indre, of Maysse and St Vincent, in the department of Ardeche, and at Cerilly in the department of the Yonne. Dolomieu received the information contained in the preceding article from Stephen Buffet, who emigrated from the commune of Meunes to the banks of the Seine, where he carried on his profession for above 30 years.

Gun flints are made also in the territory of Vicenza, and in one of the cantons of Sicily. They were manufactured in great quantities at Stevensklint in Zealand. They are also manufactured at Purfleet in Kent, and in various other parts of England, in a very superior stile.

See Dolomieu's Memoir in the *Memoires de l' Institut*. vol. iii. p. 148; in the *Journal des Mines*, No. xxxiii. p. 693; and in Nicholson's *Journal*, vol. i. 8vo. p. 88. In the *Journal des Mines*, No xxxiii. p. 713, and 719, will also be found a Memoir by M. Solivet, and observations by M. Tonellier, on the manufacture of gun flints in the commune of Cerilly. See also the *Hanoverian Magazine* for 1772; and Beckmann's *History of Inventions*, vol. iv. p. 609, &c.

GUN-Making is the art of manufacturing small arms, for the purposes of war and the chace. The name harquebuss, which was first given to small arms, is said to have been derived from the Italian word *arcobousa*, or bow with a hole, and the instrument was successively designated harquebuss, hackbut, hand-gun, match-lock, musket, snaplance, petrinal, firelock, carabine, and fowling-piece; hence the workmen acquired the appellation from the French, harquebussiers; and the British, gun-smiths and gun-makers.

The first application of gunpowder to small arms, appears to have been made by the Germans soon after the invention of cannon; for in 1471 we find that Edward the IV. brought over into England 300 Flemings, armed with hackbuts or harquebusses. The Spaniards are said to have, so early as the reign of Philip the II., adopted them in the army; and that monarch caused them to be made of a large calibre, and so heavy, that a forked rest was requisite to level them in taking aim. They were used at the siege of Rhige, and by the Emperor and Pope Leo, in 1521. The French had availed themselves of this arm, in 1667, to the extent of four harquebusses in each company of their army. England appears to have been earlier apprized of their superiority over the weapons then in use. Harquebuss soldiers formed a part of their forces in 1540; and Peter Van Collins is mentioned by Stowe as the first gun-smith, in 1543. By an act of Henry the VIII. the length of the hand, gun stock, and barrel, is directed not to exceed one yard; and that of the hackbut three quarters of a yard. By a statute of Elizabeth, they are ordered to be made all of one size and calibre, from which they acquired the name of culivers, a light kind of match-lock, fired without a rest; and their price was fixed at 13 shillings and sixpence, with flask, touch-box, laces and mould. In James the First's reign, the price was fixed at 14 shillings and ten pence. Charles the Second directs the musket barrel not to be under three feet in length, and to receive a ball of twelve in the pound; and in 1638, he grants a charter to the gun-smiths of London, by the name of master wardens and society of gun-makers; at which period they made wheel and snap-lance locks. The Scotch used the harquebuss or match-lock soon after its invention, from their intimate correspondence with France and Flanders; yet we have no certain information of their having any artists in that profession sooner than 1640, when they became incorporated with the hammermen of Edinburgh, as a pendicle of the lock-smith art. The city guard were armed with muskets or harquebusses in 1682, the expence of purchasing and maintaining of which was directed to be defrayed from the money exacted from those who entered burgess. After the union of the two kingdoms, the manufacture of small arms, (if ever carried on to any extent,) seems to have been confined to a few individuals. From the records of the hammermen, it appears that in 1715 there were only two, viz. Murdoch Grant, and John Simpson; and in 1741 there was only one in the profession. Since that period, however, greater encouragement has been given to that art in Edinburgh, there being at the present time (1816) six master gun-makers, who employ about thirty workmen; and there is one in a few of the principal towns in Scotland. This business has been carried on to a very considerable extent in England, by private individuals; and government, within these few years, has established extensive manufactories at Lewisham, and in the Tower of London, employing about 500 workmen, who complete at the rate of 5000 stand of muskets every week: Expert workmen have been paid seven guineas and upwards for their week's labour. The London gun-makers, who are employed in the making of fowling-pieces, rifles, and pistols, amount to about forty-three, and they have not less than 300 people in their service. Birmingham is the place where all kinds of fire-arms are manufactured to the greatest extent; although it is to be regretted that the effect of competition has introduced a superficial style of working, which is greatly detrimental to the character of the article, and to its extension as a branch of commercial export.

The manufacture of a gun is performed by the following workmen, viz. barrel forger, borer and filer, lock forger and filer, furniture filer, ribber and breecher, rough stocker, screwer together, polisher, and engraver, in all ten different persons, few of whom can execute any other branch of the art but one. Most of the principal towns in England have one or two master gun-makers, but none of them carry on the business in all its different branches, except London, Birmingham, and Edinburgh. The makers of the first and last cities have the highest prices for their guns, single fowling-pieces being from 15 to 30 guineas, and double ones from 35 to 70 guineas; indeed, to such a perfection has this insrument been brought, of late years, by the British artists, that it cannot be doubted but that they are greatly superior to every other nation in Europe; although we have learned that, at the Versailles manufactory, under the first consul's special patronage, fowling-pieces were made at the high price of 800 guineas. Instances, however, can be produced where London makers have had a thousand guineas for one gun. The variety and ingenuity in the construction of small arms, in order to gain peculiar advantages, are so various and extensive, that it would be very difficult to enter into any details upon the subject: We shall, however, enumerate a few of the different kinds of guns which are in use: guns with one barrel, to discharge from one to three balls successively; magazine guns that prime and load by one motion, and discharge from 10 to 20 balls in succession; double guns, with their barrels placed perpendicular, horizontal, and to turn round a centre; three, four, and seven barrelled guns; harpoon guns; muskets and carabines, &c.

*The gun barrel.*—The length, shape, and bore of gun barrels have materially changed, as the instrument became more generally used and better understood. Hence we find, in different countries and at different periods, their length fluctuating from six feet to 25 inches, and their diameters from half an inch to one and a quarter inch: They are generally cylindrical, but in some instances square, internally and externally, with chambers at the breech to contain the powder, as is the case with all the Asiatic matchlocks of most ancient construction. The Spaniards were the first people in Europe who excelled in the manufacture of barrels, remarkable for lightness and safety: Possessing finer iron from their smelting their ores with wood; and being sensible that the more it is wrought by heating and hammering, the purer it becomes, they naturally resorted to the old nails extracted from the shoes of their horses and mules. Juan Sanchez di Mirvena, is the first that forged the barrel in separate pieces, in the reign of Philip IV.; and so highly were the Madrid makers esteemed, in 1720, that the French gave 1000 livres, or 43*l.* 15*s.* sterling, for the barrels of Nicholas Biz, Juan Beler, and Juan Fernendez. About the year 1650, we find Lazerino Cominazio, of Brescia, in high repute. France has also had her eminent workmen, such as Nicol le Clerc, Des Champs, Jean Franc Renet, and Henry Renet, all of Paris, whose barrels are still much prized. The British are now, however, confessedly much superior to every other people in the manufacture of this article. They have, of late, introduced many ingenious improvements, such as patent steel barrels, and narrow and wire twist barrels, with a beautiful application of the fibres of the metal in welding, so as to resemble exactly the Damascus steel of Persia, or what is seen in the finest arms of Indian workmanship. At first the European barrels were all of one diameter throughout, until within these 30 years, that a London tradesman obtained a patent for a chambered breech, which, though it possessed peculiar merit, was nothing but a copy from the principle of the carronade, and both are obviously borrowed from the Indian matchlock; hence his privilege of original invention being untenable, this construction became general in a few years, and still continues, with some slight variation, to the present period.

In forming the common gun barrel, the workmen begin by heating and hammering out a bar of the best iron, into the form of a flat ruler, thinner at the end intended for the muzzle, and thicker at that for the breech, the length, breadth, and thickness of the whole plate being regulated by the intended length, diameter, and weight of the barrel. This oblong plate is then, by repeated heating and hammering, turned round a cylindrical rod of steel, called a mandril, whose diameter is considerably less than the intended bore of the barrel. The edges of the plate are made to overlap each other about half an inch, and are welded together by heating the tube in lengths of two or three inches at a time, and hammering it, with very brisk but moderate strokes, upon an anvil which has a number of semicircular furrows in it, adapted to barrels of different sizes. The heat required for welding is the bright white heat which immediately precedes fusion, and at which the particles of the metal unite and blend so intimately with each other, that when properly managed, not a trace is left of their former separation. Every time the barrel is withdrawn from the forge, the workmen strike the end of it once or twice gently against the anvil in an horizontal direction; this operation, which is called jumping, serves to consolidate the particles of the metal more perfectly, as well as to disengage the scoria from the inside and outside of the tube, and to obliterate any appearance of a seam. The mandril is then introduced into the bore, or cavity; and the barrel being placed in one of the furrows or moulds of the anvil, is hammered very briskly by two persons; the forger all the while turning it round in the mould, so that every point of the heated portion may come equally under the action of the hammer. These heatings and hammerings are repeated until the whole of the barrel has undergone the same operation, and is rendered as perfectly continuous as if it had been bored out of a solid piece. Twisted barrels are now generally used for the finest fowling-pieces, the method of fabricating of which is as follows. Four bars of stub iron, two feet in length, half an inch in breadth, and the first two bars half an inch thick or more, according to the size of the barrel, are previously prepared. An old barrel being welded to the extremity of one of those bars for a handle, it is heated and turned round like a cork-screw, by means of the hammer and anvil; after this, the turns of the spiral are united by heating the tube two or three inches at a time to a bright white heat, and striking the end of it several times against the anvil in a horizontal direction, with considerable force: This is called jumping the barrel, and the heats given for that purpose jumping heats: A mandril is immediately introduced into the cavity, and a quick light hammering is kept up on the welding part, until the ridges raised at the seams by the jumping are flattened, and the piece appears sound. As soon as one bar is rounded and jumped in this manner, another is welded to it, and treated in the same way, until the four pieces are united and form one tube: The old barrel is then cut off as being no longer requisite, and the operation of heating and hammering is frequently repeated in its whole length, until its external figure is correctly acquired, and the metal has arrived at the utmost closeness of fibre in all its parts. It is a circumstance of considerable importance with respect to a gun barrel, that it should be forged as nearly as possible to its weight when finished, so that very little may be taken away in the boring and filing; for as the outer surface, by having undergone the action of the hammer more immediately than any other part, is rendered more compact and pure, the less that is removed the better will the barrel be.

The next process is the boring, the apparatus for which is either driven by a water wheel, steam engine, or the hand, according to the extent of the manufacturer's demand. This operation consists in giving to the barrel its proper calibre. The boring bit is a rod of iron, somewhat longer than the barrel, one end being fitted into the socket of the crank, and the other furnished with a cylindrical plug of tempered steel, about an inch and a half long, and having its surface cut with spiral grooves, flat at bottom, and a quarter of an inch in breadth. This form gives the bit a very strong hold of the metal, and the threads, sharp at the edges, scoop out and remove every roughness and inequality from the inside of the barrel, and render the cavity smooth and equal throughout. Several bits, each a little larger than the preceding one, are afterwards successively passed through the barrel in the same way, until it has acquired the intended calibre. After this the fine boring bit is introduced, being a similar rod to the former, with a square bar of tempered steel, 10 or 12 inches long at its extremity, and finely sharpened on one of its sides; on the opposite side is placed a semicircular slip of wood, of a size sufficient to fill up with the bit the entire diameter of the barrel, two of its edges only acting on the tube, which passing through its whole length, and kept well oiled, is frequently repeated, and the bore enlarged by small slips of paper placed between the wood and the bit, until the inside presents a perfectly equal and polished surface. The trueness of the bore is then proved, either by a steel or leaden plug passed through its whole length. The next step towards completing the barrel is the operation on its exterior surface, which in common barrels is done by grinding on a large stone; two steel pins being inserted into the mouth and breech of the tube, and smaller than its diameter. The workman holding them in his hands, presses the barrel to the stone, which revolving on the pins, grinds off the inequalities left by the hammer; after which it is passed to another person who files and smooths it from one end to the other. The best barrel makers do not grind but turn their barrels on a lathe, which is well calculated to insure that perfect equality of thickness on which the strength and safety of the piece so greatly depends. The filing and smoothing is afterwards performed in the usual manner. The imperfections to which gun barrels are liable, and which render them dangerous to use, and apt to burst, are the *chink*, *crack*, and *flaw*. The first is a small rent in the direction of the length of the barrel, the second across it, and the third is a scale or plate adhering to the barrel by a narrow base, from which it spreads out like the head of a nail from its shank, and when separated leaves a pit or hollow in the metal. Chinks or flaws are of much worse consequence than the crack in fire-arms, the expansive force of the powder being exerted more upon the circumference than the length of the barrel; the flaw is much more frequent than the chink, the latter scarcely ever occurring but in plain barrels, formed out of a single plate of iron. The proof of gun-barrels, both musket and fowling pieces, as established by Government and the Gunmakers Company of London, is a ball that fits the diameter of the piece, and a charge of powder of equal weight, which being fired, either bursts the barrel, or demonstrates its soundness and safety. Some gunmakers are in the habit of following this test, by a water proof, in order to ascertain if the pores of the metal continue perfectly secure. Pistol barrels are forged in one piece, two at a time, joined by their muzzles, and are bored before they are cut asunder, by which means there is not only a saving of time and labour, but a greater certainty of the bores being the same.

Rifle barrels are of modern invention: The Germans have the merit of this contrivance. The rifle barrels of Kuchanrieter senior of Ratisbon are in the greatest esteem; and so fond are the Germans of excelling in the use of the rifle, that it has become one of their principal amusements, in which all ranks of society frequently indulge. Every town and village has their practising ground, or butts, where small prizes are competed for with an accuracy of aim that is truly surprising. The Americans have also, from their habits of hunting, acquired great correctness in the use of rifle guns; and within these few years our government has introduced them into the army; the ninety-fifth regiment being peculiarly clothed, and armed with that weapon. The manufacture of rifles, in their first formation, is exactly similar to that of other barrels, except that their external form is generally octagonal. The process of rifling is as follows: the barrel being previously bored, and finished to a true cylindrical form, is placed on the rifling machine, an instrument formed on a square plank of wood seven feet long, to which is fitted a tube about an inch in diameter, with spiral grooves deeply cut internally through its whole length, and to which is attached a circular plate, about five inches diameter, accurately divided in concentric circles, into from five to ten equal parts, and supported by two rings affixed to the plank, in which it revolves; an arm connected with the dividing plate, and pierced with holes, through which a pin is passed, regulates the change of the tube in giving the proper number of rifles to the barrel. An iron rod with a moveable handle at one end, and a steel cutter in the other, passes through the rifling tube. This rod is covered with a core of lead one foot in length, and the barrel is firmly fixed by means of two rings on the plank, standing in a straight line to the tube. The rod is then repeatedly drawn through the whole length of the barrel, until the cutter has formed one groove to the proper depth; the pin being shifted to another hole in the dividing plate, the operation of grooving is continued until the whole number that was required is complete. The barrel is then taken out of the machine and finished. This is done by casting on the end of a small iron rod a core of lead, which, when coated with fine emery and oil, is drawn for a length of time by the workman from one end of the barrel to the other, till it has acquired a high degree of smoothness and polish. The process is then complete, and the barrel is ready for the ribber and breecher, &c. The best degree of spirality is found to be half a turn in a length of three feet.

*The Lock* was originally a cleft piece of iron, moving on a pin fixed into the stock. The match was held in the cleft, and conveyed into the priming in the pan: A lever carried down the under part of the stock, and projecting at its extremity, served for a trigger. This simple contrivance was followed by the wheel-lock, so called from a small solid wheel of steel, nearly a quarter of an inch in thickness, and one and a half in diameter, cut on its edge with grooves, and notched transversely. The upper part of the circumference of this wheel rose up through the middle of the pan: It had an axis placed in its centre, to which a chain was attached, connecting itself to the extremity of a strong spring on the outside of the lock-plate, and the whole was fixed to the barrel by screws passing through the stock. Its application was by turning the wheel with a key, or spanger, which rolled the chain round its axis, and drew up the spring to its full tension. By this movement, a slider that covered the pan containing the priming, retired from over it, so as to permit the dog, which held the flint, to place itself on the edge of the wheel, which being let off by the trigger, the rapid revolutions of the wheel elicited fire from the flint, and inflamed the priming. See Fig. 8, Plate CCLXXXV. To this succeeded the *Snaplance*, in which a motion was given to the dog, or cock, and a movable plate of steel, called the frizel, or hammer, was placed vertically above the pan to receive the action of the flint. Numerous important advantages were acquired by this improvement over the wheel-lock; first, by securing the priming until the instant the piece was to be fired; and by increasing the quickness of its action and the lightness of its construction, &c. The great perfection to which this part of a gun has been carried within these 40 years in Britain, justly acquired the profession an acknowledged celebrity over every other nation. The important requisites in a gun lock are, that the action of the cock be as rapid as possible, and that it should be so placed, that on uncovering the pan, the flint may point into the centre of the priming, and as near to it as possible, without touching it. The main-spring should have a smooth and active motion; the hammer-spring should be light, and should give a slight resistance to the cock on its striking the steel, which ought to move on a roller; and the temper should not be too hard or too soft, the one extreme being known by a roughness on its surface, and the other by the flint's making scarcely any impression on it, and producing little or no fire. The inside of the lock ought to be freed and swivelled, and the tumbler and seer of steel, and also the nails, should be tempered.

A very great improvement in the construction of gun-locks has lately been made by the Rev. Mr Forsyth, minister of Belhelvie, in Aberdeenshire. This ingenious gentleman contrived and made with his own hands a lock to fire without a flint, and by percussion alone to inflame certain powders. This contrivance possesses so many advantages over the present lock, (even in its most perfect state) that it will ultimately supersede it entirely. Although it is not more than five or six years since it was made public, yet both the German and Prussian gun-makers have adopted it, and there is little doubt it will become general here, so soon as his patent expires. The great advantages of this discovery are, the rapid and complete inflammation of the *whole* charge in the chamber of the barrel, a prevention of the loss of force through the touch-hole, perfect security against rain or damp in the priming, no flash from the pan, and less risk of accidental discharge of the piece than when the common lock is used.

This lock is represented in Figs. 1, 2, 3, 4, of Plate CCLXXXV. It consists of a hammer or dog-head H, and a magazine MN. This magazine MN, a section of which is shewn in Fig. 3. consists of a roller A, round which the magazine is movable as about an axis, one end of which is screwed into the breech of the barrel, as shewn in Fig. 4. The roller is perforated through its axis by a channel *m*, Fig. 4. which communicates with the chamber S of the gun. On the upper side of the roller is a pan B, which communicates by a hole in its centre with the channel *m*, and consequently with the chamber of the piece. The priming powder, which consists of *three* parts of the hyperoxymuriate of potash, *one* part of sulphur, and *one* part of charcoal, is put into the cavity C of the magazine, which will hold 40 primings. The opposite cavity D contains the steel punch and spiral spring E. When this punch is pressed down, it strikes the pan B, and is again raised from the pan by the elasticity of the spiral spring. F, F are the screws, between the points of which, and the cork fixed on the inside of the magazine, the grease for oiling the roller is contained. In order to use this lock, the magazine is brought into the position shewn in Fig. 1, where the cavity containing the priming powder is above the pan. A small portion of the powder therefore falls into the pan. The magazine is then turned round into the position of Fig. 2. where the steel punch is uppermost at M. The hammer H being raised, and the trigger being pulled, it gives a blow to the steel punch, which strikes the priming powder in the pan, and inflames it by the concussion. The flame having no other exit, passes along the channel *m*, Fig. 4. and inflames the charge. One of the great advantages of this lock is, that it may be used during rain, and the piece will go off even if the lock is immersed in water.

A very elegant simplification of this lock has been made, by giving the magazine MN a horizontal instead of a rotatory motion. The magazine is connected with the hammer by a lever, so that when the hammer is raised, or the piece cocked, the lever pulls the magazine over the pan, and fills it with priming. When the hammer is let go, by pulling the trigger, the magazine is moved from the priming pan, and the powder is inflamed by the percussion of the extremity of the hammer. This form of the lock, however, is not water proof.

*The Stock and Mounting of Guns* has assumed a great variety of forms, and not only the figure, but the mode of holding small arms has undergone a change; the straight stock match-lock being placed under the right arm, the crooked short hagbut and the poitrinal on the breast, and the modern musket at the right shoulder. Guns of sport, till within these thirty years, were made very crooked in the stock, and no regard was then paid to the balance of the piece; since that period straight stocks have been universally adopted, and the length of the stock has been accommodated to the stature of the person for whom it is made. For a view of various constructions of small arms, see Plate CCLXXXV.

Fig. 5. Represents the Indian match-lock, where M is the match held in a tube or pair of pincers, and P the pan, which holds the priming.

Fig. 6. Represents the European match-lock, or harquebuss.

Fig. 7. Represents the rest for the match-lock.

Fig. 8. Represents the wheel-lock.

Fig. 9. Represents a modern fowling-piece.

Fig. 10. Represents a modern Spanish lock.

# GUNNERY,

Is the art of constructing and using great guns, for the purpose of hitting a distant object, with shot or shells, discharged from the gun by the explosive force of gunpowder.

In the present article we propose to confine ourselves to the theory of gunnery, as founded on the mathematical doctrine of projectiles, corrected and modified by experimental investigations. The art of constructing and mounting great guns, and the description of the apparatus connected with them, will form a separate article under the head of ORDNANCE.

## HISTORY.*

THE Italians seem to have been the first people that directed their attention to the subject of the motion of cannon shot. Nicholas Tartaglia, a Venetian, who was born at Brescia, published at Venice, in 1537, his *Nuova Scienza*, and in 1546 his *Quesiti e Invenzioni diverse*, in both of which he treats the subject of projectiles. In the last of these works, he gives an account of the calibre rod, or artillery measuring rod, of which he seems to have been the inventor. In another work, translated into English by Cyprian Lucas, and entitled *Colloquies concerning the Art of Shooting in Great and Small Pieces of Artillery*, Lond. 1588, he has entered more minutely into the subject. Having no knowledge of the practical part of artillery, Tartaglia investigated the subject theoretically upon fallacious principles, and can scarcely be considered as having done any great service to this branch of science. He is supposed, however, to have discovered that projectiles may be thrown to the greatest distance when they are projected at an angle of 45 degrees; and, in opposition to the notion of practical gunners, he maintained that no part of the path of a cannon ball was a straight line, but that it was like the surface of the sea, which, though to all appearance a plane, was nevertheless a portion of a circle described by the radius of the earth. Tartaglia appears also to have been the inventor of the gunner's quadrant.

The researches of Tartaglia, imperfect and unsatisfactory as they were, had the merit of directing the attention both of military engineers and mathematicians to this curious subject. Many fallacious theories of the motions of cannon shot were brought forward, and Ufano, Galeus, Ulrick, and several other writers, published tables of the comparative ranges of military projectiles, that were quite irreconcileable with experiment.

The first experimental examination of this subject was made by M. Collado, a Spaniard, who served as an engineer with the Spanish army in Italy. In his work entitled *Practica Manuale de Artiglieria*, Venice, 1586, which was first published in Italian, and afterwards in Spanish, he has given for each point of the gunner's quadrant the ranges of a falconet which carries a three pound shot. Mr Robins remarks, that it is manifest, from the number, that the falconet was not loaded with the usual quantity of powder. The following are Collado's results:

| Points of the Gunner's Quadrant. | Angle of Elevation. | Range in paces, or common steps. |
|---|---|---|
| 0 | 0° point blank | 268 |
| 1 | $7\frac{1}{2}$ | 594 |
| 2 | 15 | 794 |
| 3 | $22\frac{1}{2}$ | 954 |
| 4 | 30° | 1010 |
| 5 | $37\frac{1}{2}$ | 1040 |
| 6 | 45 | 1053 |
| 7 | $52\frac{1}{2}$ | between the 3d and 4th range. |
| 8 | 60 | between the 2d and 3d range. |
| 9 | $67\frac{1}{2}$ | between the 1st and 2d range. |
| 10 | 75 | between the 0 and 1st range. |
| 11 | $82\frac{1}{2}$ | the ball fell very near the piece. |

The next experiments which were made on this subject, appeared in the *Art of Shooting in Great Ordnance*, a work which was published in 1643 by Mr William Bourne. He assumes unity as the range for a point black shot, and ascertains the ratio of the ranges at different elevations. Bourne does not mention the nature of the piece which he used, but Mr Robins presumes that it must have been a small one. The following Table contains the results given in Chap. vii. of the above work:

| Angles of Elevation. | Ranges. |
|---|---|
| 0 | 1.000 |
| 5 | 2.222 |
| 10 | 3.366 |
| 15 | 4.366 |
| 20 | 4.833 |

36 Greatest range when a strong wind favours the motion of the projectile.
42 Greatest range in a calm day.
45 Greatest range when a strong wind opposes the motion of the projectile.

A very admirable series of experiments were made early in the 17th century, by our countrymen Eldred, who was for many years master gunner at Dover castle. His earliest experiments are dated 1611; but the book which contains them, entitled *The Gunner's Glasse*, was not published till 1646. His experiments, which are very numerous, were made with great care, and the principles on which he proceeded were simple and tolerably correct. He has published the actual ranges of different pieces of artillery, at small elevations, not exceeding ten degrees, and among these are some trials made with the famous cannon called the *basilisk*, a piece 23 feet long, and well known to those who visit Dover castle. He found that this gun, which carries a 10 lb. shot, ranged 3600 feet with 18 lb. of powder, at an inclination of 2°, and 6000 feet at an elevation of 43°.

The subject of gunnery was now destined to receive the most important improvements from the genius of Galileo. By the application of mathematics to the doctrines of motion, he has given the form of a science to this branch of natural philosophy, and has enabled us to ascertain every thing that relates to the flight of military pro-

* An account of the invention and history of ARTILLERY will be found under that article.

jectiles, on the supposition that they are discharged in a non-resisting medium. His *Discursus et Demonstrationes Mathematicæ*, &c. which contain these fine investigations, were published in 1638. They are given in the fourth dialogue, entitled *De Motu Projectorum*, and occupy fourteen propositions, in which he has proved, that a projectile must describe a parabolic curve by the combination of the force of gravity with the force of projection, and has shewn how to compute the distance to which the body will be thrown, the time of its flight, and the momentum with which it falls, when projected in a given direction, and with a given velocity. Galileo was perfectly sensible that the resistance of the air would produce a considerable change in these results, and he has described a method of discovering the magnitude of the effects which this resistance would produce on the motion of a bullet at some given distance from the gun.

The opinions which prevailed at this time respecting the extreme rarity and tenuity of the air, prevented philosophers and military engineers from availing themselves of this important part of Galileo's work. They anticipated no great variation from the theory, and accordingly we find it to have been, for a long time, the received opinion, that all projectiles moved in a parabolic curve.

This erroneous opinion was stoutly maintained by our countryman Anderson, in his treatise *Of the Genuine use and effects of the Gun*, published in 1674. This work is founded on the Galilean theory; and its author boldly undertakes to overturn all objections that can be urged against the parabolic motion of projectiles.

A similar notion is maintained by M. Blondel, in his *L'Art de jetter les bombes*, which appeared at Paris in 1683. He applies the doctrines of Galileo to the flight of shells and bullets of every kind; and after a long discussion relative to the air's resistance, he concludes that it is too minute to affect the accuracy of his deductions.

The celebrated Dr Halley held the same false opinion. He was, however, not merely misled by a belief in the extreme tenuity of the air; but he was confirmed in his errors by some very imperfect experiments. After treating of the motion of projectiles, (See *Phil. Trans.* 1685, No. 179. p. 3.) he observes, that "these rules would be rigidly true, were it not for the resistance of the medium, by which not only the direct impressed motion is continually retarded, but likewise the increase of the velocity of the fall, so that the spaces described thence are not exactly as the squares of the times; but what this resistance of the air is, against several velocities, bulks, and weights, is not so easy to determine. It is certain that the weight of air to that of water is nearly as 1 to 800; whence its weight to that of any project is given. It is very likely, that to the same velocity and magnitude, but of different matter, the resistance will be reciprocally as the weights of the shot; as also, that to shot of the same velocity and matter, but of different sizes, it should be as the diameters reciprocally; whence, generally, the resistance to shot with the same velocity, but of different diameters and materials, should be as their specific gravities into their diameters reciprocally; but whether the opposition to different velocities of the same shot be as the squares of those velocities, or as the velocities themselves, or otherwise, is yet a more difficult question. However it be, it is certain, that in large shot of metal, whose weight many thousand times surpasses that of the air, and whose force is very great in proportion to the surface, this resistance is scarcely discernible; for by several experiments made with all care and circumspection, with a mortar-piece, extraordinarily well fixed to the earth on purpose, which carried a solid brass shot of $4\frac{1}{2}$ inches diameter, and of about 14 lb. weight, the ranges above and below 45 degrees were found nearly equal; if there were any difference, the under ranges went rather the farthest; but those differences were usually less than the errors committed in ordinary practice, by the unequal goodness and dryness of the same sort of powder, by the unfitness of the shot to the bore, and by the looseness of the carriage.

In a smaller brass shot, of about $1\frac{1}{2}$ inch diameter, cast by a cross-bow, which ranged it at most about 400 feet, the force being much more equal than in the mortar-piece, this difference was found more curiously, and constantly, and most evidently the under ranges exceeded the upper. From which trials I conclude, that although, in small and light shot, the opposition of the air ought and must be accounted for, yet, in shooting of great and weighty bombs, there need be very little or no allowance made; so that these rules may be put in practice, to all intents and purposes, as if this impediment were absolutely removed."

Although the opinion which we have been considering was entertained chiefly by speculative writers, yet those who made extensive experiments on the motion of projected bodies, began to suspect some lurking error. Anderson, whom we have already mentioned, as a keen abettor of the parabolic theory, had occasion to make a number of new experiments on the ranges of shells discharged with small velocities, which he published in 1690, in his treatise entitled, *To hit a mark*. He found that the track of shells and bullets was much less incurvated in the first part of their path than they ought to be, on the Galilean theory; but instead of supposing the theory practically incorrect, or conjecturing that the deviations were produced by the resistance of the air, he imagined that the shell or bullet was discharged from the gun to a certain distance in a right line, and that gravity only began to deflect it into a parabolic curve at the end of this line, which he calls the *line of the impulse of the fire*, and which he supposes to be the same at all elevations. By giving a proper magnitude to this imaginary line, he was always able to reconcile the ranges of any two shells projected at different elevations; though, as Mr Robins remarks, he would have found it impossible to reconcile the irregularities of three or more ranges.

So deeply rooted was the erroneous notion that the air offered only an unappreciable resistance to moving balls, that the publication of Sir Isaac Newton's *Principia*, in which the resistance of the air in slow motions is ascertained and confirmed by experiment, was not able to correct it. By extending the law for slow motions to those in which the velocity was very great, it was obvious that the resistance opposed to cannon balls was too great to be overlooked; though it did not amount, by the calculation, to that enormous degree which was afterwards deduced from direct experiment. Newton has not attempted to investigate, in a direct manner, the path which a body will describe when projected into the atmosphere with a given velocity, and in a given direction. He shews, however, the particular state of density in the air, which will agree with the motion of a body in any curve whatever; and, by the application of the principle to curves, which have some resemblance to the path of a projectile, he finds it differing little from what may be considered as the path of a body projected in our atmosphere. In the second edition of the *Principia*, which appeared in 1713, he corrects some of the oversights into which he had formerly been led; and he shews that a projectile, moving in a medium, whose density varies according to certain laws, and acted upon by a force directed to the centre of the earth, will describe an eccentric spiral, whose properties he describes.

The complete solution of this problem was not obtained, till Dr Keill challenged John Bernoulli to determine the curve described by a body projected through a medium resisting as the square of the velocity. The Swiss geometer very soon gave a much more general solution than was demanded, independent of any limitation of the law of resistance, of the law of gravity, or of the law of density, provided that they were capable of being expressed algebraically. Dr Brook Taylor gave a solution of the problem in its limited form.

In the year 1690, the celebrated Huygens published a treatise on Gravity, in which he endeavoured to prove, from a series of experiments, that projectiles discharged through the air with great velocity, described paths very different from a parabola. The inconsistency of the Galilean theory, with the practice of artillery, was now particularly noticed by M. Ressons, a French artillery officer, who drew up a memoir on the subject, and presented it to the Academy of Sciences.* In this memoir, which was entitled *Methode pour tirer les bombes avec succes*, he attempts to shew that the theory is of very little service in the use of mortars, and that the theoretical path of projectiles is justly described in the works of Blondel; yet by directing mortars according to that theory, he could never obtain results that had the slightest agreement with it.

In the year 1736, a series of experiments was made at Woolwich, in order to determine the length of cannon that could enable them to shoot most efficaciously. These experiments were made with six 24 pounders, cast on purpose and of the same weight, but varying in length from 8 feet to 10½ feet. These pieces were all loaded alike, with allotments of powder equal to half the weight of the bullet; and five shot were fired from each, at an elevation of 7¼°. The following are the results which were obtained:

| Length of Pieces. | June 1st. Medium of Five ranges. | June 18th. Medium of Three Ranges. | July 2d. Medium of Three Ranges. |
|---|---|---|---|
| Feet. | Yards. | Yards. | Yards. |
| 10½ | 2486 | 2614 | 2406 |
| 10 | 2570 | 2532 | 2436 |
| 9½ | 2633 | 2560 | 2500 |
| 9 | 2790 | 2494 | 2563 |
| 8½ | 2586 | 2490 | 2466 |
| 8 | 2438 | 2473 | 2452 |

From the average range of these five shot, the effects of the different lengths were supposed to be deducible. The result of the experiments was, that the pieces of 9 and 9½ feet had the greatest range. Mr Robins has, however, shewn, that these experiments are by no means inconsistent with his opinion, that the largest pieces ought to have the greatest range. The ranges with the 9 and 9½ feet guns ought not to differ more than 35 yards from the ranges of the 8 and the 10½ feet guns, according to his theory; and yet with two subsequent trials with the 9 feet gun, the ranges differ no less than 650 yards; and the average ranges made in these successive days differ from each other 300 yards. Hence it is obvious, that these experiments differ so much from each other, that they are not sufficient to decide the point for which they were undertaken.

No step of importance seems to have been made in gunnery till the year 1742, when Dr Jurin proposed some questions, which the Royal Society appointed a committee to investigate. The first of these questions was, Whether all the powder of the charge be fired? 2*d*, Whether all the powder that is fired, be fired before the bullet is sensibly moved from its place? And, 3*dly*, Whether the distance to which the bullet is thrown may not become greater or less, by changing the form of the chamber, though the charge of powder and all other circumstances remain unchanged? The committee, after numerous experiments, found that all the powder was not fired; that the bullet was sensibly moved from its place, before all the powder that was fired had taken fire; and that a change in the form of the chamber would produce a change in the distance to which the bullet is thrown; the largest chamber of equal capacity always driving the ball farthest.† The committee, however, seem to have made some mistake; for Mr Robins afterwards proved, that the ball has not sensibly changed its place when the powder is fired.

Several experiments were about this time made in France on the ranges of cannon. M. St Remy has given us an account of a series made with pieces of cannon 10 feet in length, of the usual calibre, and elevated at an angle of 45°. The following were his results, the quantity of powder being two-thirds of the weight of the bullet.

| | Range in Yards. | | Range in Yards. |
|---|---|---|---|
| 24 Pounder . . . | 4490 | 8 Pounder . . . | 3320 |
| 16 Ditto . . . . | 4040 | 4 Ditto . . . . | 3040 |
| 12 Ditto . . . . | 3740 | | |

Pieces of the same calibre as the preceding, but somewhat shorter, had almost the same ranges when fired with only one half the former charge, or one-third of the weight of the ball in powder. See Remy's *Memoirs of Artillery*, vol. i. p. 69.

Another series of experiments was made at La Fere, in the year 1739, under the direction of the Chevalier de Borda. They were made with the usual pieces of all the preceding calibres, and were charged with various quantities of powder, and elevated to 4°, to 15°, and to 45°. Experiments were also made with a 24 pounder, at different elevations, from 4 to 45°, and the following results were obtained with a charge of nine pounds of powder.

| Angle of Elevation. | Actual Range. Yards. | Angle of Elevation. | Actual Range. Yards. |
|---|---|---|---|
| 40 . . . | . . 4100 | 20 . . . | . . . 3480 |
| 35 . . . | . . 4040 | 15 . . . | . . . 3350 |
| 30 . . . | . . 3820 | 4 . . . | . . . 1640 |
| 25 . . . | . . 3650 | | |

Another series of experiments was made at La Fere, with different pieces, elevated to different angles, and charged with different quantities of powder. The following were the results.

| Nature of the Piece. | Pounds of Powder. | Angle of Elevation. | Actual Range. Yards. |
|---|---|---|---|
| 16 | 6 | 15 | 3560 |
| 16 | 6 | 4 | 1650 |
| 12 | 4 | 15 | 3000 |
| 12 | 4 | 4 | 1640 |
| 8 | 3 | 15 | 2880 |
| 8 | 3 | 4 | 1540 |
| 4 | 2 | 15 | 3000 |
| 4 | 2 | 6 | 1724 |

In the year 1740, a series of experiments were made at Metz with great care and attention. In the experiments

* See Mem. Acad. Par. 1716, p. 79.

† See Phil. Trans. 1742, Vol. xlii. p. 172.

of La Fere, the medium ranges only were given, but at Metz the result of each trial was set down. The piece which was used was a 24 pounder, 10 feet long. It was charged with different quantities of powder, from 8 to 20 lb. It had always an elevation of 4°; but as it was placed about 78 feet above the plain where the bullets fell, the elevation should be considered as 5°. The following are the results.

| Pounds of Powder. | Ranges in Yards. | Pounds of Powder. | Ranges in Yards. |
|---|---|---|---|
| 8 | 1598 | 10 | 1676 |
| — | 1688 | 11 | 1674 |
| — | 1658 | — | 1568 |
| — | 1774 | — | 1900 |
| 9 | 1430 | — | 1784 |
| — | 1834 | — | 1584 |
| — | 1710 | — | 1660 |
| — | 1624 | 12 | 1624 |
| — | 1484 | — | 1614 |
| — | 1612 | — | 1764 |
| — | 1740 | — | 1798 |
| — | 1708 | — | 1684 |
| — | 1708 | 14 | 1680 |
| — | 1644 | — | 1696 |
| — | 1716 | — | 1756 |
| — | 1652 | — | 1900 |
| — | 1616 | — | 2120 |
| — | 1712 | — | 1686 |
| — | 2020 | 16 | 2000 |
| — | 1470 | — | 1796 |
| — | 1800 | — | 1940 |
| — | 1566 | — | 1670 |
| 10 | 1668 | 18 | 1900 |
| — | 1744 | — | 2000 |
| — | 1702 | 20 | 2200 |
| — | 1690 | — | 1682 |
| — | 1742 | | |

Hitherto no general principle had been established by the numerous experiments of which we have given a short account; but the subject of gunnery was now destined to receive the most important improvements from the labours of Mr Benjamin Robins, who published an account of them in 1742, in his *New Principles of Gunnery, containing the determination of the force of Gunpowder, and the investigation of the differences in the resisting power of the air to swift and slow motions.* In this valuable work, he begins by determining the explosive force of gunpowder, (see our article GUNPOWDER, p. 187.) and he found that this force was owing to an elastic fluid like air, which existed in a highly condensed state in the powder, and being suddenly separated from it by combustion, expanded, and impelled the bullet with prodigious force.

Mr Robins then proceeds to determine the velocity with which gunpowder will impel a shot of a given weight from a cannon of given dimensions; and in order to compare the velocities thus computed with the real velocities, he invented an instrument called the Ballistic Pendulum, by which he was enabled to measure the real velocities of bullets of all kinds with such accuracy, that in the case of a bullet moving with a velocity of 1700 feet per second, the error will never amount to $\frac{1}{500}$th part of the whole.

With this machine he made a great number of experiments, with musket barrels of different lengths, charged with different quantities of powder, and carrying balls of different weights; and the agreement between the calculated and observed velocities is so surprising as to establish his theory on the firmest foundation.

Mr Robins proceeds to point out the changes which take place in the force of gunpowder, from variations in the heat and moisture of the atmosphere: He determines the velocity which the flame of gunpowder acquires by expanding itself, to be 7000 feet per second: He ascertains the manner in which the flame of the powder impels a ball, placed at a considerable distance from the charge; and he enumerates the various kinds of powder, and describes the best methods of examining its goodness.

Mr Robins then treats of the resistance of the air, and of the track described by the flight of shot and shells. He shews, from experiments made with the ballistic pendulum, that at different velocities there was a gradual increase of the resistance over the law of the square of the velocity, as the body moved quicker. He then proves, that a 24 pound ball fired with a full charge of powder, experiences, when it first issues from the piece, a resistance more than 20 times its weight; that the paths of projectiles, when the velocity of projection is considerable, is not nearly a parabola; and that, in their flight, bullets are not only depressed beneath their original direction by the action of gravity, but are frequently deflected to the right or left of that direction by the action of some other force. Robins' *Principles of Gunnery* was translated into German by Euler, who honoured it with learned and valuable commentaries.

About eight or ten years after the publication of Robins' Works, the Chevalier D'Arcy published, in the Memoirs of the Academy for 1751, a Treatise on the Theory of Artillery, in which he gives an account of a series of experiments made with great care. He employed two pendulums, against one of which he fired the ball, while the other, from which the small cannon was suspended, served to measure the recoil. These experiments were afterwards extended, and published in his *Essais d'une Theorie de l'Artillerie*, which appeared in 1760.

In the year 1746, between the 7th February and the 30th March, a series of experiments were made by the officers of artillery at Turin, for the purpose of determining the charges of powder that give the largest ranges. The guns were mounted on a part of the fortifications of the city, where the axis of the piece was 30 feet higher than the level of the country where the shot fell. The guns were fired with their axes always horizontal. The smallest charges were at first used, and increased gradually till the ranges began to diminish. The following table shews the results of the experiments:

| Nature of Guns. | Length of Bore. | Weight. | Weight of Powder. | Range. | Recoil. |
|---|---|---|---|---|---|
| | Calibres. | Cwt. qr. lb. | lb. oz. | Yards. | Inches. |
| | | | 1 4 | 478 | 43 |
| 4 | 27 | 9 1 9 | 1 10 | 489 | 62 |
| | | | 2 1 | 472 | 72 |
| | | | 2 7 | 512 | 45 |
| 8 | 27 | 18 2 10 | 3 5 | 532 | 64 |
| | | | 4 2 | 532 | 82 |
| | | | 3 5 | 505 | 42 |
| 16 | 23 | 31 3 26 | 4 6 | 526 | 55 |
| | | | 4 15 | 522 | 78 |
| | | | 6 9 | 485 | 54 |
| 32 | 20 | 57 2 17 | 8 12 | .492 | 71 |
| | | | 9 13 | 489 | 82 |

From these results it follows, that the charge of powder which gives the longest range is equal to half the weight of the shot in four and eight pounders, and to one-third of its weight in 16 and 32 pounders. The recoil always increases in proportion to the augmentation of the charge. The length of the range increases to a certain point, and afterwards decreases in a much less ratio than the recoil increases. The charge which gives the longest range in pieces of small calibre, is proportionally longer than in pieces of large calibre.

In the spring of 1750, the Chevalier Ferrero di Ponsiglione made a series of experiments with pieces of the same calibre and proportions at Turin, for the purpose of ascertaining the charge that gives the longest range when the piece is fired at the greatest elevation its carriage will admit of. The ranges were measured on a flat piece of ground, nearly on the same level with the battery. The shot being rather larger, the windage was less than in the experiments of 1746.

| Nature of Guns. | | Weight of Powder. | Length of Range. | Recoil. |
|---|---|---|---|---|
| Pounders. | Elevation. | lb. oz. | Yards. | Inches. |
| 4 | 14° | 2 1 | 2375 | 52 |
| | | 2 8 | 2219 | 60 |
| | | 2 14 | 2422 | 70 |
| | | 3 5 | 2526 | 76 |
| 8 | 11° | 3 5 | 2321 | 46 |
| | | 4 2 | 2463 | 65 |
| | | 4 15 | 2486 | 85 |
| | | 5 12 | 2375 | 102 |
| | | 6 9 | 2675 | 119 |
| 16 | 12° | 5 12 | 2659 | 71 |
| | | 6 9 | 2860 | 76 |
| | | 7 3 | 2663 | 90 |
| | | 8 3 | 2810 | 97 |
| | | 9 0 | 2764 | 108 |
| | | 9 13 | 2892 | 113 |
| 32 | 11½° | 11 8 | 3172 | 117 |
| | | 13 2 | 3032 | 120 |
| | | 14 6 | 2995 | 124 |
| | | 16 6 | 3220 | 146 |
| | | 18 0 | 3084 | 168 |

From these experiments it follows, that the charges that give the longest ranges when cannon are fired from the greatest elevations their carriages will permit, are greater than those which produce the same effect when they are fired horizontally. Several experiments which were some time afterwards made in France, shewed, that in cannon of a large calibre, the charge should be about three-eighths of the weight of a shot. In the month of August 1747, Signior Marandone made a series of experiments for the same purpose, by orders of the Knights of Malta. From these he concluded, that the charge that ought to produce the longest range, must exceed three-eighths of the weight of the shot.

Signior Mattei, mathematical instrument maker to the King of Sardinia, invented a machine for finding the initial velocity of balls measured near the mouth of the gun; and a number of valuable experiments were made with it by Antoni, of which we shall afterwards give a more particular account. Mattei's machine consists of a horizontal circle, supported by its centre on the upper end of a vertical axis, and serving as a base to a hollow paper drum. This drum is made to revolve by means of a weight at the end of a cord passing over a pulley; and the projectile, thrown in a horizontal direction, traverses the paper drum in two points. The arc described by the system, while the projectile, in traversing the interior of the drum, is measured by the distance of the second point from the diameter which passes through the first. See the Description of Plates, and p. 179.

Another very simple machine for the same purpose was invented in 1764, by Lieutenat De Butet. "He applies a little plate of metal, provided with a moveable index, to any wheel that turns with an equable motion and sufficient velocity; the index is held at some distance from the circumference of the wheel, by a thread that is stretched across the mouth of the gun. When the gun is fired, the shot breaks the thread and sets at liberty a spring, which instantly presses the index against the wheel, upon which it describes an arch, till it is checked by the impact of the shot against a moveable butt placed at the distance of a few feet; to this effect, one extremity of a rod is fastened to the butt, and the other to the plate; thus the index is drawn back by the rod which follows the movement of the butt, and ceases to describe the arch on the circumference of the wheel. The motion of the wheel, the distance from the muzzle of the gun to the butt, and the arch described by the index being known, it is easy to ascertain the space that the shot passes through in one second of time with an uniform velocity; or, in other words, its initial velocity. To diminish the friction as much as possible, a small groove is made in the part of the wheel that receives the index, and filled with grease, which presents a very slight resistance. By means of this instrument, the time of the shot's passage along the bore of the gun, the initial velocity of shells, and the resistance of the air to their motion, may be determined; if allowance be made for the modifications that must ensue."

In the year 1779, the learned Dr Hutton of Woolwich, in conjunction with several officers of artillery, undertook a series of experiments on the motion of cannon balls. They used ballistic pendulums from 300 to nearly 600 pounds weight, and they employed cannon shot of 1, 2, and 3 pounds weight, and they varied the charge of powder from 2 to 8 ounces. From these experiments, of which a full account was published in the *Philosophical Transactions* for 1778, Dr Hutton deduced the following inferences.

1. That gunpowder fires almost instantaneously. 2. That the velocities communicated to balls or shot of the same weight by different quantities of powder are nearly in the subduplicate ratio of those quantities: a small variation in defect taking place when the quantities of powder become great. 3. And when shot of different weights are employployed, with the same quantity of powder, the velocities communicated to them are nearly in the reciprocal subduplicate ratio of their weights. 4. So that, universally, shot which are of different weights, and impelled by the firing of different quantities of powder, acquire velocities which are directly as the square roots of the quantities of powder, and inversely as the square roots of the weights of the shot, nearly. 5. It would therefore be a great improvement in artillery to make use of shot of a long form, or of heavier matter; for thus the momentum of a shot, when fired with the same weight of powder, would be increased in the ratio of the square root of the weight of the shot. 6. It would also be an improvement to diminish the windage; for by so doing, one third or more of the quantity of powder might be saved. 7. When the improvements mentioned in the last two articles are considered as both taking place, it is evident that about half the quantity of powder might be saved, which is a very considerable object. But important as this saving may be, it seems to be still exceeded by that of the article of the guns; for thus a small gun may be made to have the effect and execution of another of two or three times its size in the present mode, by discharging a shot of two or three times the

weight of its natural ball or round shot: And thus a small ship might discharge shot as heavy as those of the greatest now made use of.

In the year 1781 Count Rumford instituted a series of experiments with musket barrels. The machinery which he used was ingeniously contrived and well executed, and his object was to determine the initial velocity of bullets, the recoil of the barrel, the effect of firing the charge in different parts of it, and the most advantageous situation for the vent. The following were the principal results which he obtained. He found that when the weights and dimensions of the bullets are the same, their velocities, when discharged from the same piece, are in the subduplicate ratio of the weight of the charges; and he concludes, from numerous experiments, that the vent may be placed in any part of the chamber where it will best answer on other accounts. Hence Count Rumford recommends that the bottom of the bore should be of a hemispherical form; that the vent should be brought directly through the side of the barrel in a line perpendicular to its axis, and pointing to the centre of the hemispherical concavity of the chamber.

In these experiments, the ballistic pendulum of Robins was employed; but in consequence of a suggestion contained in Robins's new principles of gunnery, Count Rumford proposed, and put in practice, another method of determining the velocities of bullets, by suspending the gun in a horizontal position by two pendulous rods, and determining the velocity of its recoil from the arc of its ascent, measured by a ribbon, as in the ballistic pendulum. The velocity of the bullet will be $v = \frac{V-U}{B} \times W$; where W is the weight of the gun, V the velocity of its recoil when fired without a bullet, V the velocity of the recoil when the same charge impels a bullet, B the weight of the bullet, and $v$ its velocity. By comparing the results obtained in this way, with others obtained from the ballistic pendulum, Count Rumford found, that in several cases they agreed, but that in others the differences were so great, that the new method ought not in general to be relied upon.

Another very extensive set of experiments was undertaken in the year 1783, under the direction of Major Bloomfield, and by the orders of the Duke of Richmond, Master-general of the Ordnance. They were carried on in the summers of 1783, 1784, 1785, 1787, 1788, 1789, 1791, &c. principally with a view to the following objects:

1. To determine the velocity of balls impelled by equal charges, from pieces of different lengths, but of the same weight and calibre.

2. To determine their velocities with different charges, when the weight and length of the gun are the same.

3. To determine the greatest velocity due to different lengths, by making the charge as great as the gun will bear.

4. To determine the effect of varying the weight of the gun, every thing else remaining the same.

5. To determine the penetration of balls into blocks of wood.

6. To determine the ranges and times of flight, and the velocities of balls, by striking the ballistic pendulum at various distances, and to compare them with their initial velocities, in order to ascertain the air's resistance.

7. To determine the effect of wads; of different degrees of ramming; of different degrees of windage, and of different positions of the vent; of chambers and trunnions, and every other circumstance necessary to be known for the improvement of artillery.

These experiments were carried on with great success, excepting in the subject of ranges, which were less regular and uniform than could have been wished. The ballistic pendulum was from 600 to 800 pounds weight. The balls were generally one pound weight, and the powder was increased from one ounce till the bore was quite full.

The following are the general results, as given by Dr. Hutton:

1. That the velocity is directly as the square root of the weight of powder, as far as to about the charge of eight ounces; and so it would continue for all charges, were the guns of an indefinite length. But as the length of the charge is increased, and bears a more considerable proportion to the length of the bore, the velocity falls the more short of that proportion.

2. That the velocity of the ball increases with the charge to a certain point, which is peculiar to each gun where it is greatest; and that, by further increasing the charge, the velocity gradually diminishes till the bore is quite full of powder. That this charge, for the greatest velocity, is greater as the gun is longer, but not greater, however, in so high a proportion as the length of the gun is; so that the part of the bore filled with powder bears a less proportion to the whole in the long guns than it does in the short ones; the part of the whole which is filled being indeed nearly in the reciprocal subduplicate ratio of the length of the empty part. And the other circumstances are as in this Table.

*Table of Charges producing the greatest Velocity.*

| Gun. | Length of the Bore. | Length filled. | Part of the whole. | Weight of the Powder. |
|---|---|---|---|---|
| Number. | Inches. | Inches. | | Ounces. |
| 1 | 28.2 | 8.2 | $\frac{3}{10}$ | 12 |
| 2 | 38.1 | 9.5 | $\frac{3}{12}$ | 14 |
| 3 | 57.4 | 10.7 | $\frac{3}{16}$ | 16 |
| 4 | 79.9 | 12.1 | $\frac{3}{20}$ | 18 |

3. It appears that the velocity continually increases as the gun is longer, though the increase in velocity is but very small in respect of the increase in length, the velocities being in a ratio somewhat less than that of the square roots of the length of the bore, but somewhat greater than that of the cube roots of the length, and is indeed nearly in the middle ratio between the two.

4. The range increases in a much less ratio than the velocity, and indeed is nearly as the square root of the velocity, the gun and elevation being the same. And when this is compared with the property of the velocity and length of gun in the foregoing paragraph, we perceive that very little is gained in the range by a great increase in the length of the gun, the charge being the same.

And, indeed, the range is nearly as the 5th root of the length of the bore, which is so small an increase as to amount only to about one-seventh part more range for a double length of gun.

5. It appears also that the time of the ball's flight is nearly as the range; the gun and the elevation being the same.

6. It appears that there is no sensible difference caused in the velocity or range, by varying the weight of the gun, nor by the use of wads, nor by different degrees of ramming, nor by firing the charge of powder in different parts of it.

7. But a great difference in the velocity arises from a small degree of windage. Indeed, with the usual established windage only, namely, about 1-20th of the calibre, no less than between 1-3d and 1-4th of the powder escapes and is lost. And as the balls are often smaller than that size, it frequently happens that half the powder is lost by unnecessary windage.

8. It appears that the resisting force of wood to balls fired into it is not constant. And that the depths penetrated by different velocities or charges are nearly as the logarithms of the charges, instead of being as the charges themselves, or, which is the same thing, as the square of the velocity,

9. These, and most other experiments, shew, that balls are greatly deflected from the direction they are projected in, and that so much as 300 or 400 yards in a range of a mile, or almost 1-4th of the range, which is nearly a deflection of an angle of 15°.

10. Finally, these experiments furnish us with the following data to a tolerable degree of accuracy, viz. the dimensions and elevation of the gun, the weight and dimensions of the powder and shot, with the range and time of flight, and the first velocity of the ball.

The experiments made by Dr Hutton in the years 1787, 1788, 1789, and 1791, were principally intended to ascertain the resistance of the air to military projectiles. Balls of 2 inches, 2.78 inches, and 3.55 inches in diameter, were employed, to determine the resistance of very high velocities. They were discharged with velocities from 300 to 2000 feet per second, and were made to strike the pendulum at several different distances from the guns. In all these experiments, the resistances varied nearly as the $2\frac{1}{10}$th power of the velocity, the exponent being 2.028 for a velocity of 200 feet per second, and increasing gradually to 2.136, which it reached when the velocity was 2000 feet per second.

In the year 1804, a new machine for measuring the initial velocity of projectiles was proposed and used by Col. Grobert; and a very favourable report of its accuracy was made to the National Institute of France, by Messrs Bossut and Monge. The apparatus consists of a horizontal revolving axis, about 34 decimetres long, having at each of its extremities a circle or disc of pasteboard placed perpendicular to the axis. A rotatory motion is communicated to the axes, and consequently to the discs, by means of a weight suspended at the extremity of a rope, which, passing over a pulley 10 or 12 yards above the ground, coils itself about the arbour of a wheel and axle fixed at the same level as the discs. The motion given to the wheel and axle by the descent of the weight is communicated to the axis of the discs by an endless chain, passing round the wheel and axle, and also round a pulley on the axis of the discs. The instrument being thus constructed, let us suppose that a ball traverses the two discs when in motion, in a direction parallel to their axes. It is obvious that the hole in each disc will not coincide with one another, and that the angular motion which the second disc has made while the ball was passing between them will be a measure from which the velocity of the ball can be computed. Hence it is necessary to impress upon the discs an uniform and known velocity, and to measure accurately the arch passed over by the second disc during the transit of the ball from the one to the other. In the experiments which were made with this machine, the motion became sensibly uniform when the weight had arived nearly at the half of the vertical space which it traversed. The following is the formula for calculating the velocity of the ball.

$$V=\frac{2\pi n}{kt}\cdot\frac{r}{a}b, \text{ or}$$

$$V=\frac{6.282n}{k\,t}\cdot\frac{r}{a}b, \text{ in which}$$

$V$=the velocity of the ball between the discs, considered as uniform;

$\pi$=3.141, the ratio of the circumference to the diameter of a circle;

$k$=the ratio between the respective numbers of the turns made at the same time by the wheel of the axle, and the pulley of the axis of the discs, which in the following experiments was $\frac{1}{7.875}$;

$t$=the time employed by the wheel of the axle to make $n$ number of turns;

$r$=the distance of the hole made by the ball in the second disc from the axis of the discs;

$a$=the arc passed over by that hole while the disc goes from the one to the other;

$b$=the distance between the two discs.

The following experiments were made with a horse musketoon, 0.765 metres of interior length. The weight of the ball was 24.7 grammes, and it was projected with half its weight of powder. The mean velocity deduced from these experiments is 390.47; whereas the mean velocity found from experiments with the common infantry musket, 1.137 metre of interior length, was 428, exceeding the former in the ratio of 11 to 10. All the values of $a$ are referred to that of $r$=1 metre.

| Number of the experiments. | Values of $n$, or the number of turns made by the wheel of the axle. | Values of $t$, or the time in which the number of turns were made. | Values of $a$, or the arc passed over by the hole in the second disc. | Values of V, or the velocity of the ball. |
|---|---|---|---|---|
| | | Seconds. | Metres. | Metres. |
| 1 | 8 | 10 | 0.3510 | 402.3 |
| 2 | 8 | 10 | 0.3800 | 371.7 |
| 3 | 8 | 10 | 0.368 | 362 5 |
| 4 | 15 | 22 | 0.296 | 384.1 |
| 5 | 15 | 22 | 0.264 | 430.7 |
| 6 | 10 | 18 | 0.268 | 345.7 |
| 7 | 15 | 16 | 0.392 | 398.8 |
| 8 | 15 | 16 | 0.392 | 398.8 |
| 9 | 15 | 16 | 0.416 | 375.8 |
| 10 | 15 | 16 | 0.360 | 434.3 |

In order to afford the means of traversing the discs by throwing balls in different directions from 0° to 45°, Colonel Grobert gives to each disc a particular horizontal axis, to which a pulley is affixed; and the rotatory motion is communicated by an endless chain to both axes, so that they may perform the same number of revolutions in the same period. The supporter of the second disc is capable of rising vertically, and fixing itself at different heights. The adjustment of this apparatus must, however, be attended with great difficulty.

## CHAP. I.

### *On the Parabolic Theory of Gunnery.**

In the process of our examination of the motions in the solar system, it appears that terrestrial gravity, or the heaviness of common sublunary bodies, is only a particular case of the mutual tendency of all matter towards all mat-

* This valuable Chapter was written by the late John Robison, LL. D. F. R. S. E. It was intended to form a part of his *System of Mechanical Philosophy*, and was the last production of that eminent philosopher. It is now published for the first time, with the permission of Mr Murray, the proprietor of the MSS. and will appear in the first volume of his *System of Mechanical Philosophy*, now in the press.

ter. It further appears, that a body on the surface of our globe gravitates in a line that is directed very nearly to the centre of the earth; and that the intensity of this gravitation is inversely proportional to the square of its distance from this centre.

Bodies let fall, or projected in any direction on the surface of this earth, move under the influence of this force; and their motions may be computed from the general doctrines of dynamics, in the same manner as we computed the motions of the planets. They will either fall in the direction of gravity, or will rise in the opposite direction, or will describe a curve line concave toward the earth, which will be an ellipsis, parabola, hyperbola, or circle, according as the velocity and direction of the projection may have been combined

But, in the greatest projections that we can make, the force of gravity is so nearly the same in every point of the path, that we may suppose it to be accurately so, without any sensible error, were it ten times greater than it is. Therefore in all disquisitions about projectiles, it would be useless affectation to embarrass ourselves with the variations. None of our projectiles rise a mile in the air, which is about $\frac{1}{3960}$ of the mean radius of the earth, and will occasion a diminution of gravity nearly equal to $\frac{1}{1980}$, a quantity altogether insignificant.

For the same reasons, although the directions of gravity in the different points of the projectile's flight, are lines converging nearly to the centre of the earth, we may consider them as all parallel, because none of our projectiles fly four miles, which produces a convergency of nearly four minutes, a deviation from parallelism which needs not be regarded.

In general, therefore, we may consider all such projectiles as under the influence of equal gravity, acting in lines parallel to the vertical or plum-line drawn through the place of projection. This reduces the theory of projectiles to a great degree of simplicity.

Accordingly, this is the first department of mechanical philosophy which first received improvement by the application of mathematical knowledge. We are indebted for this fortunate introduction of mathematics into the doctrines of motion, to the celebrated Florentine, Galileo Galilei. This excellent philosopher read his discourses on local motion about the beginning of the 17th century. Those lectures contain the whole of this doctrine, nearly in the state in which it continued till about the middle of last century. There is no branch of natural philosophy that has met with so much assistance and encouragement, it having been considered in all nations as the foundation of the art of gunnery; an art unfortunately too much connected with the security of every nation. It has therefore been patronised by princes and magistrates—most costly establishments have been made for its cultivation; the mathematicians have occupied themselves with its problems, and more numerous and expensive volumes have been published on this than on any other part of mechanical philosophy. Yet there is none in which so little improvement has been made. Galileo's lessons contain every thing that has been done in a scientific way, till M. Robins, in 1742, gave it a form altogether new.

We shall first consider the perpendicular ascents and descents of heavy bodies; and in the next place, their curvilineal motion, when projected in directions deviating from the vertical.

The motion of a falling body is uniformly accelerated, and that of a body thrown straight upward is uniformly retarded.

For the accelerating or retarding force is constant, and therefore the motions are such as were considered in Dynamics.

All the characteristic phenomena of these motions having already been sufficiently considered, all that is wanting for the application to this class of mechanical phenomena, is merely one experimental determination of the accelerative power of gravity, that is, the velocity, or increment of velocity, which gravity will generate in a body by acting on it uniformly during some given time. Galileo, who first demonstrated that an invariable gravity must produce a uniformly accelerated motion, was also among the first who appealed to experiment in all inquiries. We now think lightly of this, and wonder that a man shall think of another argument who has this in his power. But when Galileo began to communicate his knowledge to the world, this was the last support that a philosopher would think of. They had received a parcel of topics from their master, which had been handed down in the schools during many ages; and from these was every thing accounted for or explained. Aristotle, or his immediate pupils, had said that the velocities of falling bodies increased with their weights; Galileo's doctrine was incompatible with this, and he thought himself obliged to use arguments in his support. He said, that if Aristotle's doctrine be true, two crown pieces must fall faster when sticking together than when unconnected, which, said he, is contrary to common experience. Not doubting that he had convinced his audience, he described the experiments which he was to exhibit next day, shewing that in a double time a body would fall four times as far, &c. The experiments were performed in the dome of the great church, before a vast concourse of people, and succeeded most perfectly. Yet so little were the philosophers moved by this kind of argument, that they represented Galileo as a dangerous person, unfriendly to the state; and he was obliged to leave his native city in a few days, and take shelter in Padua. It is very remarkable that Baliani, one of the first geometers and mathematicians of that age, and who perfectly understood Galileo's speculations on this subject, should teach another doctrine, reviving or supporting an old scholastic assertion, that the velocity of a falling body might be as the space fallen through, calling this motion also a uniformly accelerated motion.

Galileo found more difficulty than one should expect in his endeavours to obtain an exact measure of the power of gravity; and indeed could not obtain one that was satisfactory. But the difficulty of the task, and his struggle to accomplish it, were big with advantages to science. A body falls so fast, that a considerable error in the conclusion arises from a very small error in estimating the time; and the great difficulty was how to estimate the time. It was in this casting about for a measure of a small portion of time that Galileo first thought of the pendulum. His penetrating and sagacious mind enabled him to see that there must be a fixed proportion between the time of a vibration and that of falling through its length, although his mathematical knowledge did not yet enable him to find it out; he saw an immediate consequence of this, if true, namely, that the vibrations of two pendulums should be in the subduplicate ratio of the lengths, because this must be the proportions of the times of falling through those lengths. This he would try; and he found that it was so. Delighted with this success, he immediately compared the time of falling from the top of the great dome with that of a pendulous vibration, by making a pendulum of such a length that it performed precisely one vibration in the time of the fall. In this time the body, moving with the final velocity, would describe a space double of that fallen through. He then counted with patience the number of vibrations made by his pendulum in an interval of time, measured by the transit of two stars. Thus he obtained the time, and the velocity generated in that time, by the uniform action of gravity. Galileo made this to be about 31 feet of our measure in a second, and said that it was certainly somewhat more; because his experiments on falling bodies convinced him that their motion is retarded by the air.

These efforts and resources of an ingenious mind are worthy of record, and are instructive to others. But Galileo did not attain the accuracy in this measure that we now possess. The honour of the accurate statement of the time of a pendulous oscillation, and that of the fall through its length, was reserved for Mr Huygens. This proportion was determined by him by a most ingenious and elegant physico-mathematical process. He also gave us the pendulum clock, by which time can be measured with as much accuracy as a line can be divided.

Aided by these inventions, we have now obtained the most precise measure of the accelerating powers of gravity; and we can now say that its intensity is such in the latitude of London, that by acting uniformly on a body for one second of time, it generates in it the velocity of 32 feet two inches per second, and a heavy body falls 16 feet one inch in that time.

These are standard numbers, of continual use in all mechanical discussions, and should be carefully kept in remembrance. Not only so, but we should acquire distinct notions of them in this respect, viz. as standard numbers. Gravity is known to us in two ways; our most familiar acquaintance with it is as a pressure, which we feel when we carry a heavy body. With this we can compare the pressure of a spring, the exertion of an animal, the pressure of a stream of water or wind, the intensity of an attraction, &c. by setting them in opposition and equilibrium. The philosopher, and especially the physical astronomer, and cultivator of the Newtonian philosophy, is well acquainted with gravity as an accelerating and a moving force, capable of accelerating, retarding, or deflecting the body in which it inheres, or on whose intimate particles it acts without intermedium. He can compare the gravity of a stone with that of the moon, or of Jupiter, or with the force that produces the precession of the equinoxes. The general mechanician, observing that all other pressures, such as that of a spring, of an animal, &c. are also moving forces, by combining those two aspects of gravity, makes a most important use of it, by comparing other forces with weights, and thence inferring the motions which those forces will produce. Thus, knowing that an arrow $\frac{7}{8}$ oz. weight, by falling 18 inches, acquires the velocity of $10\frac{1}{2}$ feet per second, he infers, that when drawn to the head by a bow of 62 pounds, it will be discharged with the velocity of 233 feet per second.

We shall therefore, in future, compare every force with gravity, and express the accelerating power of this standard by 32, meaning, that by acting on every particle of a body for a second, it will generate the velocity of 32 feet per second, and cause the body to describe 16 feet with a motion uniformly accelerated. We may find it convenient, on some occasions, to use the numbers 386, and 193, which are the inches in $32\frac{2}{12}$ and $16\frac{1}{12}$ feet.

The questions that interest us at present are, those concerning the relations between the time $t$ of any fall, the height $h$ of that fall, and the velocity $v$ that is uniformly acquired in falling; so that when any one of those things is given, the others may be found out.

I. Since the variations of velocity are proportional to the times in which they are produced, we have

$$1'' : t'' = 32 : 32t''$$
$$\text{and } v' = 32t''$$
$$\text{and } t'' = \frac{v'}{32}.$$

N. B. The time $t$ is always supposed to be a number of seconds, and the height $h$ a number of feet, and the velocity $v$ a number of feet uniformly moved over in one second.

A falling body, therefore, acquires an increment of 32 feet per second in every second of its fall, and an ascending body has its velocity lessened as much during every second of its rise. A body *falling* during four seconds, acquires the velocity of 128 feet per second.

But if the body has been projected downward with the velocity of 100 feet per second, then at the end of 4″, it is moving at the rate of 228 feet per second.

A body projected straight upwards with the velocity of 160 feet per second, will at the end of the first second of its rise, have the velocity 128. At the end of 2″ it will be moving at the rate of 96 feet per second. Its velocity at the end of the third second will be 64. At the end of the fourth second, it will be 32, and at the end of five seconds it will stop, and begin to fall.

The times of the rise and the subsequent fall are equal.

II. Since the heights are as the squares of the times of the fall or ascent, we have

$$1'' : t^2 = 16 : 16\,t^2$$
$$\text{and } h = 16\,t^2 \text{ and } \sqrt{h} = 4\,t.$$
$$\text{also } t^2 = \frac{h}{16}, \text{ and } t = \frac{\sqrt{h}}{4}.$$

A heavy body, falling during four seconds, falls 256 feet.

A body rising straight upwards 144 feet employs 3 seconds in its ascent.

III. Because the heights fallen through are also proportional to the squares of the velocities acquired at the end of the fall, we have

$$32^2 : v^2 = 16 : h$$
$$\text{and } h = \frac{16}{32^2}\,v^2, \text{ and } \sqrt{h} = \frac{4}{32}\,v, = \frac{v}{8}$$
$$\text{and, conversely, } v = 8\sqrt{h}, \text{ and } v^2 = 64\,h.$$

All questions concerning the perpendicular ascents and descents of heavy bodies may be solved by means of the two equations

$$v = 32\,t = g\,t$$
$$h = 16\,t^2 = \tfrac{1}{2}g\,t^2.$$

An easy mode of extempore computations is had, by remarking, that since a heavy body falls 16 feet in a second, and acquires the velocity 32, it falls 1 foot in $\frac{1}{4}$th of a second, and acquires the velocity 8.

In every second of the fall, the velocity is increased by 32; and in every foot of the fall, the square of the velocity is increased by 64.

In many questions, particularly in hydraulics, it is convenient to have the measures in inches.

Now, $\sqrt{193} : \sqrt{1} = 386 : 27{,}785$. Therefore a heavy body by falling one inch acquires the velocity 27,785 inches, or nearly $27\frac{3}{4}$ inches per second.

Did gravity impel a body uniformly along a space equal to the radius of the earth, it would generate the velocity which would enable the body to describe a parabola, having the centre of the earth for its focus. If projected straight upwards with this velocity it would never return.

Now $\sqrt{16} : \sqrt{\text{Earth's rad.}} = 32 : 36{,}680$ feet. This is the velocity now spoken of. Suppose the earth uniformly dense, and a pit to the centre. A heavy body would acquire, by falling down this pit, the velocity 25,866. Greater velocities than either of these can be produced by forces which we know. *Aurum fulminans* expands with the velocity of at least 42 miles per second.

It does not seem necessary to insist further on the rectilineal ascents and descents of heavy bodies, and therefore we proceed to consider their curvilineal motions, when projected in any direction that deviates from the perpendicular. These are the motions which are understood to form what is called PROJECTILES.

These motions are not only interesting to the philosophical mechanist, as examples of a constant deflecting force, and a uniform deflection in parallel lines, but also to the artillerist; because the motion of shot and shells are cases of this question, which comprehend the whole of his art. It has therefore been very much cultivated; and there is no branch of mechanical philosophy on which so much has been written, or so many experiments made for its improvement. The experimental cultivation of this branch could scarcely be prosecuted by private persons; but, in all the states of Europe, there are public establishments for this purpose, and no expence has been spared for bringing to perfection an art on which the fate of nations has unfortunately much dependence.

But, notwithstanding this liberal encouragement, and the numberless volumes which have been published on the subject, it cannot be said to have improved much as a science since it came out of the hands of its inventor, and his immediate pupil Tartaglia; and we shall be greatly disappointed if we look for that nice agreement between the results of the most approved theory and what we observe in the flight of great shot and shells. The theory, however, is unexceptionable; and the enormous deviations that we see in the actual performance of artillery, is owing to the resistance of the air. This was long considered as insignificant, even after Newton had given us sufficient information to the contrary. But the gentlemen of the profession made little account of the speculations of a private philosopher, and continued to regulate their theories by notions of their own. They have been at last convinced of their mistake by the curious experiments and discoveries of Mr Robins, and are improving their practice in some measure. But we now find, that the theory of the motion of heavy bodies through a resisting fluid, is one of the most abstruse and difficult tasks that the mechanician can take in hand.

At present, we are about to consider this subject merely as a particular case of motions regulated by gravitation, reserving the particular consideration of the modifications of these motions by the resistance of the air, till we shall have made ourselves acquainted with the general laws of such resistance.

Let a body (Plate CCLXXXVI. Fig. 1.) be projected in any direction AB, which deviates from the vertical AW. Then it would move on in this direction, and in equal succeeding moments would describe the equal spaces AB, BH, HI, IK, KL, &c. But suppose, that when the body is at B it receives an instantaneous impulse in the direction of the vertical BB′, such that by this impulse it would describe the line B *b* uniformly in the same time that it would have continued its motion along BH. Or, to speak more accurately, let the motion or velocity B *b* be compounded with the motion BH. The body must describe the diagonal BC of a parallelogram B *b* CH, and, at the end of this second moment, it must be in C, in the vertical line HCC′, and moving with the velocity BC. Therefore, in the third moment it would describe CN, equal to BC. But let another impulse in the direction of the vertical CC′ generate the velocity C *c*, equal to B *b*. By the composition of this with the motion CN, the body will describe the diagonal CD of the parallelogram C *c* DN, and at the end of the third moment must be in D, moving in the direction and with the velocity CD. It would describe DO equal to CD in the fourth moment. Another impulse of gravity D *d*, in the vertical, and equal to either of the former impulses, will make the body describe DE; and an equal impulse E *e* will deflect the body into EF; and another impulse F *f* will deflect it into FG, &c.

Thus it is plain that the body, by the composition of these equal and parallel impulses, will describe the polygonal figure ABCDEFG, all in one vertical plane, and in every instant or point, such as E, will be found in the vertical line KE, drawn from the point at which it would have arrived in that instant by the primitive projection.

Now, let the interval between these impulses be diminished, and their number be increased without end. It is evident that this polygonal motion will ultimately coincide with the motion in a path of continued curvation, by the continual and unvaried action of gravity.

The line described by the body has evidently the following properties.

*1st*, If a number of equidistant vertical lines BB′, HCC′, IDD′, KEE′, &c. be drawn, cutting the curve in B, C, D, E, &c. and if the chords AB, BC, CD, DE, &c. drawn through the points of intersection, be produced till they cut the verticals in H, N, O, P, &c. the intercepted portions HC, ND, OE, PF, &c. are all equal.

*2d*, The curve is a parabola, in which the verticals BB′, CC′, &c. are diameters. The property mentioned in the last paragraph belongs exclusively to the parabola. As the circle is the curve of uniform deflection in the direction of the radius, so the parabola is the curve of uniform deflection in the direction of the diameter. That the curve in which the chords drawn through the intersection of equidistant verticals cut off equal portions of these verticals is a parabola, is easily proved in a variety of ways. Since B *b*, C *c*, D *d*, E *e*, are all equal, and the verticals are equidistant, B *c d* E must be a straight line. So must C *d e* F; BE must be parallel to CD, and CF to DE. Therefore BF and CE are parallel, and are bisected in *m* and *o* by the vertical DD′. Also, if FC be produced till it meet the next vertical in *i*, *i* B is equal to D *m*. All this is very plain. Hence

$$i\,B, \text{ or } D\,m : d\,m = BF : m\,F, = m\,F, : o\,E;$$
$$\text{but} \quad d\,m : D\,o = m\,F : o\,E;$$
$$\text{therefore } D\,m : D\,o = m\,F^2 : o\,E^2;$$

and D, E, F are in a parabola, of which D *m* is a diameter, and *o* E, *m* F are semiordinates. We should prove, in the same manner, that BG is parallel to CF, and AG to BF, and $D\,m : DD' = m\,F^2 : D'G^2$, and the points D, F, G, in the same parabola.

Thus we have demonstrated, that the equal and parallel impulse of gravity produces a motion in a parabola, whose diameters are perpendicular to the horizon. This was the great discovery of Galileo, and the finest example of his genius. His discoveries in the heavens have indeed attracted more notice, and he is oftener spoken of as the first person who shewed the mountains in the moon, the phases of Venus, the satellites of Jupiter, &c. But in all these he was obliged to his telescope; and another person who had common curiosity would have seen the same things. But, in the present discovery, every step was an effort of judgment and reasoning, and the whole investigation was altogether novel. No attempt had been made, since the first dawn of mechanical science, to explain a curvilineal motion of any kind; and even the law of the composition of motion, though faintly seen by the ancients, had never been applied to any use (except by Stevinus) till this sagacious philosopher saw its immense importance, and brought it into constant service.

The process employed by Galileo in this investigation, and which has been copied by almost all the writers on the subject, is considerably different from the one now gone through. Galileo supposes the heavy body to fall in the vertical BB′ with a uniformly accelerated motion, describing spaces as the squares of the times. He supposes this motion to be compounded with the uniform motion in the direction of the tangent BR. Then, supposing that B $t$ and BT are fallen through while B $r$ and BR are described by the motion of projection, it follows, that because B $r$ is to BR as the time of describing B $r$ to the time of describing BR, we shall have B $t$ : BT $=$ B $r^2$ : BR$^2$. Therefore, completing the parallelograms B $t$ C $r$, BTSR, we have B $t$ : BT $= t$ C : TS, and the points B, C, S are in a parabola, whose diameter is BT, and has BR a tangent in B.

No doubt, the result of these suppositions agrees perfectly with the phenomena, and gives a very easy and elegant solution of the question. But, in the first place, it is more difficult, or takes more discourse, to prove this continued composition of motion (almost peculiar to the case) than to demonstrate the parabolic figure: and, secondly, it is not a just narration of the fact of the procedure of nature. There is no composition of such motions as are here supposed. When the body is at C, there is not a motion in the direction parallel to B $r$, compounding itself with a motion in the vertical, having the velocity which the falling body would have as it passes through the point $t$. The body is really moving in the direction CS of the tangent to the parabola, and it there receives the same infinitesimal impulse of gravity that it received at B. Its deflection, therefore, from the line of its motion, does not make any finite angle with that motion. Therefore, although Galileo's demonstration does very well for a mere mathematical process, like the navigator's calculation of the ship's place by tables of difference of latitude and departure, it by no means answers the purpose of the philosophical investigation of a natural phenomenon. The method we have followed is a bare narration of the facts; considering the motion of the body in every instant as it really is, and stating the force then really affecting its motion.

We have not scrupled to make use of the method employed by Newton in the demonstration of his fundamental proposition on curvilineal motions, first conceiving the action of gravity to be subsultory, and the motion to be polygonal, and then inferring a similar result from the uninterrupted action of gravity. But if any person is so fastidious as to object to this, (as John Bernoulli has done to Newton's method,) he may remark, that the motion B $b$, which we compared with BH, in order to produce the motion BC, is just double of the space B $t$, through which the body falls during the motion along BH. Therefore the figure will be such, that the curvilineal deflection will be one half of B $b$, or of HC, and the tangent to the curve, whatever it is, will bisect HC. Then, during the next moment, since the deflective action of gravity is supposed the same, the body will be as much deflected from its path in C, that is, from the new tangent CS, whatever direction that tangent may have, as it was in the preceding moment. This gives us $s$ D equal to $r$ C, and this obtains throughout. Without entering on any discussion on the progress of the deflection in the different points of the arch BC or CD, it is enough for our purpose to shew that the curve described is such, that when equidistant verticals are drawn, and tangents drawn through their intersections with the curve, the portions of the verticals cut off by the tangents are everywhere equal. This also is a property of the parabola exclusively. That BCD is a parabola, of which BT is a diameter, and BR a tangent, is easily seen. For, drawing D $u$ parallel to BR, it is plain that $v$ N $=2\,r$ C, and ND $=2\,s$ D, $=2\,r$ C. Therefore $v$ D $=4\,r$ C, and B $u=4$ B $t$, and B $t$ : B $u = t$ C$^2$ : $u$ D$^2$. And we should prove, in the same manner, that $y$ E $=9\,r$ C, &c.

Having thus ascertained the general nature of the path of a projectile, we must now examine its motion in this path, determining its velocity in the different points, and the time employed in the description of the arches. For this purpose we must first ascertain the precise parabola described under the conditions of the projection, that is, depending on its direction and velocity. To do this in a way naturally connected with the acting forces, we shall consider the velocity of projection as having been generated by falling through some determinate height.

Let us therefore suppose that the body is projected from B, Plate CCLXXXVI. Fig. 1. in the direction BR, with the velocity acquired by falling through the vertical VB. Make BT equal to VB, and BR equal to VT or 2 VB, and, lastly, draw TS parallel to BR, meeting the parabola in S.

It is plain that BR is the space which would be uniformly described with the velocity of projection in the time of falling through VB. Also B $r$ is the space that would be uniformly described, with the same velocity, in the time of falling through B $t$. Therefore BR is to B $r$ as the time of falling through VB to that of falling through B $t$. But, since BT is equal to VB, B $r$ is to BR as the time of falling through B $t$ to the time of falling through BT. Therefore BR is to B$r$ as the time of falling through VB to that of falling through B$t$. But, since BT is equal to VB, B $r$ is to BR as the time of falling through B $t$ to the time of falling through BT. Therefore we have B $t$ : BT $=$ B$r^2$ : BR$^2$. But, in the parabola, we have B $t$ : BT $= t$ C$^2$ : TS$^2$, $=$ B$^2$ : TS$^2$. Therefore TS is equal to BR, or to twice VB or BT. Therefore TS$^2$ $=4$ BT$^2$, $=4$ BT $\times$ BV, $=$ BT $\times$ 4 BV. But, in a parabola, the square of any ordinate TS is equal to the rectangle of the absciss BT and the parameter of that diameter. Therefore 4 VB is the parameter of the diameter BT, and VB is the fourth part of that parameter.

If, therefore the horizontal line VZ be drawn, it is the directrix of the parabola described by a body projected from B in any direction, with the velocity acquired by falling from V.

*Cor.* 1. As this is true for any other point, C, D, &c. it follows that the velocity in any point of the path is that which a heavy body would acquire by falling from the directrix to that point.

*Cor.* 2. Hence also we learn that the velocities in any two points, such as B and D, are proportional to the portions $v\,y$ and D $t$ of the tangents through those points which are intercepted by the same diameters. Thus, $vy$ is a portion of the tangent B $y$, intercepted by the diameters DD′ and EE′, which also intercept a portion of the tangent D $t$. For these portions of tangents are in the subduplicate ratio of the lines VB and ZD. Now the velocities acquired by falling through VB and ZD are in this subduplicate ratio of the spaces fallen through.

Such is the Galilean Theory of the parabolic motion of projectiles; a doctrine valuable for its intrinsic excellence, and which will always be respectable among philosophers, as the first example of a problem in the higher department of mechanical philosophy.

We are now to consider it as the foundation of the art of gunnery. But it may be affirmed, at setting out, that the theory is of very little use for directing the practice of cannonading. Here it is necessary to approach as near as possible to the object, and the hurry of service allows no time for geometrical methods of pointing the piece after each discharge. When the gun is within 300 yards of the object, the gunner points it straight on it, or rather a little above, to compensate for the small deflection which obtains, even at this small distance. Sometimes the piece is elevated at a small angle, and the shot, discharged with a very moderate velocity, drops on the ground, and bounds along, destroying the enemy's troops. But, in all these cases, the gunner is directed entirely by practice, and it cannot be said that the parabolic theory is of any service to him.

Its principal use is for directing the bombardier in the throwing of shells. With these it is proposed to destroy buildings, to break through the roofs of magazines, to destroy troops by bursting among them, &c. Such objects being generally under cover of the works of a place, cannot be hit by a direct shot, and therefore the shells are thrown with such elevated directions, that they get over the works, and produce their effect. These shells are of great weight, sometimes exceeding 200 lb. The mortar from which they are discharged must be exceedingly strong, that it may resist the explosion of the powder able to impel this vast mass to a great distance. They are therefore most unwieldy; and it is found most convenient to have them almost solid, and unchangeable in their position. The shell is thrown to the intended distance by employing a proper quantity of powder. This is found incomparably easier than to vary the elevation of the mortar. We shall also find, that when a proper elevation has been selected, a small deviation from it, unavoidable in such service, is much less detrimental than if another elevation had been chosen. Mortars, therefore, are frequently cast in one piece with their bed or carriage, having an elevation that is not far from being the best on all ordinary occasions, and the rest is done by repeated trials with different charges of powder.

Still, however, in this practice, the parabolic motion must be understood, that the bombardier may avail himself of any occasional circumstance that may be of advantage to him. We shall therefore consider the chief problems that the artillerist has to resolve, but with the utmost brevity; and the reader will soon see, that more minute discussion would be of very little service.

The velocity of projection is measured by the fall that is necessary for acquiring it. It has generally been called the force, or IMPETUS; we shall distinguish it by the symbol $f$. Thus, in Plate CCLXXXVI. and Fig. 2, 3, 4, FA is the height through which the body is supposed to fall, in order to acquire the velocity with which it is projected from A.

The distance AB between the piece of ordnance and the object, is called the AMPLITUDE, and also the range $=r$.

Let the angle EAB contained between the vertical and the direction of the object be called the ANGLE OF POSITION $=p$.

And let the angle DAB, contained between that direction and the axis of the piece, be called the direction of the mortar $=d$, and let $z$ express the zenith distance or angle EAD, contained between the axis of the mortar and the vertical line AE.

The leading problem from which almost all the others may be derived, is the following.

Let a shell be thrown from A, (Fig. 3, 4.) with the velocity required by falling through the vertical FA, so as to hit an object B. Required the direction AD of the projection.

Let AH be a horizontal line, and AB the line of position of the object. In the vertical AF, take AE $=$ 4 AF, and on EA describe an arch of a circle ED $d$ A, which shall touch the line of position AB. Draw through the object the vertical line BD, cutting the circle in D and $d$, and join AD and A $d$. I say that AD or A $d$ are the directions required. Join ED and E $d$.

For, because AB touches the circle in A, the angle ADE is equal to the exterior angle EA $a$, or DBA, and the alternate angles EAD, ADB are equal. The triangles ADB and EAD are therefore similar, and DB : DA $=$ DA : AE, and $DA^2 = DB \times EA$. Therefore B is in a parabola, of which the vertical AI is a diameter, AD a tangent in A, and AE the parameter of that diameter. If, therefore, the body be projected from A in the direction AD, with the velocity acquired by falling through FA, the fourth part of this parameter, it will describe a parabola AVB which passes through B.

By the same reasoning, it is demonstrated that the body will hit the mark B, if projected in the direction A $d$ with the same velocity, describing the parabola A $v$ B.

From this very simple construction, we may draw several very instructive corollaries.

*Cor.* 1. When the vertical line passing through B cuts the circle EDA, it always cuts it in two points D and $d$, giving two directions AD and A $d$, either of which will solve the problem.

*Cor.* 2. But if the vertical through $b$ only touch the circle, as it touches it in one point only, it gives but one direction, along which the body must be projected to hit the mark $b$. This direction is AG.

*Cor.* 3. The direction AG evidently bisects the angle EAB, and the directions AD and A $d$ are equidistant from the middle direction AG.

*Cor* 4. If the vertical passing through B do not meet the circle described on AE, according to the conditions specified, the object is too remote to be struck by a body projected from A with the velocity acquired by falling from F. There is no direction that will enable it to go so far on the line AB. The distance A $b$ is the greatest possible with this velocity, and it is attained by taking the elevation AG which bisects the angle EAB. We may therefore call A$b$ the *maximum range* on the line AB, and AG the *middle direction.*

*Cor.* 5. The distances on a given line of position to which a body will be projected in a given direction AD, are proportional to the squares of the velocities of projection. For the figure being similar, the range AB has the same proportion to AF, the fall necessary for acquiring the velocity. Now the falls are in the duplicate ratio of the velocities required by falling. Therefore, &c.

The converse of this problem is solved with the same facility of construction.

Let a body be projected in the direction AD, with the velocity acquired by falling through FA, it is required to find to what distance it will reach on the line AB.

Describe, as before, on AE, $=$ 4 AF, the circle EDA, touching AB, and cutting AD in D. Through D draw the vertical DB, cutting AB in B. Then B is the point to which the projectile will reach. The proof is too evident to need discussion.

Lastly, suppose the object B to be given, and also the line of direction AD (which is a very common case, seeing that our mortars are often so fixed in their beds that their elevation can be very little altered) it is required to determine the velocity that must be given to the projectile.

Draw through the object the vertical BD, meeting the direction in D. Draw the vertical AE, and make it a third proportional to DB and DA, that is, make $AE = \frac{DA^2}{DB}$, and take $FA = \frac{EA}{4}$. Then FA is the fall which will generate the velocity required for the projection. The demonstration of this is also very evident.

Notwithstanding the great simplicity of the construction of these problems, we cannot obtain numerical solutions for practice with equal simplicity, except when the line of position is horizontal, as in Fig. 2. This indeed is the most general case, and there are few situations so abrupt as to deviate very far from this case, the greatest height of a fortress commonly bearing but a small proportion to the distance of the mortar.

When AB is a horizontal plane, as in Fig. 2. the arch EDA is a semicircle.

In this case the maximum range A $b$ is equal to AC, the radius of the circle, and equal to twice the height FA necessary for acquiring the velocity of the projection. This greatest range is obtained by elevating the mortar 45 degrees from the horizon.

The ranges with different directions, are proportional to the sines of twice the angles of elevation. For drawing GC, DL, $dl$, perpendicular to EA, and drawing the radii CD and C$d$, we have CG equal to the range A $b$, and $l\,d$ equal to the range AB. Now CG is the sine of the angle ACG, which is double of GAB, and $l\,d$ is the sine of AC$d$, which is double of AE$d$, which is equal to the elevation $d$AB; and the same is true of all other elevations. We may always employ this analogy as radius to the sine of twice the angle of elevation, so is twice the height necessary for acquiring the velocity to the range of the projection on a horizontal plane.

The height to which the projectile rises above the horizontal plane is as the square of the sine of elevation. For OV, the axis of the parabola, is $\frac{1}{4}$th of DB or LA;—and FA, the height to which the projectile would rise straight upwards, is $\frac{1}{4}$th of EA. Now EA : LA$=$EA$^2$: AD$^2$$=$rad.$^2$: sin.$^4$ AED,$=$rad.$^2$ sin.$^2$ elevation. Therefore FA : VO$=$rad.$^4$ : sin.$^2$ elevation; also VO : $v$ O$=$sin.$^2$ DAB : sin.$^2$ $d$AB, &c.

The times of the flights are as the sines of the elevation. For the velocities in the directions AD, A $d$, being the same, the times of describing AD and A $d$ uniformly will be as AD and A $d$. Now AD and A $d$ are as the sines of the angles AED and AE $d$, which are equal to the angles DAB and $d$AB. Now the times of describing AD and A $d$ uniformly with the velocity of projection, are the same with the times of describing the parabolas AVB and A $v$ B.

When the object to be struck is on an inclined plane, AB, ascending, as in Fig. 3. the arch EDA is less than a semicircle; and when it is on a descending plane, as in Fig. 4. EDA is greater than a semicircle. This considerably embarrasses the process for obtaining the direction, when the impetus and the object are given, or conversely. It has been much canvassed by the many authors who deliver theories of gunnery, and the parabola affords many very pretty methods of solving the problem. Dr Halley's, in the *Philosophical Transactions*, No. 179, is peculiarly elegant. Mr Thomas Simpson's also, in No. 486, is extremely ingenious and comprehensive, and has been reduced to a very elegant simplicity by Frisius in his *Cosmographia*. But neither of these methods shew so distinctly the connection between the different circumstances of the motions, or keep the general principle so much in view, as the one here given; and all the arithmetical operations which finally result from them, are precisely similar to those deduced from our construction.

The following method, suggested by the simple construction now given, is probably as easy and as expeditious as any.

Draw the horizontal line HA $a$, Fig. 3. and 4. cutting the vertical drawn through B in K; let C be the centre of the circular arch EDA. Join AC, and draw GC, cutting the verticals through A and B in the points $f$ and $g$. Also draw CD and C $d$. Let $p$ represent the angle of position EAB, and $d$ the angle of direction DAB, which the axis of the piece makes with the line of position AB. Also let $z$ be the angle EAD which the axis makes with the vertical. Let $r$ express the range AB, and $f$ the fall FA necessary for communicating the velocity of projection. Then the parameter of the parabola at the point of projection is $4f$, $=$AE, and using S to express the sine,

We have AB : DB$=$S, EAD : S, DAB,$=$S, $z$ : S, $d$.
DB : DA$=$S, DAB : S, DBA,$=$S, $d$ : S, $p$.
DA : AE$=$S, DEA : S, EDA,$=$S, $d$ : S, $p$.
Therefore AB : AE$=$S, $z\times$S, $d$ : S$^2$, $p$.
That is $r : 4f=$S, $z\times$S, $d$ : S$^2$, $p$.
And $r\times$S$^2$, $p=4f\times$S, $z\times$S, $d$.

Hence are derived formulæ, which solve all the questions contained in the problem.

$$\text{I. } r=\frac{4f\times \text{S}, z\times \text{S}, d.}{\text{S}^2, p.}$$

$$\text{II. } f=\frac{r\times \text{S}^2, p.}{4\,\text{S}, z\times \text{S}, d.}$$

$$\text{III. S}, d=\frac{r\times \text{S}^2, p.}{4f\times \text{S}, z.}$$

The answers to these questions expressed in the two first cases are obtained by a single operation. In the first case, the maximum value of $r$, which corresponds with the elevation AG, is a third proportional to AE and AD, and will be had by the analogy sin.$^2\,p$ : sin. $\frac{1}{2}p=4f : r$.

We also may remark, that the ranges made with the same velocity, and on the same declivity, are as the products of the sines of $d$ and of $z$.

But these formulæ do not afford so ready an answer, when $d$ is the thing wanted, as one would expect from their simplicity. When $d$ is unknown, $z$ is also unknown. In this case we must remark, that S, $z\times$S, $d$ is equal to $\frac{\cos.\,\overline{z\backsim d}-\cos.\,\overline{z+d}}{2}$, and that $z+d=p$.

This changes our formula into $r\times\sin.^2 p=4f\times\frac{\cos.\,\overline{z\backsim d}-\cos.\,\overline{z+d}}{2}$,$=2f\times\overline{\cos.\,z\backsim d-\cos.\,p}$,$=2f\times\cos.\,\overline{z\backsim d}-2f\times\cos.\,p$. Therefore we have

$$r\times\sin.^2 p+2f\times\cos,\,p=2f\times\cos.\overline{z\backsim d}.$$

Having obtained the arch $z\backsim d$, and having $z+d=p$, we easily obtain $d$, it being $=\frac{p+z\backsim d}{2}$. The process is much expedited by the help of a table of natural sines. We must remember, that when the projection is made on an ascending plane, the quantity $2f\times\cos.\,p$, is to be added to $r\times\sin.^2 p$; but that it is to be subtracted from it if the projection is made on a declivity.

But a plainer method may be taken, although not so obviously deduced from the general principle. The position of the object B being known, its horizontal distance AK is known. Call this $h$. The middle direction AG is also known. The line $f$ A is also known, being $=2f$. Now $f$ C$=2f\times$ tan. $f$ AC, $=2f\times$ cotan. $p$. Call this $b$. Then C $g$ is $=h+b$, or $=h-b$, according as the projection is made on an ascending or a descending plane. Now we have

$$f\text{A} : \text{C}\,g=\cos.\,\text{p} : \cos.\,\overline{d-z}, \text{ or}$$
$$2f : h\pm b=\cos.\,p : \cos.\,\overline{d-z}.$$

Then to $\frac{1}{2}p\,(=\frac{1}{2}\overline{d+z})$ add $\frac{1}{2}\overline{d-z}$, and we obtain $d$.

This is, in fact, the process to which we are ultimately led by every method that is taken for the solution of this case of the problem.

The construction suggests another process, which may be more acceptable to some readers. The angle $f$AG is $\frac{1}{2}$ EAB. Therefore $f$G$=2f\times$ tan. $\frac{1}{2}p$, and $2f\times$ tan. $\frac{1}{2}p$—

AK$=g$ G, = the versed sine of $z \propto d$, CA, or $\frac{2f}{\sin. p}$ being radius.

There are two questions more that must be solved before the artillerist can have all the information he requires. In throwing of shells, it is of peculiar importance that the fuse of the shell burn during the whole time of the flight, but no longer; and it would be best of all, were it ended when the shell is about six feet from the ground. This requires an exact knowledge of the time of the flight.

The time of the flight is the same with that of falling through DB. We must therefore calculate DB in feet.

Then $t = \frac{\sqrt{DB}}{4}$; $t^2 = \frac{DB}{16}, = \frac{r \times \sin. d}{16 \sin. z}$. From the sum of the logarithms of the range (measured in feet) and the sine of the direction, take the sum of the logarithm of 16 and the sine of the zenith distance, and half the remainder is the time of the flight, measured in seconds.

If the best or middle direction had been chosen, which is generally not far from being the case, DB is equal to BA or $r$. Therefore in this case we have $t = \frac{\sqrt{r}}{4}$.

Lastly, with respect to the velocity and momentum with which the projectile makes its stroke, this is easily deduced from the property of the parabolic motion. We know the velocity of projection, or the velocity at A, namely, that which is acquired by falling through FA. In like manner, the velocity at B is that acquired by falling through F $\alpha$, (B $\alpha$ being drawn parallel to the horizon). Therefore, $\sqrt{FA} : \sqrt{F\alpha}$ = velocity at A : velocity at B.

## CHAP. II.

### *On the Determination of the Initial Velocity of Projectiles from the explosive force of Gunpowder.*

In our article Gunpowder, we have already noticed Mr Robins' investigations respecting the explosive force of gunpowder, and we have suggested some important corrections upon the data which he employed. We shall now proceed to give an account of the solution of the important problem of determining the initial velocity of a ball, when the elasticity of the powder at the instant of its firing is given, and when the density of the ball, the quantity of the charge, and the dimensions of the piece of artillery from which it is thrown, are known.

The solution of this problem depends upon the two following principles.

1. That the action of the powder upon the ball ceases as soon as it is out of the piece.

2. That all the powder is converted into an elastic fluid before the ball is sensibly moved from its place.

The first of these principles is sufficiently manifest from the consideration, that the flame will very suddenly extend itself in every direction when it reaches the mouth of the gun, and therefore its force on the bullet will be completely extinguished.

The second principle, though less obvious, is equally certain. If the powder was fired successively, and not all at once, it occurred to Mr Robins, that by using two or three bullets instead of one, a greater quantity of powder would be fired, since a heavier weight would require a longer time to pass through the barrel. Hence two or three balls should be impelled with a much greater force than one. This, however, is by no means the case. Mr Robins found, from experiment, that the velocities with which different numbers of balls were discharged were reciprocally in the subduplicate ratio of the number of balls; that is, if one ball was discharged with a velocity of 1700 feet per second, the same charge would impel two balls with a velocity of from 1250 to 1300 feet per second, and three balls with a velocity of from 1050 to 1110. But when bodies, containing different quantities of matter, are successively impelled through the same space, with the same power acting at each point of that space with a given force, then the velocities communicated to these different bodies should be reciprocally in the subduplicate ratio of their quantities of matter. Hence, since the velocities are in the subduplicate ratio of the number of balls, the action of the powder must, in all these cases, have been nearly the same, and consequently the truth of the principle is established.

Let us now suppose that AB, Plate CCLXXXVI. Fig. 5. is the axis of the gun, DCGE the part of the cavity filled with powder, and that the hinder surface of the ball lies at GE. Then if we take FH to represent the force with which the ball is impelled at the point F, and if through H we draw an hyperbola KHNQ to the asymptotes AI, AB forming a right angle, the ordinate MN will represent the force with which the ball is impelled at M; for since the densities of the elastic fluid at the points F and M are as AM to AF, or as FH to MN, the forces will be in the same ratio. Take EL to FH as the force which impels the ball at F is to the weight of the ball, and draw LP parallel to EB. Then the equal lines LF, RM, &c. will be to the corresponding ordinates FH, MN as the gravity of the ball is to the force with which it is impelled at the points F and M. But by Prop. 39. Book I. of Newton's *Principia*, the areas FLPB, FHQB are as the squares of the velocities which the ball would acquire when acted upon by its own gravity through the space EB, and when impelled through the same space by the force of the gunpowder. Hence we shall have

$$V = \sqrt{\frac{FHQB \times (\text{Vel. of falling through FB})^2}{FLPB}}$$

If we therefore put

V = velocity of the ball.
L = length of the charge of powder.
B = length of the bore AD.
S = specific gravity of the ball.
D = the diameter of the bore, and
W = the weight of the ball in ounces, we shall have

$$V = 27130\sqrt{\frac{10\,L}{SD} \times \text{Log.}\frac{B}{L}}, \text{ or}$$

$$V = 100\sqrt{\frac{223\,LD^2}{W} \times \text{Log.}\frac{B}{L}}.$$

Thus making L = $2\frac{5}{8}$ inches.
B = 45 inches.
S = 1.345 for a leaden ball.
D = $\frac{3}{4}$ of an inch.

Then we shall have

$$V = 27130\sqrt{\frac{7}{2269} \times \text{Log.}\frac{120}{7}} = 1674$$ for the velocity of the ball per second; or if the weight of the ball W = $1\frac{9}{20}$ oz. or $\frac{29}{20}$ oz. then,

$$V = 100\sqrt{\frac{1115 \times 189}{29 \times 32} \times \text{log.}\frac{120}{7}} = 1674$$ feet, as formerly.

Having thus determined theoretically the initial velocities of projectiles, Mr Robins was anxious to compare his theory with experiment. He was thus led to the invention of the ballistic pendulum, by which the real velocities may be measured with such a degree of exactness, that in a velocity of 1700 per 1″, the error will never exceed the 500th part.

## CHAP. III.

*On the Methods of determining experimentally the Velocities of Projectiles at any Distance from the Gun from which they are discharged.*

The ballistic pendulum, which Mr Robins invented for measuring the initial velocity of projectiles, is shewn in Plate CCLXXXV. Fig. 12. where ABCD represents the body of the machine consisting of three poles B, C, D, joined at A. On the sockets R, S, screwed upon two of these poles, rests the horizontal axis EF, which suspends a pendulum GHIK, made of iron, with a broad surface at its extremity. A thick piece of wood GHIK is fastened by screws to the broad surface of the iron. A little below the bottom of the pendulum is a brace OP, joining the two poles B, C; and on this brace is fastened a contrivance MNU, made somewhat like a drawing pen, with two edges of steel, bearing on each other in the line UN, the pressure of these edges being regulated by a screw Z. To the bottom HI of the pendulum is fastened a narrow ribbon LN, which passes between the steel edges, and which hangs losely down, as at W, through an opening cut in the lower piece of steel.

Dr Hutton made some considerable improvements on the ballistic pendulum. At first he used a narrow tape, divided into inches and tenths, to which he adapted a contrivance different from that of Mr Robins. From the bottom of the pendulum proceeded a tongue of iron, which was raised or depressed by means of a screw. This tongue was cloven at the bottom to receive the end of the tape, and the tips were pinched together by a screw. Immediately below this, the tape was passed between two slips of iron, which could be brought to any degree of approach by two screws. These pieces were made to slide vertically up and down a groove in a heavy block of wood, and could be fixed at any height by a screw.

This method of measuring the chord of the arc of vibration by the tape was however often attended with uncertainty; and Dr Hutton adopted the following simple contrivance. He took a block of wood, having its upper surface formed into the arc of a circle of nearly the same radius as the extreme length of the pendulum. In the middle of this arch was a shallow groove three or four inches broad, running along the middle of the block through its whole length. This groove was filled with a composition of soft soap and wax, of about the consistency of honey, or a little firmer, having its upper side smoothed off with the general surface of the broad arch. A sharp spear proceeded from the bottom of the pendulum, so as just to enter and scratch the surface of the composition in the groove, without having its motion sensibly retarded. From the trace which was thus left, the length of the cord of the arc of vibration was easily measured.

The pendulum being thus constructed, is used in the following manner. The ball is discharged against the block of wood GHIK, which in consequence of the impulse, vibrates through an arc of a certain extent, which of course increases with the velocity of the ball. The extent of the arc of vibration is measured by the length through which the ribbon LN is pulled out through the edges UN. Hence, if the weight of the pendulum is known, and also the distance of its centre of gravity and oscillation from its axis of suspension, it is easy to determine the extent of the arc of vibration, the velocity with which it is struck by a body of a known weight entering it at a given point. In the investigation of the theorem for computing the velocity of the ball, Mr Robins committed a trifling mistake, which he corrected in the *Philosophical Transactions* for 1743, but which the editor of his works omitted to insert in the New Principles of Gunnery published in 1761. The theorem of Robins is

$$v = \frac{c}{r} \times \frac{pg}{bi} + \frac{i}{o} \times \frac{o}{\sqrt{2i}}$$

The theorem as corrected by Euler, is

$$v = \frac{c}{r} \times \frac{pg}{bi} + \frac{o+i}{2o} \times \sqrt{\frac{o}{2}}$$

The formula given by Antoni is

$$v = c\sqrt{32.18 \times \frac{\overline{pgo + bi^2} \times \overline{pg + bi}}{bir}}$$

which is $v = 5.6727c\sqrt{\frac{\overline{pgo + bi^2} \times \overline{pg + bi}}{bir}}$

The formula given by Dr Hutton is

$v = \frac{5.6727c}{bir}\sqrt{\overline{pgo + bii} \times \overline{pg + bi}}$, almost the same as Antoni's, which he reduces to the following very simple formula:

$$v = 5.6727gc\,\frac{p+b}{bir}\sqrt{o},$$

which is within $\frac{1}{5000}$dth part of the true quantity, and will always give the velocity within less than half a foot, even when the velocities are greatest. In these formulæ,

$v$ = the initial velocity of the ball at the instant of impact.

$b$ = weight of the ball.

$p$ = weight of the pendulum.

$g$ = distance to its centre of gravity.

$o$ = the distance of its centre of oscillation.

$i$ = the distance to the point of impact, or the point struck by the ball.

$c$ = the chord of the arch of vibration.

$r$ = its radius or distance to the ribbon.

The machine of Mattei for measuring initial velocities near the mouth of the gun, which we have already briefly described, was employed by Antoni. It consists of a horizontal wheel AB, mounted upon a vertical axis, and put in motion by the descent of a weight Q suspended to the rope GG, and which can be raised into a state of activity by the winch fixed to the axis of the pulley P. A circular band of writing paper AE, BF, about six inches high, is fixed round the circumference of the wheel AB, so as to form a drum 10 feet in diameter. A butt or block of elm is placed about two or three feet from the drum to receive the balls. The gun being fixed immoveably at the distance of 20 feet, so that its axis produced would pass through an exact diameter of the drum perpendicular to GG, the machine is put in motion by the descent of the weight Q. The motion soon becomes uniform, and the velocity of the drum is measured by a small eccentric wheel IL upon the axis CD, which at every revolution gives a vibratory horizontal motion to a tongue of wood, at the extremity of which is suspended a common pendulum, which is shortened or lengthened till its vibrations are isochronous to those of the tongue. The time in which the wheel performs a revolution will be shewn by the length of the pendulum. When the pendulum and the tongue have acquired an isochronous motion, the gun is discharged, and the wheel stopped. The hole made in the drum at the first entrance of the ball will be easily distinguished from the other hole which is made at its exit, by the edges of the holes being turned to the point by which the ball went out of the drum. A thread is then stretched in the direction in which the ball was fired, so as to pass through the centre of the first hole, and the point where the line cuts the drum is marked. The distance between this mark and the second hole is the distance through which the circumference of the drum has moved while the projectile was passing through a space equal to its diameter.

In order to find the uniform velocity of the shot in a second of time, call $d$ the diameter of the wheel, $c$ its circumference, $t$ the time in which the wheel performs one revolution, $m$ the distance through which a part of the circumference of the drum moves while the ball is traversing the distance D, and $v$ the initial velocity of the shot in a second of time: then $m : d = c : \frac{cd}{m}$ = the space passed through by the shot with a uniform velocity during one revolution of the wheel: then as $t : 1 = \frac{cd}{m} : \frac{cd}{tm} = v$.

In using this machine, Antoni used wads of parchment torn in several places, that they might not injure the drum of paper. An account of the experiments themselves will be given in the next Chapter.

Antoni has given an account of other three methods of measuring the initial velocities of projectiles. The first consists in measuring their respective penetrations into a homogeneous butt of a known consistency. If we call $b$ the consistency of the butt, $d$ the diameter of the shot, $p$ the depth of its penetration, and $v$ the initial velocity, we shall have $v = \sqrt{\frac{bp}{d}}$. In order to find $b$, the consistency of the butt, fire a piece of small calibre, with an iron shot one inch in diameter, and measure its initial velocity by the methods already described, and let it be 1000 feet, then $v = 1000$. Let the same piece be then loaded as before, and fired into the butt, and let its penetration be 12 inches, or 1 foot, $= p$. Then, since $bp = dv^2$, we shall have $p \times 1 = \frac{1}{12} \times 1000^2$, or $p \times 83333$. Substituting then, in the formula, $bp = dv^2$, we have $83333\,p = dv^2$. The consistency of the butt being thus found, place the great gun, the initial velocity of whose shot is required, and having fired several rounds in a horizontal direction against the butt, let the mean of the different depths of penetration be $7 = p$, and let $d$, the diameter of the shot, be equal 4 inches, then we have $83333 \times 7 = \frac{4}{12} v^2$, and $v =$

$$\sqrt{\frac{83333 \times 7 \times 12}{4}} = 1323,$$ the initial velocity required.

The second method proposed by Antoni of determining initial velocities, consists in analysing and resolving into its simple movements the curve described by the projectile on quitting the piece. In order to effect this, a gun AB, Plate CCLXXXVI. Fig. 7, mounted on its carriage, and laid on an even and solid platform, is placed with its axis in a horizontal direction AC, so that the shot, at its first graze, may touch the earth in the point C of the horizontal line DF. The vertical distance KG is obviously the space through which the shot has descended by the action of gravity, which may be called $s$, and the horizontal distance AK or DG is the space which it has passed through in the same time, in virtue of the impulsive or projectile force. Then since $s = \frac{32.18\,t^2}{2}$, and $t = \sqrt{\frac{2s}{32.18}}$, we have, by substituting KG for $s$, $t = \sqrt{\frac{2\,KG}{32.18}}$ = the time in which the shot is impelled from A to K. Having obtained DG accurately from the mean of several trials, call it $r$, and considering it as uniformly passed over, say, as $t : r = 1 : \frac{r}{t}$, the initial velocity, or the space through which the shot would move in a second, without considering the air's resistance. Let KG = four feet, then we have $t = \sqrt{\frac{2 \times 4}{32.18}} = \frac{1}{2}$ a second; and if DG = 700 feet, we have $\frac{r}{t}$, or $v = \frac{r}{\sqrt{\frac{2 \times 4}{32.18}}} = 1400$ feet, the initial velocity required.

As the initial velocity thus determined is not absolutely correct, on account of the resistance of the air, a more accurate result may be obtained, by placing a butt LMN nearer the gun. Let a line be drawn on the butt at M, where it is cut by the horizontal line of direction AM, and by firing several shot at the butt, the vertical distance MH = $s$ will be ascertained. By measuring the distance DL, and using the formulæ already given, the initial velocity $v$ will again be found. The nearer the gun is brought to the butt, the more correct will the initial velocity be found. Both these methods may be applied to guns of all lengths and calibres.

The third method of determining initial velocities is, by deducing them from the thickness of the metal of the fire arm when it is in equilibrio with the pressures of the elastic fluid in every point of its length. This method, however, is not applicable to guns of large calibre fired with the common charges of powder, but only to fusils and pieces of small calibre. Antoni informs us, that in Piedmont musket barrels are proved, by charging them with 17 drachms of common cannon powder, over which is put a very high wad of hard tow, which is with difficulty pressed into the barrel, and which is afterwards rammed down with all the force which the armourer can exert. A leaden bullet, weighing $18\frac{1}{2}$ drachms, is then put in, and wadded as before. The barrels being placed with their breech upon a strong beam of wood, are each fired twice. Many of them burst, sometimes at the breech, and sometimes in the middle of the bore, and sometimes near the muzzle; but as the bursting never happened more frequently on one part than another, the officers and manufacturers did not consider it as necessary to make any change in the thickness of the metal. Hence in guns of this kind, the thickness of the metal may be considered as proportional to the pressure of the elastic fluid in every part of their length.

As this method is not likely to be of much use, we shall merely refer the reader to Antoni's *Treatise on Gunpowder*, translated by Thomson, p. 87, 88, 165, &c.

## CHAP. IV.

*Comparison of the Initial Velocities of Bullets, as computed from the Theory, with the actual Velocities, as determined by the Ballistic Pendulum.*

In determining the initial velocity of bullets, Mr Robins used a musket barrel, nearly as thick at the muzzle as at the breech, and its thickness was made equal to the diameter of its bore. It was always charged with a ladle, as in the case of cannon, and the wadding was never greater than was necessary to confine the powder to its proper place. In order to prevent the impulse of the flame from acting upon the pendulum, the mouth of the musket should be sixteen or eighteen feet from it, when the charge is half an ounce of powder. With larger charges, Mr Robins has often found the impulse to be sensible at the distance of twenty-five feet.

His first set of experiments was made with a musket 45 inches long; the diameter of the ball was $\frac{3}{4}$ths of an inch, and the cavity containing the powder was $2\frac{5}{8}$ inches, which, as the barrel exceeded the bullet by about the 40th of an inch, contained exactly 12 penny-weights of powder. This barrel we shall call A.

The weight of the whole pendulum was 52 lb. 3oz. The distance of the centre of gravity from the axis of suspension was 52 inches; 200 of its small swings were performed in 253 seconds, and therefore the distance of its centre of oscillation from the axis of suspension, was $62\frac{2}{3}$ inches.

The following results were obtained with this pendulum and the barrel A.

| Number of experiments. | Barrel employed. | Quantity of Powder. | Chord of its Ascending Arch measured on the Ribbon. | The same by the Theory. | Error of the Theory. |
|---|---|---|---|---|---|
| | | Dwts | | | |
| 1 | A | 12 | 18.7 | 19.0 | +.3 |
| 2 | A | 12 | 19.6 | 19.0 | —.6 |
| 3 | A | 6 | 13.6 | 13.4 | —.2 |

Another set of experiments was made with the same barrel, but with a pendulum exceeding a little the weight of 56 lb. 3 *oz.* and the following results were obtained.

| Number of Experiments. | Barrel employed. | Length of the Cavity containing the Powder, or Line AF in Fig. 5. | Quantity of Powder. | Chord of the Ascending Arch measured on the Ribbon. | The same by the Theory. | Error of the Theory. |
|---|---|---|---|---|---|---|
| | | Inches. | Dwts | Inches. | Inch. | Inches. |
| 4 | A | $2\frac{5}{8}$ | 6 | 11.9 | 12.1 | +.2 |
| 5 | A | $2\frac{5}{8}$ | 6 | 12.2 | 12.1 | —.1 |
| 6 | A | $1\frac{1}{4}$ | 6 | 13.2 | 13.6 | +.4 |
| 7 | A | $1\frac{1}{4}$ | 6 | 13.9 | 13.6 | —.3 |
| 8 | A | $2\frac{5}{8}$ | 12 | 16.7 | 17.2 | +.5 |
| 9 | A | $2\frac{5}{8}$ | 12 | 17.5 | 17.2 | —.3 |
| 10 | A | $2\frac{5}{8}$ | 12 | 16.9 | 16.8 | —.1 |
| 11 | A | $2\frac{5}{8}$ | 12 | 17.0 | 16.8 | —.2 |
| 12 | A | $2\frac{5}{8}$ | 6 | 11.7 | 11.5 | —.2 |
| 13 | A | $2\frac{5}{8}$ | 6 | 11.1 | 11.5 | +.4 |
| 14 | A | $2\frac{5}{8}$ | 12 | 16 7 | 16.3 | —.4 |

In calculating the theoretical results for the experiments 10—14, an allowance was made for the quantity of bullets lodged in the board, which increased the weight of the pendulum.

The next experiments made by Mr Robins were with another barrel C, which had the same bore with the last, but which was only 12.375 inches long. The pendulum was rather lighter than 56 lb. 3 oz.

| Number of Experiments. | Barrel Employed. | Extent of the cavity containing the Powder. | Quantity of Powder. | Chord of the ascending Arch measured on the Ribbon. | The same by the Theory. | Error of the Theory. |
|---|---|---|---|---|---|---|
| | | Inches. | Dwts. | Inches. | Inches. | Inches. |
| 15 | C | $2\frac{5}{8}$ | 12 | 12.7 | 12.8 | +.1 |
| 16 | C | $2\frac{5}{8}$ | 12 | 12.6 | 12.8 | +.2 |
| 17 | C | $2\frac{5}{8}$ | 12 | 12 4 | 12.8 | +.4 |
| 18 | A | $2\frac{5}{8}$ | 12 | 17.0 | 17.3 | +.3 |
| 19 | A | $2\frac{5}{8}$ | 12 | 17.2 | 17.2 | .0 |
| 20 | A | $2\frac{5}{8}$ | 12 | 17.1 | 17.2 | +.1 |
| 21 | A | $2\frac{5}{8}$ | 12 | 17.2 | 17.2 | .0 |
| 22 | A | $2\frac{5}{8}$ | 6 | 12.4 | 12 2 | +.2 |

Another barrel B, of the same bore with A and C, but 24.312 inches long, was now used, with a pendulum a little heavier than 56 lb. 3 oz. A correction was made for the increase of weight, as formerly.

| Number of Experiments. | Barrel employed. | Extent of the Cavity containing the Powder. | Quantity of Powder. | Chord of the ascending Arch measured on the Ribbon. | The same by the Theory. | Error of the Theory. |
|---|---|---|---|---|---|---|
| | | Inches. | Dwts. | Inches. | Inches. | Inches. |
| 23 | A | $2\frac{5}{8}$ | 12 | 17.1 | 17.2 | +.1 |
| 24 | A | $2\frac{5}{8}$ | 9 | 15.2 | 15.0 | —.2 |
| 25 | A | $2\frac{5}{8}$ | 9 | 15.4 | 15.0 | —.4 |
| 26 | C | $2\frac{5}{8}$ | 12 | 11.5 | 12.8 | +1.3 |
| 27 | C | $2\frac{5}{8}$ | 12 | 11.5 | 12.8 | +1.3 |
| 28 | C | $2\frac{5}{8}$ | 6 | 8.7 | 9. | +.3 |
| 29 | C | $2\frac{5}{8}$ | 12 | 12.3 | 12.5 | +.2 |
| 30 | B | $2\frac{5}{8}$ | 12 | 14.4 | 14.4 | 0.0 |
| 31 | B | $2\frac{5}{8}$ | 12 | 14.4 | 14.4 | 0.0 |
| 32 | B | $2\frac{5}{8}$ | 6 | 10.3 | 10.5 | +.2 |
| 33 | A | $1\frac{3}{4}$ | 8 | 14.7 | 14 5 | —.2 |
| 34 | A | 4 | 12 | 15.7 | 15.3 | —.4 |

Mr Robins suspects, that in experiments 26 and 27 a mistake had been made in the weight of the powder, or that the barrel had been damp.

Another barrel D was now used, 7.06 inches long, and 0.83 in diameter. Its bullet, which weighed $33\frac{1}{2}$ dwts. was exactly fitted to the bore without any windage, so that it went in with difficulty.

| No. of Expts. | Barrel Employed. | Length of the Cavity containing the Powder. | Quantity of Powder. | Chord of the ascending Arch measured on the Ribbon. | The same by the Theory. | Error of the Theory. |
|---|---|---|---|---|---|---|
| | | Inches. | Dwts. | Inches. | Inches. | Inches. |
| 35 | A | $2\frac{5}{8}$ | 12 | 9.2 | 9.2 | .0 |
| 36 | A | $2\frac{5}{8}$ | 12 | 9 5 | 9.2 | —.3 |
| 37 | A | $5\frac{1}{4}$ | 24 | 11.7 | 11.3 | —.4 |
| 38 | A | $7\frac{7}{8}$ | 36 | 13 2 | 12.6 | —.6 |
| 39 | A | $2\frac{5}{8}$ | 12 | 9.3 | 9.1 | —.2 |
| 40 | A | $1\frac{3}{4}$ | 8 | 7.6 | 8.1 | +.5 |
| 41 | C | $2\frac{5}{8}$ | 12 | 6.1 | 6.6 | +.5 |
| 42 | C | $2\frac{5}{8}$ | 12 | 6.5 | 6.6 | +.1 |
| 43 | B | $2\frac{5}{8}$ | 12 | 8.0 | 8.2 | +.2 |
| 44 | B | $2\frac{5}{8}$ | 12 | 8 3 | 8.2 | —.1 |
| 45 | A | $2\frac{5}{8}$ | 12 | 9 5 | 9.1 | —.4 |
| 46 | A | $2\frac{5}{8}$ | 12 | 9.1 | 9.1 | .0 |
| 47 | A | $2\frac{5}{8}$ | 6 | 7.2 | 6.5 | —.7 |
| 48 | A | $2\frac{5}{8}$ | 6 | 6.7 | 6.5 | —.2 |
| 49 | C | $2\frac{5}{8}$ | 12 | 6.8 | 6.7 | —.1 |
| 50 | C | $2\frac{5}{8}$ | 12 | 7 5 | 6 7 | —.8 |
| 51 | C | $2\frac{5}{8}$ | 6 | 4.7 | 4.8 | +.1 |
| 52 | C | $2\frac{5}{8}$ | 6 | 5.0 | 4.8 | —.2 |
| 53 | D | $2\frac{1}{4}$ | 12 | 7.0 | 7 2 | +.2 |
| 54 | D | $2\frac{5}{8}$ | 12 | 7.1 | 6.8 | —.3 |
| 55 | D | $2\frac{5}{8}$ | 6 | 4.7 | 4.8 | +.1 |
| 56 | D | $2\frac{5}{8}$ | 6 | 4.8 | 4 8 | .0 |
| 57 | A | $2\frac{1}{16}$ | 6 | 6.4 | 6.5 | +.1 |
| 58 | A | $2\frac{1}{16}$ | 6 | 6 4 | 6.5 | +.1 |
| 59 | A | $2\frac{1}{16}$ | 6 | 6.6 | 6.5 | — 1 |
| 60 | A | $2\frac{1}{16}$ | 6 | 6 7 | 6.5 | —.2 |
| 61 | A | $2\frac{1}{16}$ | 12 | 9 0 | 9.1 | +.1 |

Mr Robins supposes, that the error in the 50th experiment was owing to the wind. All the preceding experiments were made and registered, before they were compared with the theory.

A set of valuable experiments on the initial velocities of bullets were made by Antoni, with the machine invented by Mattei.

The first series was made with a musket 3 feet 6 inches in the length of its bore, and with a charge of powder of 7 drams.

| Nature of the Powder. | Moist Weather. | Mean state of the Atmosphere. | Very dry Weather. |
|---|---|---|---|
| | Feet. | Feet. | Feet. |
| Common war powder | 1392 | 1542 | 1618 |
| Fine do. | 1569 | 1736 | 1829 |
| Fowling powder | 1566 | 1703 | 1784 |
| Firework powder | 1566 | 1706 | 1779 |

The following experiments were made under a mean state of the atmosphere, with guns of different lengths and calibres.

| Nature of the Guns. | Kind of Powder. | Weight of Powder. | Initial Velocity. |
|---|---|---|---|
| A musket with a bore 1 ft. 10 inch. long | Fine war powder | 7 | 1390 |
| | Fowling do. | 7 | 1367 |
| | Firework do. | 7 | 1372 |
| Rifled carabine | Fine war powder | 7 | 1956 |
| | Fowling do. | 7 | 1920 |
| | Firework do. | 7 | 1934 |
| A wall-piece carrying a leaden bullet $2\frac{1}{2}$ oz. in weight | Fine war powder | 20 | 1956 |
| | Fowling do. | 20 | 1928 |
| | Firework do. | 20 | 1923 |
| A musket with a bore 3 ft. 6 inch. long | Fine war powder | 7 | 1736 |

In order to ascertain the effect produced by a difference in the weight of shot, and in the windage, three bullets were fired from a wall-piece, and two from the musket 3 feet 6 inches in length of bore.

| Weight of Balls. | | Quantity of fine War Powder. | Initial Velocities. |
|---|---|---|---|
| Wall-piece | $3\frac{1}{2}$ oz. | 23 drams | 1770 |
| | 3 | 23 | 1855 |
| | 3 oz. but of the same diameter as the first ball | 23 | 2068 |
| Musket | 1 oz. | 7 | 1736 |
| | $\frac{7}{8}$ | 7 | 1834 |
| | Carabine ball. | 7 | 1863 |

The following experiments were made in a mean state of the atmosphere, to shew how the initial velocities vary with different charges of fine war powder:

| Weight of Powder in drams. | | Initial Velocities. |
|---|---|---|
| Musket with a bore 3 ft. 6 in. | 5 | 1399 |
| | 7 | 1736 |
| | 10 | 1984 |
| Wall-piece with a bullet $2\frac{1}{2}$ oz. | $11\frac{1}{2}$ | 1504 |
| | 18 | 2056 |
| | 25 | 2060 |

The following results were obtained with four muskets of different lengths. The ball was 1 oz. in weight, and the charge was seven drams of fine war powder:

| Length of Barrel from the Ball to the Muzzle. | | Initial Velocities. |
|---|---|---|
| Feet. | Inches. | |
| 0 | 11 | 1037 |
| 1 | 10 | 1390 |
| 3 | 8 | 1736 |
| 4 | 8 | 1815 |

## CHAP. V.

### *On the Actual Ranges of Projectiles in a resisting Medium.*

Hitherto we have considered only the state of projectiles immediately after they have quitted the mouth of the gun or piece from which they have been discharged. We shall now proceed to consider the effects which are produced by the resistance of the air; and we shall again have occasion to admire the singular address with which Mr Robins has investigated this branch of the subject.

The resistance opposed to a body moving in a medium of uniform density was always considered by philosophers as proportional to the square of the velocity; that is, if a ball moved with four times the velocity in one part of its path that it did in another, the resistance to the greater velocity would be 16 times as great. Now, if we take a ball $\frac{3}{4}$ of an inch in diameter, moving with a velocity of 1600 feet in a second, it will be found, from theory, (see Newton's *Principia*, Prop. 38.), that its resistance will be $4\frac{1}{6}$ pounds avoirdupois, the weight of water being taken to that of air as 850 to 1.

In order to compare this result with experiment, Mr Robins used his ballistic pendulum, with which he could easily measure the velocity of a projectile at any point of its path. He charged a musket barrel three times in succession with a leaden ball $\frac{3}{4}$ of an inch in diameter, and with about half its weight of powder, and fired it against the pendulum at 25, 75, and 125 feet distance from the mouth of the piece respectively. The following were the results:

| Distance from the Muzzle. | Tract of air passed through. | Velocity in a second. |
|---|---|---|
| | Feet. | |
| 25 | 50 | 1670 |
| 75 | | 1550 |
| 125 | 50 | 1425 |

Hence, in passing through 50 feet of air, the bullet lost a velocity of 120 or 125 feet per second; and as it passed through that space in $\frac{1}{32}$ or $\frac{1}{30}$ of a second, the medium quantity of resistance must have been about 120 times the weight of the ball, or 10 lb. avoirdupois, since the ball weighed $\frac{1}{12}$ of a pound. It follows, therefore, that the theoretical is to the observed resistance as $4\frac{1}{6}$ to 10.

The following results were obtained with the same piece:

| Distance from the piece. | | Velocity. |
|---|---|---|
| 25 feet . . . | Medium of three trials. | 1690 |
| 175 . . . . . | Medium of five trials. | 1300 |

In this experiment, the ball lost a velocity of 390 feet in a second, in traversing 150 feet of air; and the velocity computed from these data is 11 and 12 lbs. avoirdupois, even greater than before.

The following experiments were made in smaller velocities. The same barrel, and balls of the same size, but less powder, were now used.

| Distance from the piece. | | Velocity. |
|---|---|---|
| 25 feet | Medium of five trials | 1180 |
| 250 | Medium of five trials | 950 |

The ball, therefore, in passing through 225 feet of air, lost a velocity of 230 feet in a second; and as it passed through that space in $\frac{3}{14}$ths of a second, the resistance to the middle velocity will be 2 lbs. 10 oz. avoirdupois, whereas the theoretical resistance will be only $\frac{7}{11}$ths of this.

From these experiments it is manifest, that the theory of the resistance of air in slow motions, as established by Sir Isaac Newton and others, is quite incorrect when applied to the rapid motions of military projectiles. The parabolic theory of gunnery is, therefore, in every respect erroneous. The path of military projectiles is neither a parabola, nor approaching to a parabola, unless when their velocities are very small; and instead of their path lying in the same place, it is in reality doubly incurvated, the ball being frequently driven to the right and left of its original direction by the action of some force acting obliquely to the progressive motion of the body, occasioned no doubt by the whirling motion of the shot about its axis.

In computing the paths of bodies moving rapidly through the air, Mr Robins lays down the following principles, which he has deduced from numerous experiments.

*First*, That the resistance varies as the squares of the velocities, when the velocities do not exceed 1100 feet per second; and that a 12 pound shot, moving with a velocity of 25 feet per second, is half an ounce avoirdupois. Hence we shall have its resistance for different velocities thus:

| Velocity. | Resistance. |
|---|---|
| 25 feet per second | $\frac{1}{2}$ oz. |
| 100 | 8 oz. |
| 500 | $12\frac{1}{2}$ lb. |
| 1000 | 50 lb. |
| 1700 | $144\frac{1}{2}$ lb. |

*Second*, That if the velocity be greater than 1100 or 1200* feet per second, then the resistance will be three times as great as it should have been by a comparison with the smaller velocities. Thus the 12 lb. shot above-mentioned, instead of being resisted by 144 lbs. will now suffer triple that resistance, or $433\frac{1}{2}$ lbs.

In proceeding to give an account of Mr Robins' method of computing the resistance, we must first explain the terms which he employs.

1. The *potential random* of a projectile is the horizontal distance to which it would be thrown in a non-resisting medium, at an angle of 45°. If $v$ be the initial velocity of the projectile in a second, in feet, then the potential random or $p=\frac{2v^2}{64\frac{1}{3}\text{ feet}}$, or $v=\sqrt{\frac{64\frac{1}{3}p}{2}}$ when the potential random is given.

2. The *potential range* is the horizontal distance to which the projectile would be thrown at any angle different from 45°.

3. The *actual range* is the horizontal distance to which the projectile is actually thrown.

In computing the effects of resistance, he assigns a certain quantity F, adapted to the resistance of the particular projectile. This quantity F expressed in yards, in iron shells, or bullets, is $d\times300$ when $d$ is the bullet's diameter in inches. When the bullet has a different specific gravity from iron, then F must be increased or diminished in the ratio of the specific gravities. Mr Robins then gives the three following propositions, which are suited to velocities below 1100 or 1200 feet in a second. The application of the principle to greater velocities will be shown in the corollary to Prop I.

PROP. I.

To determine the potential range, and consequently the potential random and initial velocity of a given shell or bullet, when its actual range is given, and when its elevation does not exceed 8° or 10°.

Enter the following Table with the quotient arising from dividing the actual range by F, and the corresponding number in the 2d column, multiplied by F, will be the potential range required; and as the ranges at different elevations are proportional to the sines of twice the angle of elevation, (see Chap 1. p. 177. col. 1.) the range at 45°, the potential random is also given. Then, as the velocity is that which is due to a height equal to one half of the potential random, (See p. 177.) the initial velocity is likewise given. Thus we have $v=\sqrt{\frac{64\frac{1}{3}p}{2}}$

| Actual ranges expressed in F. | Corresponding potential ranges expressed in F. | Actual ranges expressed in F. | Corresponding potential ranges expressed in F. | Actual ranges expressed in F. | Corresponding potential ranges expressed in F. |
|---|---|---|---|---|---|
| 0.01 | 0.0100 | 1.55 | 2.7890 | 3.3 | 13.8258 |
| 0.02 | 0.0201 | 1.6 | 2.9413 | 3.35 | 14.4195 |
| 0.04 | 0.0405 | 1.65 | 3.0994 | 3.4 | 15.0377 |
| 0.06 | 0.0612 | 1.7 | 3.2635 | 3.45 | 15.6814 |
| 0.08 | 0.0822 | 1.75 | 3.4338 | 3.5 | 16.3517 |
| 0.1 | 0.1034 | 1.8 | 3.6107 | 3.55 | 17.0497 |
| 0.12 | 0.1249 | 1.85 | 3.7944 | 3.6 | 17.7768 |
| 0.14 | 0.1468 | 1.9 | 3.9851 | 3.65 | 18.5341 |
| 0.15 | 0.1578 | 1.95 | 4.1833 | 3.7 | 19.3229 |
| 0.2 | 0.2140 | 2. | 4.3890 | 3.75 | 20.1446 |
| 0.25 | 0.2722 | 2.05 | 4.6028 | 3.8 | 21.0006 |
| 0.3 | 0.3324 | 2.1 | 4.8249 | 3.85 | 21.8925 |
| 0.35 | 0.3947 | 2.15 | 5.0557 | 3.9 | 22.8218 |
| 0.4 | 0.4591 | 2.2 | 5.2955 | 3.95 | 23.7901 |
| 0.45 | 0.5258 | 2.25 | 5.5446 | 4.0 | 24.7991 |
| 0.5 | 0.5949 | 2.3 | 5.8036 | 4.05 | 25.8506 |
| 0.55 | 0.6664 | 2.35 | 6.0728 | 4.1 | 26.9465 |
| 0.6 | 0.7404 | 2.4 | 6.3526 | 4.15 | 28.0887 |
| 0.65 | 0.8170 | 2.45 | 6.6435 | 4.2 | 29.2792 |
| 0.7 | 0.8964 | 2.5 | 6.9460 | 4.25 | 30.5202 |
| 0.75 | 0.9787 | 2.55 | 7.2605 | 4.3 | 31.8138 |
| 0.8 | 1.0638 | 2.6 | 7.5875 | 4.35 | 33.1625 |
| 0.85 | 1.1521 | 2.65 | 7.9276 | 4.4 | 34.5686 |
| 0.9 | 1.2436 | 2.7 | 8.2813 | 4.45 | 36.0346 |
| 0.95 | 1.3383 | 2.75 | 8.6492 | 4.5 | 37.5632 |
| 1.0 | 1.4366 | 2.8 | 9.0319 | 4.55 | 39.1571 |
| 1.05 | 1.5384 | 2.85 | 9.4300 | 4.6 | 40.8193 |
| 1.1 | 1.6439 | 2.9 | 9.8442 | 4.65 | 42.4527 |
| 1.15 | 1.7534 | 2.95 | 10.2752 | 4.7 | 44.3605 |
| 1.2 | 1.8669 | 3.0 | 10.7237 | 4.75 | 46.2460 |
| 1.25 | 1.5845 | 3.05 | 11.1904 | 4.8 | 48.2127 |
| 1.3 | 2.1066 | 3.1 | 11.6761 | 4.85 | 50.2641 |
| 1.35 | 2.2332 | 3.15 | 12.1816 | 4.9 | 52.4040 |
| 1.4 | 2.3646 | 3.2 | 12.7078 | 4.95 | 54.6363 |
| 1.45 | 2.5008 | 3.25 | 13.2556 | 5.0 | 56.9653 |
| 1.5 | 2.6422 | | | | |

* Mr Robins has noticed the remarkable fact, that the velocity at which the projectile begins to follow a new law of resistance, is nearly the same as the velocity of sound. It follows, however, from Dr Hutton's experiments, that there is no such *saltus* from the law of the squares of the velocities; but that the increase of the resistance above this law takes place gradually from the slowest motion, and never rises so high as to be three times that quantity.

The following examples will make this proposition easily understood. An 18 pounder, with a five inch iron shot, and a charge of 2 lb. of powder, ranged 975 yards, at an elevation of 3° 30′. In this case. $F = d \times 300 = 1500$, and $\frac{975}{1500} = 0.65$, which gives in the 2d column of the Table 0.817, consequently 0.817 F=1225 yards, equal the potential range required, which increased in the ratio of the radius to the sine of twice the angle of elevation, gives 10050, for the potential random. The original velocity is then

$$v = \sqrt{\frac{64\frac{1}{3}p}{2}} = 984 \text{ feet in } 1'',$$ where $p$ is the potential random, or 10050 yards, or 30150 feet.

In order to find the actual range from the potential range at a small angle, enter the second column of the Table with the quotient of the potential range divided by its correspondent F, there will be found opposite to it in the first column, a number which, when multiplied by F, will give the actual range required.

If the potential random deduced from the potential range exceeds 13,000 yards, then it ought to be corrected for the treble resistance already mentioned. In order to find the correct potential random, take a 4th continued proportional to 130,000, and the potential random is found by this proposition; and this 4th proportional is the potential random, corrected for the treble resistance. In like manner, when the true potential random is given greater than 13,000 yards, we must take two mean proportionals between 13,000 and this random, and the first of these proportionals must be assumed, instead of the random given in all the operations described under this proposition.

For example, a 24 pounder charged with 12 lbs of powder, ranged about 2500 yards at an angle of 7° 15′. In this case, F is 1700, and $\frac{2500}{1700} = 1.47$, opposite which, in the 2d column, is 2556, which gives the potential range 4350 yards, and the potential random 174,000; but as that is more than 13,000, we must take a 4th continued proportional to 13,000 and 17,400, which is 31,000 yards, the correct potential random required, whence the velocity is nearly 1730 feet in a second.

### Prop. II.

The actual range of a given shell or bullet, at an angle not exceeding 45°, being given, to determine its potential range at the same angle, and thence its potential random and original velocity.

Let A be the angle of elevation, then multiply F by cos. $\frac{3A}{4}$, and the product will be E corrected for the given angle. Use this corrected value of F instead of F in the way described in Prop. 1. and the potential range will be had; consequently the potential random and original velocity.

Thus a mortar charged with 30 lb. of powder, throws a shell $12\frac{3}{4}$ inches diameter, and 231 lb. weight, to the distance of 3450 yards, or two miles, at an elevation of 45°. The value of F corresponding to this shell is $12\frac{3}{4} \times 300$, or 3825 yards; but as the shell is only four-fifths of a solid globe, the true value of F will be $\frac{4 \times 3825}{5} = 3060$, which when multiplied by cos. $\frac{3A}{4}$ gives 2544 for F corrected. Now the quotient of the potential range divided by E, or $\frac{3450}{2545}$, is 1.384, which when sought in the 1st column of the Table gives 2,280, which being multiplied by corrected F, gives 5800 yards for the potential range required. This is also the potential random, as the elevation is 45°, and the original velocity of the shell will be 748 feet in a second.

In order to find the actual range from the potential range, divide corrected F by the potential range; and entering the 2d column of the Table with this quotient, the number in the 1st column multiplied into corrected F will be the actual range sought.

### Prop. III.

The potential random of a given shell or bullet being given, to determine its actual range at 45°.

Make $q$ = the given potential random divided by F corresponding to the shell or bullet.

$d$ = the difference between the tabular logarithms of 25 and of 9, the logarithm of 10 being supposed unity. Then the actual range sought will be

$$3{,}4\ F + 2\,d\,F - \frac{d^2}{10}F \text{ when } q \text{ exceeds 25, and}$$

$$3{,}4\ F - 2\ d\ F - \frac{d^2}{10}F \text{ when } q \text{ is less than 25.}$$

In this solution $q$ may be any number not less than 3, nor greater than 2500.

The following Table computed in this way shews the relation between the potential randoms and the actual range at 45°, within the limits of the proposition.

| Potential Randoms. | Actual Range at 45°. | Potential Randoms. | Actual Range at 45°. |
|---|---|---|---|
| 3 F | 1.5 F | 50 F | 4.0 F |
| 6 F | 2.1 F | 100 F | 4.6 F |
| 10 F | 2 6 F | 200 F | 5.1 F |
| 20 F | 3.2 F | 500 F | 5.8 F |
| 30 F | 3.6 F | 1000 F | 6.4 F |
| 40 F | 3.8 F | 2500 F | 7.0 F |

It is singular to observe, that so enormous are the effects of the air's resistance, that when the potential random increases from 3 F to 2500 F, the actual range increases only from $1\frac{1}{2}$ F to 7 F.

In order to examine the justness of the approximations laid down in Prop. II. and III. Mr Robins has calculated a table of the actual ranges at 45° of a projectile, resisted as the square of its velocity.

| Potential Randoms, | Actual Range at 45°. | Potential Randoms, | Actual Range at 45°. |
|---|---|---|---|
| .1 F | .0963 F | 6.5 F | 2.169 F |
| .25 F | .2282 F | 7 0 F | 2.237 F |
| .5 F | .4203 F | 7.5 F | 2.300 F |
| .75 F | .5868 F | 8.0 F | 2 359 F |
| 1.0 F | .7323 F | 8 5 F | 2.414 F |
| 1.25 F | .860 F | 9 0 F | 2 467 F |
| 1.5 F | .978 F | 9.5 F | 2.511 F |
| 1.75 F | 1.083 F | 10.0 F | 2.564 F |
| 2.0 F | 1.179 F | 11.0 F | 2 651 F |
| 2.5 F | 1.349 F | 13.0 F | 2.804 F |
| 3.0 F | 1.495 F | 15 0 F | 2.937 F |
| 3.5 F | 1.624 F | 20.0 F | 3.196 F |
| 4.0 F | 1.738 F | 25.0 F | 3.396 F |
| 4.5 F | 1.840 F | 30.0 F | 3.557 F |
| 5.0 F | 1.930 F | 40.0 F | 3.809 F |
| 5.5 F | 2.015 F | 50.0 F | 3.998 F |
| 6.0 F | 2.097 F | | |

This Table was computed by methods different from those hitherto described, and is sufficiently correct to serve as a standard with which the results of the other rules may be compared.

The following Table contains the comparison of the actual potential randoms, from trials made by Antoni on the banks of the Po, in June 1764, the barometer standing at 29 inches.

| | Initial Velocity. | Elevation. | Actual Ranges. Yards | Potential Ranges. Yards. |
|---|---|---|---|---|
| Rifled carbine, bullets weighing $\frac{1}{8}$th of an oz. | 1956 | 1°5 | 901 | 19903 |
| | | 24°. 20 | 938 | 29854 |
| | | 45° | 895 | 39806 |
| Musket, the bullet weighing one oz. | 1736 | 7°.15 | 948 | 7845 |
| | | 15° | 1305 | 15691 |
| | | 24°.20 | 1335 | 23537 |
| | | 45° | 1181 | 31383 |
| Wall-pieces. Balls weighing 3 oz. | 1855 | 15° | 1433 | 17897 |
| | | 24°.20 | 1753 | 26734 |
| | | 45° | 1629 | 35794 |
| Wall-pieces. Balls weighing $3\frac{1}{2}$ oz. | 1770 | 15° | 1699 | 16307 |
| Wall-pieces. Balls weighing 3 oz. but equal in diameter to $3\frac{1}{2}$ oz. balls. | 2068 | 15° | 1630 | 22268 |

In order to determine experimentally the curve described by projectiles, Antoni recommends the following method. Choose a piece of ground on which the guns may be placed at the different heights, A, C, D, E, and fire some rounds from A, the position and charge of the gun remaining always the same. Having marked the first graze of the shot at I, fire from C, D, F, with the same elevation, direction, and charge, and mark the grazes at L, B, and Q. (Plate CCLXXXVI. Fig. 8.) The perpendiculars IH, LK, BM, and QF, will be the abscissæ of the curve described by the shot and horizontal lines; AH, CK, DM, and EF, will be the corresponding ordinates, from which the curve may be deduced, or traced mechanically.

The same result may be obtained by firing the gun from different points of a horizontal plain against the face of a mountain.

## CHAP. VI.

*Mr Robins' Practical Maxims relative to the Effects and Management of Artillery, the flight of Shot and Shells.*

### *Maxim* I.

In any piece of artillery whatever, the greater quantity of powder it is charged with, the greater will be the velocity of the bullet.

### *Maxim* II.

If two pieces of the same bore, but of different lengths, are fired with the same charge of powder, the longer will impel the bullet with a greater celerity than the shorter.

### *Maxim* III.

If two pieces of artillery, different in weight, and formed of different metals, have their cylinders of equal bores and equal lengths; then, with like charges of powder and like bullets, they will each of them discharge their shot with nearly the same celerity.

### *Maxim* IV.

The ranges of pieces at a given elevation, are no just measures of the velocity of the shot; for the same piece fired successively, at an invariable elevation with the powder, bullet, and every other circumstance as nearly the same as possible, will range to very different distances.

### *Maxim* V.

The greatest part of that uncertainty in the ranges of pieces, which is described in the preceding maxims, can only arise from the resistance of the air.

### *Maxim* VI.

The resistance of the air acts upon projectiles in a twofold manner; for it opposes their motion, and by that means continually diminishes their celerity; and it, besides, perpetually diverts them from the regular course they would otherwise follow; whence arises those deviations and inflections mentioned in Maxim XI.

### *Maxim* VII.

That action of the air by which it retards the motion of projectiles, is in many instances an immense force; and hence the motion of these resisted bodies is totally different from what has been generally supposed.

### *Maxim* VIII.

This retarding force of the air acts with different degrees of violence, according as the projectile moves with a greater or lesser velocity; and the resistances observe this law: that to a velocity which is double another, the resistance (within certain limits) is fourfold, and to a treble velocity ninefold; and so on.

### *Maxim* IX.

But this proportion between the resistances to two different velocities does not hold, if one of the velocities be less than that of 1200 in a second, and the other greater. For in that case the resistance to the greater velocity is near three times as much as it would come out by a comparison with the smaller, according to the law explained in the last maxim.

### *Maxim* X.

To the extraordinary power exerted by the resistance of the air it is owing, that when two pieces of different borders are discharged at the same elevation, the piece of the larger bore usually ranges farthest, provided they are both fired with fit bullets, and the customary allotment of powder.

### *Maxim* XI.

The greatest part of military projectiles will, at the time of their discharge, acquire a whirling motion round their axis, by rubbing against the inside of their respective pieces; and this whirling motion will cause them to strike the air very differently from what they would do, had they no other but a progressive motion. By this means it will happen, that the resistance of the air will not always be directly opposed to their flight; but will frequently act in a line oblique to their course, and will thereby force them to deviate from the regular tract they would otherwise describe. And this is the true cause of the irregularities described in Maxim IV.

*Maxim* XII.

From the sudden trebling the quantity of the air's resistance, when the projectile moves swifter than at the rate of 1200 feet in a second, (as has been explained in Max. IX.) it follows, that whatever be the regular range of a bullet discharged with the last-mentioned velocity, that range will be but little increased, how much soever the velocity of the bullet may be still farther augmented by greater charges of powder.

*Maxim* XIII.

If the same piece of cannon be successively fired at an invariable elevation, but with various charges of powder, the greatest charge being the whole weight of the bullet in powder, and the least not less than the fifth of that weight; then, if the elevation be not less than 8° or 10°, it will be found that some of the ranges with the least charge will exceed some of those with the greatest.

*Maxim* XIV.

If two pieces of cannon, of the same bore but of different lengths, are successively fired at the same elevation, with the same charge of powder, then it will frequently happen, that some of the ranges with the shorter piece will exceed some of those with the longer.

*Maxim* XV.

In distant cannonadings, the advantages arising from long pieces and large charges of powder are but of little moment.

*Maxim* XVI.

In firing against troops with grape shot, it will be found, that charges of powder much less than those generally used are the most advantageous.

*Maxim* XVII.

The principal operation in which large charges of powder appear to be more efficacious than small ones, are the ruining of parapets, the dismounting of batteries covered by stout mortars, or battering in breach; for in all these cases, if the object be but little removed from the piece, every increase of velocity will increase the penetration of the bullet.

*Maxim* XVIII.

Whatever operations are to be performed by artillery, the least charges of powder with which they can be effected are always to be preferred.

*Maxim* XIX.

Hence, then, the proper charge of any piece of artillery, is not that allotment of powder which will communicate the greatest velocity to the bullet, (as most practitioners have hitherto maintained,) nor is it to be determined by an invariable porportion of its weight to the weight of the ball; but, on the contrary, it is such a quantity of powder as will produce the least velocity necessary for the purpose required; and instead of bearing always a fixed ratio to the weight of the bullet, it must be different according to the different business which is to be performed.

*Maxim* XX.

No field piece ought at any time to be loaded with more than $\frac{1}{6}$, or the utmost $\frac{1}{5}$ of the weight of its bullet in powder. Nor should the charge of any battering piece exceed $\frac{1}{3}$ the weight of its bullet.

*Maxim* XXI.

The depth to which the bullet penetrates in a solid substance is a much more definite criterion of its comparative velocity than the distance to which it ranges when fired at an elevation. For when the velocity of the bullet is doubled, it penetrates into an uniform substance near four times as deep, and with three times the velocity near nine times as deep;* so that, with different velocities, the penetrations vary in a much greater proportion than the velocities themselves.

*Maxim* XXII.

Hence then, in all contests about the greater or less velocity which a bullet acquires from different quantities of powder, or from different lengths of pieces, or different methods of loading, the most decisive experiment is to try the penetration of the bullet into some uniform substance, placed at a small distance from the muzzle of the piece; since that bullet which, in repeated trials, penetrates deepest, may be concluded to have been discharged with the greatest celerity.

For farther information on the subject of gunnery, see Tartaglia's *Colloquies concerning the Art of shooting in great and small Pieces of Artillery*, translated by Lucas, Lond. 1588. Collado's *Practica Manuale D'Artiglieria*, Venice, 1586. Bourne's *Art of shooting in great Ordnance*, 1693. Eldred's *Gunner's Glasse*, 1646. Galileo's *Discursus et Demonstrationes Mathematicæ*, 1638. Anderson *on the genuine Use and Effects of the Gun*, 1674. Blondel, *L'Art de jetter les Bombes*. Greaves *on the Force of Guns*, in the *Phil. Trans.* 1685, vol. xv. p. 1090. Halley, *Phil. Trans.* 1686, vol. xvi. p. 3; 1695, vol. xix. p. 68. Newton's *Principia*. John Bernoulli, *Mem. Acad. Par.* 1711; and *Act. Lips.* 1713. Brook Taylor, *Phil. Trans.* 1726, vol. xxxiv. Keill, *Journal Literaire de la Haye*, 1719, p. 151. D. Bernoulli, *Comment. Petrop.* vol. iv. p. 136. Mariotte *on the Recoil of Fire Arms*, in the *Mem. Acad. Par.* vol. i. p. 233 Cassini *on the Recoil*, Id. 1703. Cassini *on the Effect of different Charges*, *Id.* 1707. Guisnée on the *Galilean Theory*, *Id.* 1707. Ressons, *Id.* 1716, p. 79; and 1719 and 1720. Maupertuis, *Id.* 1731, p. 297. Jurin. *Phil.*

* Dr Hutton has found that the penetrations are in a much lower proportion.

*Trans.* 1742, p. 172. St Remy's *Memoirs of Artillery*, vol. i. p. 69. Robins' *New Principles of Gunnery, Id.* translated by Euler, and retranslated into English by Brown. Euler, *Mem. Acad. Berlin*, 1753, p. 34. Krafft, *Acta Petropol.* vol. iv. i. 154, ii. 175. Leutmann, *Comment. Petrop.* iv. p. 265. Deidier, *Mem. Acad.* 1741. D'Arcy, *Mem. Acad.* 1751, p. 45. D'Arcy, *Essais sur la Theorie de l'Artillerie*, 1760. Borda, *Mem. Acad.* 1769, p. 116. Montalembert, *Mem. Acad.* 1755, p. 463; *Id* 1759, p. 358. Lambert, *Mem. Acad. Berl.* 1765, p. 102; *Id.* 1773, p. 34. Cassali, *Comment. Bonon*, vol. v. 1. Bernoulli, *Mem. Acad. Berl.* 1781, 347. Sulzer, *Mem. Acad. Berl.* 1755. Tempelhoff, *Mem. Acad. Berl.* 1788, p. 216. Moreau, *Journal Polytechnique*, vol. iv. xi. 204. Devalliere, *Mem. Acad. Par.* 1772. Mattei, see *Antoni's Work*. Butet, see Antoni's *Treatise on Powder*, and *on Fire Arms*, translated by Thomson. Hutton, *Phil. Trans.* 1778, and *Tracts* vol. ii. iii. Rumford, *Phil. Trans.* 1781, p. 229; *Id.* 1797, p. 222. Franceur, *Mecanique*, Grobert, *Journal des Mines*, 1804, No. 92. or Tilloch's *Phil. Magazine*, vol. xxii. p. 220. Glenie's *History of Gunnery*.

GUNPOWDER, is a compound of nitre, sulphur, and charcoal. The chemical action which these few elementary bodies exert on each other has many times determined the fate of nations. More human beings have fallen victims to its power than at present exist upon the face of the globe, and it is now considered as the most effective agent in modern warfare.

The history of this surprising substance is clouded with much obscurity, and this we deem sufficient for not entering minutely into this branch of our subject.

Polydore Virgil and Thevet attribute the discovery of gunpowder to a monk named Constantine Anelzen, who was a chemist of some celebrity in his time. Others assert, with much probability, that it was discovered by Bartholdus Schwartz about the year 1320.

The Venetians are said to have used gunpowder during a war with the Genoese, in the year 1330. In 1346, cannon and gunpowder were used at the battle of Cressy; and about the same time at the seige of Calais.

Long before any of these periods, gunpowder is said to have been discovered by Roger Bacon. In a work written by him in 1280, he points out the composition of gunpowder; and was so much aware of its importance, as to recommend its explosive powers as the means of destroying armies.

The Chinese, and probably other nations of the East, with whom most of the arts have originated, appear to have been acquainted with a variety of these explosive compounds long before they were known to Europe. It appears almost impossible, that, in countries where nitre is found in the soil, the commonest people should have been ignorant of the action between carbon and nitre. If sulphur were not present, still the effects would be remarkable.

The preparation of gunpowder is divided into three principal departments. 1st, The choice and purification of the materials; 2d, The adjustment of the proportions, by which a maximum of explosive power may be produced; and 3d, The incorporation of the materials, which is a mechanical process not of less importance than the other departments.

In the choice of nitre, no rule is so important as the form and size of the crystals. It is necessary first to examine whether the nitre affords any foreign matter different from nitric acid and potash. It sometimes contains nitrate or muriate of lime, magnesia, and perhaps muriate of potash. First dissolve a small portion of the nitre, and filtre the solution. To a little of this, add a few drops of a solution of sulphate of silver.(*) If a bluish white precipitate falls down, which turns darker coloured by exposure to the light, then the nitre contains muriatic acid, combined with some of the bases above mentioned; namely, lime, magnesia, potash, and probably soda. Take another portion of the solution of nitre, and drop into it a solution of oxalate of ammonia. If a white precipitate falls down, it shows the presence of lime. To a third portion of the solution add a little pure ammonia, then, if any precipitate is found, the nitre contains magnesia.

In particular experiments, the tests above mentioned

(*) The sulphate of silver recommended by our author is by no means so eligible as the nitrate. The solution may contain muriate of lime, (a frequent contamination,) of course sulphate of lime would precipitate with the muriate of silver, a circumstance which could not fail to embarrass a mere manufacturer; to whom the article is chiefly interesting.

We have had frequent opportunities to examine crude salt-petre from Kentucky, and in several parcels, found sulphate of magnesia mixed with it. It is perhaps not generally known that some of the salt-petre caves in Virginia and Kentucky contain immense quantities of the latter salt. With a letter which we received in 1804, from Mr Tristram Patton, dated Second Creek, Moroe County, Virginia, we received a quantity of very pure sulphate of magnesia (epsom salt.) Mr. Patton writes, "I have a quantity of that salt, (sulphate of magnesia) in a salt-petre cave of mine, and one of my neighbours has any quantity of it, in a cave of his; we could load several waggons with it."

From the above, manufacturers will perceive that they may be led into great errors, by confining their examinanations of *crude* salt-petre exclusively to muriatic salts. The solution should be tested with nitrate of barytes; if a a precipitate ensues, it indicates the presence of sulphuric acid; separate the precipitate by filtration, and into the filtered liquor drop nitrate of silver; if a further precipitate appears, it indicates the presence of muriatic acid.

(*a*) Having thus ascertained the presence of sulphuric and nitric acids, let another portion of the solution be taken, and nitrate of barytes added as long as any precipitate appears; when that ceases, let the whole be thrown on a filter —the precipitate is sulphate of barytes.

(*b*.) Into the filtered liquor, add a solution of nitrate of silver as long as it occasions any precipitate; when that ceases, let it be separated by filtration—it will be muriate of silver. The solution now can contain no salts but the earthy and alkaline nitrates.

(*c*.) To detect the presence of lime, add a few drops of oxalate of ammonia to the filtered solution (*b*); a precipitate will appear if lime be present, provided there is no excess of nitric acid; if there is, it should previously be saturated with an alkali.

(*d*.) Magnesia and *alumina* (if the solution contains any) may be separated by adding pure ammonia or lime water to the filtered solution (*c*), provided the carbonic acid (if the solution contains any) be previously expelled by nitric acid and boiling.

Soda, if the solution contains any, may be detected by evaporating the filtered solution (*d*) to dryness, then heating the dry mass to redness with a little charcoal, to decompose the nitric acid. The remainder dissolved in muriatic acid, filtered and concentrated by evaporation, will afford cubic crystals of muriate of soda (common salt.)

If no sulphuric should be detected in the solution, the process (*a*) must be omitted.

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might be used to separate the foreign matter; but for general use this would be too expensive; and the only practicable method of purifying nitre, is by frequent solution, evaporation, and careful crystallization. When the crystals are transparent, clear, and well formed into distinct prisms, the nitre may be looked upon as pure. It is well to test it after every fresh crystallization, to know when it may be relied upon. If nitre should contain any alkaline sulphate, the test for this substance will be a solution of nitrate of barytes. If a precipitate is produced, add more of the same substance carefully till no more is precipitated. By this means the sulphate of the alkali becomes a nitrate, which is nitre.

The French method of purifying nitre for the manufacture of gunpowder is very simple, and has been practised with success. The nitrate or muriate of lime, or the same acids with magnesia and even common salt, are more easily soluble in cold water than the nitre itself; but particularly the earthy salts, which are most injurious. This property presents an easy means of separating them from the nitre.

The French, for this purpose, first coarsely pound the crude nitre, and put it into a copper, adding to it 20 per cent. of cold rain water. The mixture is then stirred, and allowed to remain for 6 or 7 hours. The liquid part is now drained off, and 10 per cent. more water added, which, after stirring as before, is allowed to remain one hour, and then drained off as formerly. Lastly, 5 per cent. of water is to be added, and drained off as before, leaving the whole to drain completely. By this means the deliquescent salts are carried off, and also a portion of nitre, which may afterwards be separated for common purposes.

The drained mass is now to be dissolved, by adding to it 50 per cent. of pure water at 212°. This solution is next to be placed in shallow leaden vessels in a cool place, in order to allow the nitre to crystallize, which very soon takes place. During the crystallization the solution is frequently agitated, to prevent the crystals from being too large. It is an object to have the prisms not thicker than needles, in order to promote their more speedy desiccation, previous to its being reduced to powder, for mixing with the sulphur and charcoal. As the crystals are deposited, they are removed into baskets to drain. They are ultimately placed in wicker wooden vats with double bottoms, the superior bottom being perforated, so as to allow the water to drain through into the cavity below. This nitre is deemed sufficiently pure for making gunpowder.(*)

The choice of the sulphur for making gunpowder, is easy to those who are experienced. It should be of a lively yellow colour. Its specific gravity should not be great. It should appear porous, but not shining. When a bit of it is burned upon a piece of clean glass or porcelain, it should leave no residuum.

If it does not answer these characters, it should be melted at a low heat, and skimmed from time to time. If this is not sufficient, it should be sublimed at the lowest possible heat. The sulphur which is extracted from pyrites is never sufficiently pure for this purpose. That from Italy and Sicily, which is naturally sublimed by the heat of volcanos, is the most pure.

In the choice of charcoal, it was once deemed an object even to make use of peculiar kinds of wood; but now any kind of wood properly charred is employed. The charcoal which is formed during the distillation of the pyrolignic acid is now generally preferred.

Having pointed out the proper materials, it will now be necessary to shew the manner of intimately mixing them together; for certainly we cannot with propriety call gunpowder a compound. Since that sort of contiguity essential to their readily exploding depends upon mechanical and not chemical union, it will not be wondered that gunpowder should differ so much in its qualities even with the best proportions. All the explosive chemical compounds, such as fulminating gold and silver, are uniform in their effects, because their formation is the result of chemical union.

The first business in preparing gunpowder is, to pound the materials separately and pass them through fine sieves. Then for 100 pounds of powder, weigh 75.4 nitre, 11.8 sulphur, and 12.8 charcoal. These powders are to be intimately mingled, till the mass assumes a uniform colour; that is, till no specks of yellow, white, or black appear; for the nitre, after its crystals have been dried and powdered, becomes as white as flour. Water is now to be added, and the mass agitated till it assumes the form of a stiff but kneadable paste. In this state it has been formerly kneaded or beaten in mills, called turning mills. This apparatus consists of large mortars, with pistons, or stampers of lignum vitæ. These are still worked in some manufactories, but in the works of government they are laid aside, on account of the danger arising from the heat of percussion. The machine substituted for this seems much better. It consists of a large stone in the form of a grindstone, which is made to roll upon its edge in the circumference of a circle. A vertical shaft turns in the centre of the circle. A horizontal shaft works in the centre of the stone, the height of which is equal to the radius of the circle, in the periphery of which the stone is to roll, the end of this horizontal shaft being fastened into the vertical shaft. It will be evident that, when the latter turns round, the rolling stone will go round just as a cart wheel is carried round by drawing the cart forward. The edge is a little rounded on the face, and works in a circular bed or trough, containing the paste to be worked or kneaded. The stone now goes round upon the paste, squeezing it flat. The point of contact is constantly preceded by a scraper, which goes round with the stone, and which constantly turns the paste, previously flattened, into the track of the stone, so that a new surface is always presented to its action. The size of this apparatus is sufficient to work from 50 to 60 pounds at once. It is driven by a steam engime, a water wheel, or by horses.

The paste being sufficiently worked, which cannot be too much, is now sent to the corning house, where a separate mill is used for forming the paste into corns or grains.

This process is performed in sieves with parchment bottoms, perforated with holes. These sieves are placed upon a revolving horizontal plane. The paste, in a certain state

(*) We are nevertheless satisfied, that much of the purest nitre contains some carbonate of potash mixed with it, and to that admixture we attribute much of the dampness which powder used in the navy acquires. We have elsewhere stated our conviction, founded on experiments made expressly for the purpose, that the carbonic acid cannot be expelled from its combinations but by an excess of acid and boiling. Hence, it would be proper, previously to suffering a solution of nitre to crystallize, to boil a small portion in a flask, and gradually add a few drops of pure nitric acid; if any air bubbles should rise in the liquid, it may be relied on, that the solution contains some carbonate of potash, and that gunpowder made from the nitre will attract moisture from the atmosphere—such a solution, should have pure nitric acid added to it, previously to being suffered to crystallize.

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of dryness, is put into the sieves, and a piece of lignum vitæ in the shape of an oblate spheroid laid upon it. A rotatory motion is given to the spheroid at the time the sieves are revolving. This forces the paste in small grains through the holes in the parchment, which is received below.

The granulated matter consists of particles of very different sizes, and some reduced to dust. These are passed through wire sieves of different sizes, to give the different sized grains in which it is sold. Those which pass through the finest sieve, and which are called dust, are made up into paste, and worked over again.

The proper grains are next to be glazed or polished. This is performed in a very expeditious manner, by putting the grains into a revolving cylinder, working like a barrel churn. This vessel should not be more than half full at once. The grains, by rubbing one against another, become smooth, and approach a spherical form.

The next operation, which has been attended with the greatest danger, is the drying. This has generally been effected by placing the powder upon shelves on three sides of a small room, on the other side of which is an iron stove; the fire being fed from the back of the wall. When we recollect that the stove itself is frequently hot enough to explode gunpowder, it is surprising that more safe methods have not been adopted. Steam appears to be the most proper agent to be employed, not only for the sake of avoiding danger, but it is better calculated to dry the powder more effectually, without any fear of the powder being injured in its quality. It is recommended that powder be not dried too quick, or with too great a heat, for fear of volatilizing the sulphur. All these precautions are unnecessary with steam, as sulphur only evaporates at 220°; and steam would not raise it so high as 212° without pressure. The shelves on which the powder is laid to dry might be made of cast iron, and hollow. The inner cavity might have a sloping bottom, so that when the steam came into it from a boiler below, the water, after condensation, might run back into the boiler. There would, of course, be no waste of water, which should be rain water. The steam might be formed from a fire, at a sufficient distance to avoid the risk of any accident. This method would not be less desirable in an economical point of view. The powder should be kept on the stove till the time of barrelling, for which the finest dry weather is always preferred.

A very great improvement has lately been made in preserving gunpowder, by using barrels of copper instead of wood. These barrels are first made water and air tight; and then the lid screws on so as to exclude completely all communication with the atmosphere. This has been of the greatest importance, particularly in the navy.

Having given the direct practical method of forming gunpowder, we shall now give some account of its chemical properties, from which alone we can get at any true theory of its effects.

The ingenious Mr Robins appears to have been the first who has examined gunpowder scientifically. He very properly conceived, that its power consisted in the evolution of an abundance of some elastic fluid liberated in an instant, and strongly increased in its force by the heat attendant on the explosion. Having convinced himself that a permanently elastic fluid was generated during the explosion of gunpowder, his next business was to ascertain what proportion this bore to the whole weight of the powder. For this purpose, he exhausted the receiver of an air-pump, the capacity of which was equal to 520 cubic inches. In this he suspended a hot iron capable of firing gunpowder, and a mercurial gauge to ascertain the force of the air generated. On letting 27 grains of powder fall on the iron, the mercury indicated an increase of elastic fluid, which raised it two inches; and upon repeating the experiment, he found this result confirmed. The barometer at this time was 30 inches, so that the quantity of elastic fluid generated was equal to $\frac{1}{15}$ of an atmosphere. He guesses the temperature of the receiver to be such as to increase the volume $\frac{1}{5}$th of the whole. He then calculates the weight of this volume of gas, allowing its specific gravity to be the same with common air, to weigh 131 grains, for every ounce of 437.5 grains of gunpowder, which is $\frac{131}{437}$, or nearly $\frac{3}{10}$ of the whole.

From determining the specific gravity of gunpowder, he found that the bulk of the powder to the volume of gas generated, was as 1 to 244.

He next supposes that the heat generated by the explosion of the powder, would have the same effect in expanding the generated elastic fluid which a red heat would produce. He then ascertained, by an experiment, that air was increased in volume by a red heat 4.1 times nearly. This would make the volume of the powder to that of generated air as 1 to 1000 nearly. The force which would arise from such an increase of volume, Mr Robins finds adequate to the effect of the powder in practice, and in a very ample manner agreed with his theory.

We have to lament that these experiments were not made with more precision. The gases generated were considered by Mr Robins as common air, the specific gravity of which is 1. These gases, however, being a mixture of carbonic acid, carbonic oxide, and azotic gases, should have been taken at a mean not less than 1.25. There is also some uncertainty about the allowance made for the heat of the receiver; and the volume was not increased by that circumstance so much as $\frac{1}{5}$th of the whole, which he supposes to be the case. The very little which was known of gaseous chemistry at the time Mr Robins made his experiments, does not admit of our wondering that no more was established by his labours. The constituents of nitre were then little known; and therefore the nature of the gases resulting from the decomposition of gunpowder could not be ascertained. He was satisfied with calling the gaseous product air, and supposed it to have only the properties of common air. In order to apply the chemical facts at present known to explain the nature of gunpowder, we shall compare the proportions of the ingredients used by different manufacturers with those proportions which theory could point out, in order to produce a *maximum* effect.

An intelligent account of making gunpowder has been given by Mr Coleman, of the royal gunpowder mills at Waltham Abbey. (*Phil. Mag.* vol. ix.) In some observations at the end of the paper, Mr. Coleman has taken a very proper view of the theory of gunpowder, by giving some calculations relative to the resulting products. He has taken into the account the water, which he rates at 4 per cent. It has not been ascertained, that water undergoes any change in the decomposition of gunpowder; nor, indeed, is it very probable that any such effect takes place. He has also given too little oxygen for sulphurous acid. He states it to be 30 per cent. when it is actually 50. It appears from experiments made in the firing of gunpowder, that very little of the sulphur enters into combination with the oxygen, and we believe not after the carbon is kindled. The residuum is always very near a complete sulphuret of potash; and the quantity of sulphur used in the composition is seldom more than is just sufficient to form the sulphuret. This is rendered highly probable, from the fact of gunpowder possessing the same strength with very different proportions of sulphur. Indeed, M. Chaptal has made very good gunpowder without sulphur. It is however different, in a mechanical point of view, and on that account would not answer in practice. It is therefore highly probable, that the sulphur does not form sulphurous acid when the explosion takes place, since oxygen seems to unite with the carbon alone. The potash, when deserted by oxygen and the nitrogen, assumes the form of a fine dust of powder, and the sulphur the form of vapour. These combine, forming a sulphuret of potash, which appears in white fumes, and adheres to surrounding bodies. The moment this white efflorescence is touched with the tongue, the exact taste of sulphuret of potash is perceived. If the carbon were very defective in quantity, and the sulphur in the usual proportion, some sulphurous acid would doubtless be formed, and the smell of it would be very perceptible in the fumes resulting from its decomposition; but no smell of this kind is perceived in the explosion of ordinary gunpowder.

The following Table contains some of the proportions used by different manufacturers in this and other countries.

| Varieties of Gunpowder. | Nitre. | Charcoal | Sulphur |
|---|---|---|---|
| Mr Coleman, of the Royal Mills at Waltham Abbey, . . | 75 | 15 | 10 |
| General use in France, . . | 76 | 12 | 12 |
| War powder of France, . . | 75 | 12.5 | 12.5 |
| Result of experiments by M. Chaptal, . . . . . . | 77 | 14 | 9 |
| Used in China, . . . . . | 75.7 | 14.4 | 9.9 |
| Result of Mr Napier's method of approximating the true proportions, . . . . . . | 80 | 15 | 5 |
| Average, . . . . | 76.45 | 13.81 | 9.73 |

Doubtless all these varieties are very good powder, which would not have been the case, had the charcoal been as uncertain in its proportions as the sulphur.

It will be admitted on all hands, that the best gunpowder must result from such materials as explode the quickest, leaving the least possible residuum, and affording the greatest possible volume of elastic fluid. Now, if sulphur did, by its combination with oxygen, form an elastic fluid, the resulting gas, which is sulphurous acid, is nearly 1.5 times heavier than carbonic acid, and therefore contributes less force in a given weight. It will be found, when nitre is deflagrated with charcoal, that carbonic oxide is formed as well as carbonic acid, which contributes more elastic force than the same weight of carbonic acid.

There is one good reason to be given for the use of the sulphur, although it does not contribute to the production of any elastic fluid. The carbonic acid which is generated would doubtless combine with the potash, if it were not for the presence of the sulphur; and thus so much elastic fluid would be lost. That this is the case, we know from the fact, that carbonate of potash is always formed when nitre is decomposed by charcoal alone. This would be the case to a certain extent with gunpowder made without sulphur; some carbonate of potash would be formed.

It will appear, from these facts and observations, that the propositions for gunpowder will be those in which the carbon will just consume the oxygen of the nitre, and the sulphur as much as will exactly saturate the potash. This will be effected by an atom each of nitre and sulphur, and three atoms of carbon, or nitre 95.5; charcoal 16.2; and sulphur 15. These will give in the 100 nitre 75.4; of charcoal 11.8; and sulphur 12.8. These proportions agree with the best in practice. The bodies which result from the decompositions of this compound, will be in 126.7 parts, 60 of sulphuret potash; 40 8 of carbonic acid; 12.9 of carbonic oxide; and 13 of azot.

The three latter are elastic fluids, equal to 66.7 out of 126.7, or $\frac{4}{21}$ of the whole nearly. Mr Robins made the gaseous product $\frac{3}{10}$ of the whole. This last number, when the specific gravity of the gas is taken right, will differ very little from our calculation.

In the 66.7 by weight, (suppose grains,) we have

| | | |
|---|---|---|
| Carbonic acid . . . . | 10.8 = 87 | cubic inches. |
| Carbonic oxide . . . | 12.9 = 42 | |
| Azot . . . . . . . . | 13. = 40.6 | |
| | Total 169.6 | |

Now Mr Robins found that 27 grains of powder generated as much air as made $\frac{1}{15}$ of an atmosphere in a space equal to 520 cubic inches. This, at the pressure of the atmosphere, which was at the time equal to 30 inches, would make 34.6 cubic inches. The increased temperature which the receiver got by the explosion might reduce this to 30 or 31. We find from our calculation that 126.7 of gunpowder generates 169.6 cubic inches of gas. Then as 126.7 : 27 : : 169.6 : 35.7 cubic inches, which is only three cubic inches different from Mr Robins' experiment. This might arise from his powder not consisting of proper proportions.

In the present improved state of chemical science, when the nature of the bodies constituting gunpowder are so well understood, as well as the compounds resulting from their action on each other, the proportions above given may be taken as the best for practice. The charcoal should, in particular, not be less in proportion to the nitre, as the smallest portion less than a whole atom would be the same as to leave out the whole atom, in which case there would be no carbonic oxide formed. If, for instance, instead of the proportions 95.5 nitre, 16.2 charcoal, and 15 sulphur, the carbon was 16, then there would be 4.2 of carbon left in the resid[illegible] no carbonic oxide would be formed; since bodies cannot unite but in definite proportions.

The reason why carbonic oxide is formed during the decomposition of nitre by charcoal will be obvious from nitric acid having five atoms of oxygen. Four of these unite with two of carbon to form two atoms of carbonic acid, while the odd atom of oxygen is compelled to take another atom of carbon to form carbonic oxide. The writer of this article found the presence of the latter substance a fatal objection to getting pure carbonic acid by deflagrating nitre with charcoal.

The goodness of gunpowder is known to those experienced in it by its appearance. It should not be strictly black, but of azure grey inclining to red. The grains should appear uniform, both to the eye and to the touch. If some rub to powder sooner than others, it shows that the mass is not well mixed.

When it is fired on clean paper, or on a clean board, it should not soil it, or leave black spots. The smoke arising from it will form a circle or ring, more or less perfect as the explosion is more or less rapid, and is a good test of its strength.

The best and most certain test of the strength of gunpowder is the *eprouvette*. This is a machine in which the powder acts against a weight, in order to raise it to a given height. The powder in these machines, however, acts by a sudden impulse, and not as it acts in a gun, which is by gradual pressure during the whole time the charge is passing through the barrel. Hence the common powder powers are very imperfect, and have been long deemed insufficient. The French method of trying powder is more to be depended upon, but it is more tedious, and takes up too much time for practice.

Each of the magazines for powder have a small mortar, exactly of the same size, and capable of containing a ball of $7\frac{1}{2}$ inches in diameter. The mortar is elevated to an angle of 45°; and when the powder is of the required strength, 3 ounces of it is capable of projecting the ball of the above size 55 French fathoms.

Mr Robins proposed a much more certain apparatus for trying the strength of powder, which has since been executed and reduced to practice by Dr Hutton. It is founded on the principle, that the momentum of the gun and the charge must be equal, or that the force of the powder, which is equally exerted upon both, will generate velocities in each, which will be inversely as their quantities of matter. Thus, if the weight of the charge were 1, that of the gun being 100, then their velocities will be reciprocally as these numbers. For this purpose, Dr Hutton's machine consists of a brass cannon of about one inch bore.* Plate CCLXXXIV. Fig. 10, 11. It is suspended in such a way, that the arch of its recoil can be easily ascertained. The gun is generally charged with two ounces of powder. The arch of recoil gives the velocity with which it is propelled, and hence the force of a given quantity of powder. No wadding is used in this method, the powder being merely collected into as compact a mass as possible. In these experiments, it should always be ascertained whether the whole of the powder be fired.

The strength of powder might be very conveniently and correctly ascertained, by firing a bullet into some uniform medium, such as sand or clay. The medium may first be tried, by letting a ball fall from a given height into it, and observing the depth to which it has penetrated. Since these depths are the spaces through which the ball has passed to lose motion, which is supposed to have been uniformly retarded, they will therefore be as the squares of their velocities. Hence, when the space has been determined by the falling body, of which the velocity was known, the first velocity of the projected body may be determined, the space through which it has penetrated being known.

Since the force of gunpowder is exerted in a manner similar to the action of condensed air, which is analogous to the action of a spring, there appears nothing more necessary to be known than the volume of elastic fluid set free, and its temperature, to know what is its velocity of expansion when no matter has to be moved.

Mr Robins first ascertained the volume of air formed by a given quantity of gunpowder, and then supposed that this elastic fluid was exposed to a heat equal to redness, by the explosion of gunpowder. He also found, by experiment, how much the volume of a given bulk of air was increased by a red heat. The first production of air gave him a force of about 244 atmospheres, or that the original volume of gunpowder was multiplied by that number. The red heat he found would multiply this volume by about 4.1. This gave about 1000 times for the increase of volume. The force of its first action would therefore equal so many atmospheres, or $1000 \times 15$ pounds upon a square inch. When this force begins to move, it decreases with the dilatation, and exactly in the same ratio. Mr Robins not only ascertained the velocity given to the bullet by a given weight of powder, but he fired the powder alone, which having no weight to move, would expand itself with the greatest velocity. He found that, under these circumstances, the velocity of expansion was 7000 feet in one second.

In these experiments, the charge, at a small distance, was fired at a piece of wood, constituting the bob of a pendulum. Plate CCLXXXIV. Fig. 12. This pendulum had a ribbon attached to it, which was slightly held between two surfaces, so that, when the pendulum vibrated, the length of the ribbon drawn out measured the cord of the arch of vibration, by which the velocity of the striking body was known. See the *Description of Plates*.

Count Rumford has advanced some new notions respecting gunpowder, deeming the reasons for its power given by Mr Robins insufficient, viz. the gases and the heat. He attributes the power of the powder to the vapour of the water it contains, and supposes the heat to be the result of friction. His views of the subject have not been countenanced by other philosophers, as they appear to be contrary to experience. Mr Robins, and more recently Mr Coleman, found that powder was the strongest in its most dry state, if none of the materials were injured, and that it became weakened by the slightest quantity of moisture.

Notwithstanding all the caution used in purifying the nitre, all powder has a great tendency to absorb moisture from the atmosphere. This may go on to a considerable extent, without any permanent injury to the powder, its power being restored by drying. If, however, the water absorbed be sufficient to effect a solution of nitre, the latter afterwards crystallizes, and appears like hoar-frost upon the grains of the powder. This is called the starting of the salt-petre, when the powder is not capable of being restored to its original strength by drying; for the nitre is, to a certain extent, detached from the other two ingredients. Powder is sometimes so much injured by dampness as to be of no value, except in so far as the nitre can be recovered from it by solution. (c. s.)

GUNPOWDER Plot. This conspiracy, one of the most iniquitous and daring treasons recorded in history, was the memorable offspring of religious bigotry. It had its origin in the disappointed zeal of the Catholics, and has contributed more than any thing to fix upon themselves that very intolerance, of which they have given so many and such dreadful examples.

After the death of Mary, who was regarded as a martyr to their cause, they rested their last hope on the favour and protection of her son. Of these they pretended to have received the most unequivocal assurance; and mere toleration was among the lowest of their anticipations. James quickly undeceived them; and though certainly less hostile to their religion than jealous of the papal supremacy, he shewed a confirmed resolution of at all times enforcing against them the enactments of the two preceding reigns. Their surprise and rage at this conduct were excessive. They saw nothing before them but submission or revenge; and they chose their part. Robert Catesby, a gentleman of ancient family, and whose character in other respects suited little with the desperation of a zealot, formed the terrible scheme of at once avenging and retrieving their lost ascendancy. He imparted his thoughts to a few zealous Catholics, among whom were Piercy, Rookwood, and Sir Everard Digby. A meeting was held, to consult what measures would best accomplish their purpose. Piercy, in the true spirit of fanaticism, proposed to assassinate the king, and to be himself the instrument; but Catesby, with deeper purpose, laid before them a wider plan of vengeance. He represented to them the inefficacy and the danger of striking a single victim, which would but mark out themselves for a more dreadful atonement. He shewed them that the whole of their enemies might be struck at once,

* See the Description of this Plate at the end of the volume.

by running a mine below the House of Parliament, and when all should be assembled, at the opening of the session, blowing them up in one common ruin, and consigning them, as he chose to express himself, "from flames above to flames below." The scheme was received with enthusiasm. A few more Catholics were taken into the plot; and, with the others, had their consciences absolved by the Jesuits Garnet and Tesmond. Among these was the famous Guy Fawkes, who had been sent for from Flanders, and was well fitted, by his zeal and intrepidity, to take a prominent share in this extraordinary enterprize.

The plot being now fully concerted, a house adjoining the House of Parliament was hired in Piercy's name, and the operation commenced towards the end of the year 1604. Nothing could exceed the industry with which it was forwarded. A store of provisions was taken in, to prevent the necessity of interruption; and the conspirators came armed to the work, determined to succeed, or perish in the attempt.

Between the houses was a partition wall, three yards thick. This, after much labour, they succeeded in piercing; but just as the work opened to the other side, they were alarmed by an unaccountable noise from below. Fawkes, who passed himself for Piercy's valet, went out to enquire into the cause, and learned, to their inexpressible satisfaction, that the sounds they had heard proceeded from a coal vault under the House of Lords, where coals were at that moment selling off, and that the vault itself would be let after the sale. The conspirators seized with eagerness the opportunity, bought up the remainder of the coals, and hired the place. Thirty-six barrels of gunpowder were procured from Holland, conveyed into the vault, concealed under coals and faggots, and the doors boldly thrown open, as if to challenge inspection.

Matters being thus far in preparation, there remained but one obstacle to the completion of the enterprize. The Duke of York and the Princess Elizabeth, on account of their youth, would be absent from Parliament, and escape destruction. It was resolved, therefore, that when the explosion should have done its work, Piercy, who, as a gentleman pensioner, had access to the Palace, should carry off or assassinate the Duke, while Sir E. Digby, having assembled his friends on pretence of a hunting match, was to seize the princess, then at Lord Harrington's house in Warwickshire, and proclaim her queen.

Every thing was now arranged for the dreadful issue. The day approached (the 5th of November) appointed for the meeting of parliament. The conspirators looked forward to a certain triumph, when, fortunately for the country and for Protestantism, the indiscretion of a Catholic laid open the treason.

Ten days before the sitting of parliament, Lord Monteagle, a Catholic, son of Lord Morely, received from a person unknown the following letter. It had been put into the hand of his servant, with express injunctions to be delivered only to himself. "My Lord, out of the love I bear to some of your friends, I have a care of your preservation. Therefore I would advise you, as you tender your life, to devise some excuse to shift off your attendance at this parliament. For God and man have concurred to punish the wickedness of this time. And think not slightly of this advertisement; but retire yourself into your country, where you may expect the event in safety. For though there be no appearance of any stir, yet I say they will receive a terrible blow this parliament, and yet they shall not see who hurts them. This council is not to be contemned, becsuse it may do you good, and can do you no harm. For the danger is past as soon as you have burned the letter, and I hope God will give you grace to make good use of it." Neither Monteagle nor Salisbury, to whom he carried the letter, was inclined to regard it seriously. James was the first to penetrate its meaning. The words quoted by Salisbury, to prove to him the folly or insanity of its author, viz. "the danger is past *as soon* as you have burnt the letter," James interpreted to signify, not that the danger would be past when the letter was burnt, but that it would pass in a space of time as short as the burning of the letter might occupy. This, compared with the preceding threat of a "terrible blow," the authors of which would be concealed, suggested to the king the agency of gunpowder. It was determined, therefore, to have an inspection of all the rooms and vaults below the houses of parliament. This duty was performed the day before the meeting by the Lord Chamberlain, who, besides noticing the prodigious pile of fuel, did not fail to observe also the dark, intrepid, and suspicious countenance of Fawkes, who, still passing himself for Piercy's servant, loitered about the cellar. This being reported to the council, a more particular search was deemed advisable. Accordingly, Sir Thomas Knevet, justice of peace for Westminster, went with proper attendants at midnight, and seized Fawkes, just as he had completed his preparations, and was leaving the vault. He was dressed in a cloak and boots, and held in his hand a dark lantern. Matches being found upon him, and the powder discovered under the fuel, the guilt became apparent, and he no longer sought to conceal it. He broke out in a tone of defiance and contempt, expressing, in the strongest manner, his extreme regret that so many heretics had escaped his vengeance, and declaring that he could attribute only to the devil the frustration of so good a work. He met the council with the same scornful intrepidity, and obstinately refused giving any account of his accomplices; but, after two days solitary confinement in the Tower, and the rack being just set before him, his courage was shaken, and he made a full disclosure of the treason. Upon the first notice that Fawkes was arrested, Catesby, Piercy, and Winter, fled hastily into Warwickshire, where they joined the party of Sir E. Digby. Sir Everard, having failed in his attempt to seize the Princess, was already pressed, and almost beset by the sheriffs. After being driven for some time from place to place before their enemies, they made a resolute stand at the house of Holback, in Staffordshire; but here part of their powder having accidentally exploded, they were thrown into the utmost confusion, the gates were flung open, and the armed multitude rushed in upon them from all sides: Catesby and Piercy, fighting back to back, fell by the same shot; Winter, Digby, and Rookwood, were taken alive, and, with the Jesuits Garnet and Oldcorne, suffered by the executioner. More were afterwards convicted; and some owed their lives to the clemency of James.

Stourton and Mordaunt, two Catholic lords, having been absent from parliament, were suspected of connivance, and fined, the former in 4000*l.*, and the latter in 10,000*l.* The Earl of Northumberland fell under the same suspicion. It was discovered, that, as captain of the band of Gentlemen pensioners, he had excused his cousin Piercy, upon his admission into that corps, from taking the customary oaths. He was stripped of his employment, imprisoned during the king's pleasure, and fined in 30,000*l.*

Such was the issue of this memorable treason,—a treason scarcely more memorable for the desperate zeal and devoted bigotry of its conductors, than for the magnitude of its purpose, and the deep atrocity of its guilt. It has not the excuse of precipitation or passion. Though undertaken perhaps in the freshness of imagined injury, it was meditated for years, and with increasing zeal and approbation. Neither was it the offspring of ignorance and depravity; its leaders were the most esteemed and most enlightened of their religion. Hence may be traced in the minds of Protestants, a jealousy and a prejudice, which, even in these times, yield, with much reluctance, to the better views and more tolerant spirit of enlightened Christianity. (*v*)

GUNSHOT Wounds. See Surgery.

GUNTER'S Line. See Arithmetic, and Logarithmic Scales.

GURNIGHEL, is the name of a mountain in the canton of Bern, and situated to the north of the chain of the Stockhorn, on the confines of the country of Schwartzenbourg, and six leagues to the south of Bern. It is principally remarkable for its baths of sulphurous waters, which are situated on the north-west side of the mountain, at the side of a fine wood of firs, and which are accessible to carriages, notwithstanding the great height of their situation. One of the springs, called Stockwasser, issues from the ground, about a quarter of a league from the baths. Its temperature is $+ 6°$ of Reaumur. Fourteen ounces of this water contains, according to M. Morell of Bern, carbonic acid gas, mixed

| | |
|---|---|
| With hepatic gas | $3\frac{1}{2}$ cubic inches. |
| Carbonate of magnesia | $2\frac{3}{4}$ grains. |
| Lime | $1\frac{1}{2}$ grain. |
| Sulphate of lime | $8\frac{1}{8}$ grains. |
| Sulphate of magnesia | $\frac{3}{24}$ grain. |
| Sulphate of soda | $\frac{3}{29}$ grain. |
| Iron | $\frac{3}{40}$ grain. |

A second spring, which is called Schwartzbrunlein, has a strong sulphurous odour. It is at first very limpid, but is rapidly decomposed by the air, and becomes as white as milk. It is more powerful than the other spring, and great quantities of it are sent in bottles hermetically sealed to Bern, at the price of about 11 sous. The lodging-house is commodious, though by no means sumptuous. The expence of board is about 6 or 7 French livres per day. From the house there is a fine view over the whole of the canton which is comprehended between the Jura and mountains of Emmenthal, and also of the town and lake of Neufchatel. See Ebel's *Manuel*, &c.

GUSTAVUS Adolphus, commonly called the Great, King of Sweden, was born at Stockholm in the year 1594. He was educated with particular care, and instructed in all the learning and accomplishments which are calculated to form a statesman and a hero. His genius was great, his memory prodigious; and he discovered an uncommon docility and desire of acquiring knowledge. In the year 1611, he ascended the throne of Sweden, being then only 18; but the vigour of his character, and his various acquirements, compensated the disadvantage of his youth: and the choice which he made of his ministers and counsellors, evinced his ability to conduct the government of the kingdom, at the head of which he was placed.

Soon after his accession, he was involved in war with the Danes, the Russians, and the Poles, from which he extricated himself with great valour and prudence; having increased his hereditary dominions by the acquisition of Livonia, which he wrested from the two last mentioned powers. In the year 1630, he was invited by the German Protestants to join the league against the Emperor; and by his powerful assistance, and the good conduct of his arms, he greatly contributed to the ultimate success of their cause. On his departure from Sweden, he called together the states of the kingdom; and having caused them to do homage to his daughter Christina, then only four years old, he took leave of them in a discourse, in which he explained, at length, the motives that prompted the enterprize he was about to undertake.

In the month of June 1630, Gustavus landed on the coast of Pomerania, with an army of 15,000 men. At first, his operations were greatly impeded by the jealousy and discord that reigned among the Protestant Princes of Germany, who seemed to be actuated rather by their own selfish interests, than by any enlarged view to the general good. However, he soon expelled the imperial troops from Pomerania, and forced the Elector of Brandenburgh to embrace his true interest, by affording every facility to the enterprize of the Swedes. The King then resolved to hasten to the relief of Magdeburg, which was besieged by the imperial generalissimo Count Tilly; but his views were frustrated by the strange conduct of the Elector of Saxony, who refused to permit him to pass the Elbe; and he had the mortification to receive intelligence of the fall of that important fortress, accompanied with circumstances of atrocity, which have stamped indelible infamy on the name of Tilly. The haughty and cruel conduct of the imperial commander soon brought the Elector of Saxony to a sense of his situation and true interest; and having joined his forces to those of the King of Sweden, they encountered the enemy under Tilly, at Breitenstein, near Leipsic, on the 7th of September 1631. A battle ensued, which terminated in the total discomfiture and rout of the Imperialists. The victorious King now advanced along the Maine, as far as the Rhine; forced the city of Mentz to capitulate; drove the Spaniards out of Germany, and freed the Palatinate. He then turned his arms against Bavaria; and Tilly, who endeavoured to dispute with him the passage of the Lech, was again defeated, and perished in the attempt.

His loss was supplied by Wallenstein, who was now placed at the head of the imperial armies; and commenced his operations by driving the Saxons out of Bohemia. Meanwhile Gustavus, pursuing his victorious career, had advanced into the heart of Bavaria, and made himself master of Munich. As he approached the Austrian dominions, Wallenstein hastened to their relief, and compelled the king to retire. The two armies met at Nuremberg, and formed entrenched camps opposite to each other, where they remained inactive during two months. It was the policy of Wallenstein to avoid a battle, in hopes that the Swedish army would be weakened by famine and disease. At length the latter made a vigorous attempt to storm the entrenchments of the Imperialists; but, for the first time since their landing in Germany, they received a severe check; and, after a fruitless exhibition of valour, Gustavus found himself compelled to retire, the whole of the neighbouring country being completely exhausted of provisions. He was followed into Saxony by Wallenstein; and the two armies again met at the village of Lutzen, near Weissenfels. Here a sanguinary battle took place on the 6th of November 1632, which was fought with great skill, and with the most obstinate courage, on both sides. The intrepidity and discipline of the Swedes, however, at length prevailed, and the Imperialists were driven from the field. But the victory was dearly purchased. Besides a great loss of men, the conquerors had to lament the death of their adored king, who was killed by a musket shot, while gallantly leading on his cavalry to a charge against the broken ranks of the enemy. After the battle, his body was found lying near a large stone, which, in commemoration of this circumstance, was called the *Schwedenstein*, (Swede stone,) and which still indicates the spot where the great vindicator of the religious liberties of Germany terminated his victorious career. Thus fell Gustavus Adolphus, in the thirty-eighth year of his age. The ball which inflicted the mortal wound entered his back, and passed through his body. This circumstance, among others, excited a suspicion of treachery; and the Duke of Saxe-Lawenburgh, one of his generals, who immediately afterwards left the Swedish service, has been expressly pointed out by some historians as the assassin of his royal commander. There is, however, no positive evidence of his guilt, and the fact is to this day doubtful.

Gustavus left behind him the character of a good Christian, a great king, a prudent statesman, and a consummate general. Amidst the operations of war, he did not neglect the cultivation of the sciences. He enriched the university of Upsal, established a royal academy at Abo, and founded an university at Dorp in Livonia. Before his time, there were no regular troops in Sweden; but he formed and executed the project of having 80,000 men, constantly well armed, clothed, and disciplined. He was acknowledged to be the greatest captain of his time, and the bravest soldier in his army; and the military art is indebted to his genius for several great improvements. He formed his cavalry into smaller subdivisions, which enabled them to move with greater ease and rapidity; his order of battle was composed of two lines, (instead of one, according to the usual practice,) in order that the second might advance, in the event of the first being broken; and he was the first who demonstrated, in modern times, the importance of a well-disciplined infantry in the field. His own army was a perfect pattern of good order. The morals of his soldiers were to him an object of equal attention with their courage and military discipline. Temperance was commanded as a duty by the Swedish laws of war; excesses of every kind were severely punished; and every regiment mustered, morning and evening, around its chaplain, to perform their devotions in the open air; the king himself being always present upon those occasions. He endured all the hardships and privations of war with the meanest of his army; and never spared his person in the hour of danger.

He not only extended his dominions, and raised the reputation of Sweden abroad, but also turned his attention to the constitution of his country, which he would probably have improved had he lived to return into his own kingdom. By his regulations, however, the succession to the crown, which had been previously limited to the male line, devolved upon his daughter Christina, who was only six years old at the period of her father's death. See Harte's *Life of Gustavus Adolphus*; Schiller's *History of the Thirty Years War*; and the *Gen. Biog. Dict.* (z)

GUSTAVUS I. and III. See SWEDEN.

GUTTA SERENA. See SURGERY.

GUTTEMBERG. See PRINTING.

GUZERAT, or GUJRAT, a large province in Hindostan, situated principally between the 21st and 24th degrees of North Latitude, is about 320 miles in length, and 180 at its average breadth. Its south-west portion approaches the form of a peninsula, lying between the gulfs of Cutch and Cambay; but it stretches far inland towards the north-east, having the province of Cutch on the west, Malwah and Khandesh on the east, Aurungabad on the south, and Agimere or Ajimeer on the north. It was one of the 11 soubahs,* into which Akbar divided Hindostan; and is understood to have, at that time, extended southward as far as Damaun. It contained nine circars, namely, Guzerat proper or Ahmedabad; Putten; Nadowt; Behrodeh, or Baroda; Behroatch, or Baroche; Chumpaneer; Kodehra; and Surat. These were subdivided into 198 pergunnas, of which thirteen contained sea ports. The whole Soubah furnished 67,375 cavalry, and 8900 infantry; and, in the reign of Aurungzebe, the amount of its revenue was equivalent to 1,800,000*l.* sterling.

Guzerat was subdued in 975 by the Afghans or Patans, a hardy race, from the mountainous regions between Persia and Hindostan, who established the extensive empire of Ghizni, and maintained their authority till the end of the thirteenth century, when the Moguls commenced their ravages. In the fifteenth century, it was governed as an independent kingdom, by a dynasty of Rajpoot princes, who had adopted the Mahommedan religion, and removed the seat of government from the ancient capital Nehrwallah to Ahmedabad. In 1572, it was reduced by the emperor Akbar; and was, at that period, in a flourishing state as a maritime and commercial country. In the beginning of the 18th century, after the death of Aurungzebe, many of the more distant provinces renounced their allegiance to the Mogul emperor; and the governor of Ahmedabad and Cambay, following these examples, assumed the sovereignty of that part of Guzerat. About the middle of the 18th century, it was conquered by the Mahrattas under Ragonauth Row; and its nabob Mohman Khan, took refuge in Cambay, where he held a small territory, subject to the payment of an annual tribute to the Mahrattas. The capital was taken from the Mahrattas by general Goddard in 1779; but for political reasons was ceded to Futty Singh, a Hindoo chieftain, and at the end of the war in 1783 was restored to the Mahratta government. The more civilized and cultivated districts are at present possessed by the East India Company, the Guicowar and the Peishwa. The territories of the Company comprehend a considerable extent of country on both sides of the Gulf of Cambay; and include the populous cities of Surat, Baroche, Cambay, and Gogo. The sea-coast, from the Gulf of Cambay to the river Indus, is occupied by different independent chiefs, who are generally addicted to piracy, and are kept only in awe by the naval superiority of the British. The northern, western, and even central quarters of the province, have been but recently explored, and are overrun, or rather occupied by numerous tribes of armed banditti, who are thieves not so much by profession as by nation.

The province of Guzerat, in its general aspect, is flat and unvaried. In many places, not the smallest stone is to be seen; and there is scarcely a rising ground in the whole district to the west of Powagur, the name of the mountain by which it is separated from the interior of Hindostan. It is more hilly towards the eastern frontier, and much covered with jungle. Much of the more level tracts is either an arid sandy country, or a saline swamp of a singular description, which, even when dried up, remains in a great measure sterile and unproductive. In those places, also where the surface is apparently smooth to the eye, it is much intersected by ravines, of considerable extent and depth, which in the rainy season are filled with rapid torrents, and cannot be crossed without the assistance of rafts or boats. It is, nevertheless, especially in its western districts, full of the richest prospects, and is inferior to no part of Hindostan in beauty or fertility.

The only mountain in the province is that of Powagur, a steep and rocky height, resembling the Table Land of the Cape of Good Hope, but apparently more lofty. On its summit is a strong hold, deemed impregnable, and supposed to be the Tiagura of Ptolemy.

Guzerat is watered by several large rivers, of which the most considerable are the Myhi, which takes its rise near

* Akbar divided Hindostan into eleven soubahs, or grand divisions; each of these into smaller provinces called circars; and each of these again into districts or pergunnas. A twelfth was afterwards added, formed of countries west of the Indus.

Amjerrah, the capital of Rajode, and, running in a south-west direction, falls into the bottom of the Gulf of Cambay; the Nerbudda, supposed to be the Narmada of the Greeks, which rises in the mountain of Pindara, near the north-east corner of Berar, and proceeding westwards about 640 miles, terminates its course on the east coast of the Gulf of Cambay; and the Taptee, which descends from the mountains of Burhanpour, and after a course of above 320 miles, nearly parallel to that of the Nerbudda, falls into the sea below Surat. These larger rivers are ordinarily extremely gentle and pellucid; but begin to swell some time before the rain falls in the low countries; and then become furiously rapid, frequently sweeping away whole villages, with the inhabitants and their cattle. In the rainy season, the mountain torrents swell the smallest streams in a wonderful manner, so as to make them rise in a few hours 20 or 30 feet above their usual level. In the dry season, nevertheless, a great scarcity of water is experienced in many places, especially in the sandy soil to the north of the Myhi river, where the periodical rains are speedily absorbed, and wells must be dug to the depth of 80 and 100 feet.

The rainy season sets in with the south-west monsoon before the middle of June, accompanied with tempestuous weather, and continues with more or less violence about four months. The greatest quantity of rain always falls in July; yet, in the province of Guzerat, there is not so much rain during the wet season as there is at Bombay, and the southern part of the Malabar coast. In December, January, and February, the mornings and evenings are cold and sharp, and sometimes ice has been seen at Surat in the month of January. At this period the thermometer is frequently under 60° at sun-rise, and seldom exceeds 70° at noon; and the weather throughout the whole day is temperate and agreeable. But, in the succeeding months, during the prevalence of the hot winds, though the morning may be tolerably cool, the thermometer gradually rises from 70° to 100°; and in the plains near Cambay, has been observed at 116° in the soldier's tents. During the hot and dry months, the surface of the country is covered with sand or dust; and, in the rainy season, becomes a thick mire, and often a sheet of water.

The soil is generally sandy or marshy; but, in the cultivated districts, is a reddish light earth, or a rich black mould, both of which are highly fertile and productive. Except for the richer crops, manure is seldom required; and the dung of the cow-house is then the principal substance employed. In some of the pergunnas, particularly in Brodera and Jambooseer, the fields are inclosed, and the country enriched with plantations of mango, tamarind, and banian trees. The different kinds of grain are generally sown in June, and reaped in September. Wheat and barley are raised in many districts. Rice is a principal article of cultivation; and a great variety of Indian grains is every where produced. Of these may be mentioned the juarree, or cush-cush, (*holcus sorchum* of Linnæus,) a fine large plant, resembling maize or guinea corn, growing to the height of eight or ten feet, each stalk bearing several ears, the largest of which will frequently contain 2000 seeds; bahjeree, (*holcus spicatus* of Linnæus,) resembling the last, but inferior in size, and only used by the poorer classes; codra, chena, buntee, bowtah, growing to the height of two or three feet, and yielding grain of a nutritious quality; various pulses, especially tuar, (*cytisus cajan*) resembling split peas; mutt and gram, (*dolichos biflorus*) chiefly used for nourishing cattle. Cotton is a staple commodity; and that of the Ahmood pergunna is of so superior a quality, that it generally brings the highest price in the markets of Bengal and China. Sugar, tobacco, and indigo, flourish luxuriantly in the province, and might be cultivated with great profit. Hemp and flax grow well in the northern districts; but are often raised chiefly for the sake of the oil contained in the seed, and an intoxicating drug called Chang made from the leaves. Mustard seed is raised in considerable quantities, and is greatly esteemed in pickles. Occasionally may be seen, in gardens, large crops of poppies, (the seeds of which are very commonly mixed by the natives in cakes and confections,) ginger, turmeric, fenue greek, and betel leaf, extensive fields of capsicum or chilies, and large tracts of yellow cossumba, (*carthamus*,) which yield a valuable red dye. In those places where there is no cocoa nuts, various shrubs and plants are cultivated for producing oil, especially the sesamum, and ricinus, palma Christi. The water melons, especially those of Baroche, are superior to any in India. The white, red, and curling mulberry flourishes in the gardens; and the cuttings require only to be put into the ground in the rainy season, where they take root, and grow up withour farther trouble. The bamboo grows wild in most districts, is frequently planted in hedges around the villages, and in seasons of scarcity sometimes furnishes an article of food. Mango, tamarind, and banian trees are to be found in most parts of the province. One of the last mentioned, (the banian or *ficus indicus*) the most magnificent tree of the kind in India, grows on an island in the river Nerbudda; and has nearly 1350 trunks, all traced to one parent stem, froming a canopy of verdant foliage, impenetrable even to a tropical sun, extending over a circuit of 2000 feet.

Many milch cows and buffaloes are reared in the villages; and ghee, or clarified butter, forms a principal article in the markets of Guzerat. Many horses also are bred in the province; and those of Cutch and Cottywar are held in great estimation. The oxen of Guzerat are accounted the finest in India. They are perfectly white, with black horns, a delicately soft skin, and eyes not inferior in lustre to those of the antelope. They will travel 10 or 12 miles a-day successively for a considerable time, under a load of 200 or 300 lbs.; and are fed upon straw, grass, cotton seed, or oil cake. Those which are reared in the northern districts are of superior size, strength, and docility; and some of them are capable of travelling in a hackery (or light cart) 30 or 40 miles a day. A more ordinary breed is employed in agriculture, and in the conveyance of merchandize; and others, of all different colours, as in other parts of Hindostan, are to be found in the province. The uncultivated and wood tracts abound in wild animals of various kinds. Lions, though not generally supposed to be found in the country, have been seen even in the vicinity of Cambay; and tigers are very common, sometimes so large as to weigh 250 lbs. Leopards, hyænas, wolves, foxes, jackals, and wild hogs, are the ordinary inhabitants of the swamps and jungles. Deer, elks, guanas, antelopes, hares, cameleons, porcupines, &c. are the most common kinds of game. Monkeys and squirrels are every where abundant, and remarkably tame. The former, particularly, often inhabit the towns, where they are generally protected, and in some places are revered as sacred animals. They are sometimes rendered instruments of a bloodless, but sufficiently malicious revenge among neighbours. A handful of rice, or other grain of which the monkeys are fond, is thrown upon the roof of the house of the obnoxious person, about the commencement of the wet season; and, in order to get at the grain which has slipped under the tiles, these mischievous animals soon uncover the whole habitation, at a time when labourers being generally occupied in repairing the houses, it may be impracticable for the hapless owner to have his home secured from the heavy torrents which are beginning to fall. Of the birds of prey, the most common are hawks and brahminee kites, which last are so remarkably voracious, as sometimes to dart upon a dressed fowl, or other food, while the servants are carrying it from the kitchens, (which are frequently at a little distance from the house,) to the dining-table. There are bats of an extraordinary size, (nearly six feet between the tips of the extended wings,) called flying foxes, and extremely disagreeable in smell and aspect. Peacocks, doves, and green pigeons, assemble in flocks around the villages, and are almost as tame as poultry in a farm yard. Partridges, snipes, woodcocks, wheatears, &c. are very abundant; and there is a great variety of water-fowl in the lakes and rivers, particularly storks, cranes, quails, flamingoes, pelicans, ducks. The sahras and cullum (*ardea virgo* of Linnæus) are very stately birds, generally six feet high, of an azure hue, with crimson coloured heads. But the florican, or curmoor, (*otis houbara* of Linnæus,) is at once the most elegant of Indian birds, and exceeds all other wild fowl in delicacy of flavour. It is distinguished by its lofty carriage, variegated plumage, and especially by a tuft of black feathers falling gracefully from its head. Lizards are abundant in Guzerat, and many of them are extremely beautiful. Serpents are found in great numbers and varieties; and some of the largest kinds, which are accounted harmless, are held sacred by the natives as guardians of the spot which they frequent, are allowed to occupy the gardens. One of the most venomous is the cobra de capello, or coluber naja, which is very common in Guzerat. There are many varieties of water snakes, (some of them spotted with the most beautiful colours,) which seize upon the frogs, lizards, young ducks, and water rats, and are in their turn devoured by the larger water fowls. Locusts, though less destructive than those of Arabia and Africa, are frequent visitors in the province; and leave every vegetable substance over which they pass stripped and browned, as if scorched with fire. The large locust, called "the creeping leaf", and which has been described under the article GUIANA, is common in Guzerat.

The principal towns in the province are Ahmedabad, Surat, Cambay, Baroche, Baroda, Dhuboy, Gogo, and Chumpaneer. They are generally in a ruinous condition, presenting, in their decayed palaces, tottering minarets and mouldering aqueducts, many vestiges of their former splendour. Their commerce has never been so flourishing as it was under the Mogul government, even in the times of its most violent convulsions. The principal trade of the province is carried on with Bombay. The chief exports are cotton, piece-goods, and grain; and the imports consist mostly of sugar, raw-silk, pepper, cocoa nuts, cochineal, woollens, and bullion. Almost all castes in Guzerat, excepting the Brahmins and Banyans, occasionally follow the occupation of weaving; which, together with the labours of agriculture, employs the greatest number of the more industrious of the lower classes. Fortifications were formerly very numerous in the province, and are still preserved in the more remote quarters. The natives every where live in towns or villages, for security against banditti and wild beasts. A single farm house, or separate cottage, is rarely to be seen; and, at night, the cattle are always brought within the hamlet, which is commonly surrounded by a mud-wall or bamboo hedge. The larger towns are usually situated near an extensive lake, the banks of which are adorned with Hindoo temples and caravansaries, and its surface covered by the various kinds of lotus. The houses, especially in the villages, are rarely built of brick, and provided with tiled roofs, but chiefly constructed of mud, and thatched with straw or reeds.

As many parts of Guzerat have never been subdued by any invader, the natives there retain their original character unchanged; but in the maritime district, in consequence of the many sea ports and commercial advantages, which have attracted strangers of all descriptions, the province contains a greater variety of castes and religions, than any other in Hindostan. It is commonly believed among the natives, that the province was originally peopled by the rude castes which still exist, and which are known by the names of Cooles and Bheels; but neither record nor tradition remains respecting their religion or government in their primeval state. In the town of Rajpeepla, however, the Rajpoot successor is still formally invested with the nominal sovereignty by a family of Bheels descended from their original chieftains. When the Rajpoots acquired the ascendancy, the most powerful of their princes resided at Neherwallah, (or Putten,) on the northern frontiers; and three dynasties are said to have successively occupied the throne, from which many of the modern Gracia families pretend to trace their descent. The Gracias are a numerous class of landholders in some parts of the province; and in others only possess a sort of feudal authority over certain villages and districts. They are described as consisting of four castes or families,—the Coolees, the Rajpoots, the Seid Mahommedans, and the Mole Islams or modern Mahommedans. The places principally occupied by the Gracias are Rajpeepla and Mandwee, the former south, and the latter north of the Ferbudda river; Meagam and Ahmode, between the Nerbudda and the Myhi; and Mandowee or the Taptee. Many tribes of them also reside in a kind of independent state on the rugged banks of most of the rivers, and in different parts of the peninsula. Criminals, who fly to their haunts for refuge, are readily incorporated among them; and all of them are habitual plunderers, forming one half of the population north of the Myhi. Of all the banditti who infest the province, the most cruel and untameable are the Coolees, who maintain amidst their fastnesses an armed independence, and plunder without distinction all who travel without an escort, or whom they are able to master. They are taught to despise all approaches to civilization; and are said to hold cleanliness in the utmost contempt, as a mark of cowardice. They are well mounted, and often roam in troops to a distance from their own settlements, to plunder villages or surprise travellers. Their own villages, at the same time, are large and populous, their fields inclosed, and their lands in general in a state of good cultivation. The Rajpoots are of a high caste, and are well bred to the use of arms. They are athletic in their persons, faithful to their engagements, magnanimous and brave above most other natives of India, and make the most excellent soldiers. They chiefly inhabit the districts north of the Nerbudda; and the great body of them occupy the province of Ajimeer, where they have never been subdued by the Mahommedans, and where they preserve in their strongholds and fastnesses the original manners of the Hindoo race. Their country is said to resemble greatly the more habitable mountainous tracts of Swisserland, and to afford some of the grandest and most picturesque scenery in India. The Bheels are like the Coolees, savage robbers, but generally poorer; and inhabit chiefly the districts around Turcaseer. The high Moguls or Mahommedans, especially those who inhabit the towns along the coast, are a polite and respectable people. In all the larger towns are found a singular race, who are Mahommedans in religion, but Jews in features, manners and disposition. They are called Borahs, and form every where a distinct community. They profess a total uncertainty of their own origin; but Boorhanpour, in Khandesh, is the rendezvous of the sect, and the residence of their moulah or high priest. They are noted for their address in bargaining, their minute parsimony, and constant attention to gain. They are the principal traders in the commercial cities, and are found straggling over the whole province, and the other western parts of Hindostan, as itinerant pedlars. In Guzerat is found, also, the greater part of the Gabres or Parsees, or worshippers of fire, who inhabit the continent of India, and who preserve the slender remains of the religion of the Magi; (See Gabres.) Of the proper Hindoos there are many castes and sects in Guzerat. The different families of Brahmins, settled in the province, amounted to 84 in number, and are named after the places of their ancestors nativity or inheritance. Each of these has several subdivisions, and innumerable distinctions, which prevent the members of one from intermarrying with another. The Banyans, or Vaneeya, are very numerous in Guzerat, and are also separated into many subdivisions. They are all merchants, and frequently travel to very distant countries, where they remain for several years, in the prosecution of traffic, and then return to their families with the gains of their adventure. Their language, the Guzeratee, which is nearly allied to the Hindee, is well known in all the great Indian markets, and forms the chief medium of mercantile intercourse in that continent. A singular custom among the Guzerat merchants may here be noticed, namely, that when any of them finds himself failing in trade, he sets up a blazing light in his house or shop; absconds, till his creditors have examined into the state of his property; and wears the tail of his waist-cloth tucked up, till they have acquitted him of all suspicion of dishonesty. Persons, who take this step in time, so as not to injure their creditors much, are held in great esteem, and are so frequently observed to be subsequently prosperous, that some have been known, in hopes of future good fortune, to set up the sign of bankruptcy without any necessity. The class of Bhauts, or Bharots, abound more in this province than in any other part of India. They are a very honourable tribe, and are principally occupied as historians, heralds, soothsayers, recorders of births and deaths, itinerant bards or minstrels, trading or begging on their way. In this last capacity, they repeat verses (which are either of their own composition, or selected from the Hindoo legends) with a pleasing modulation of voice, and gracefulness of action; and one of them is generally connected with the household of every Hindoo rajah or Mahratta chief, attending them on days of public ceremony, enumerating their titles, and proclaiming their praises They also become guarantees of treaties between princes, securities for bonds between private persons, or cautioners for the payment of revenues from districts, and farmers of the taxes. They receive an annual stipend, or a per centage from the districts, villages, or individuals, whom they thus guarantee; and, upon signing the agreement, add the figure of a dagger as their seal, and as an emblem of the fatal consequences attending a breach of contract. Should any party fail in the obligation, the Bhaut, who had offered himself as guarantee, proceeds to the house of the defaulter, and there destroys himself or one of his family, imprecating the vengeance of the gods upon the heads of those, who had compelled him by their misconduct to commit the deed of desperation. To be the object of these imprecations, is accounted by the Hindoos the most direful of all catastrophes; and hence the security of a Bhaut is the strongest and most sacred of all bonds. They are frequently also engaged in agriculture; but, as a privileged class, are exempted from all payment of taxes; and, when any attempts have been made to subject them to assessments, they do not fail to murder some of their tribe, with the usual imprecations on those who have infringed their rights. The Charons are nearly allied to the Bhauts in manners and customs; and, being generally possessed of large droves of carriage cattle, they carry on an inland traffic in grain to a considerable distance. They are frequently hired for the protection of travellers; and, when attacked by banditti, they take a solemn oath to die by their own hands, if any injury be done to the persons under their care. So great is the veneration in which they are held by the superstitious natives, that this threat of suicide is generally effectual in restraining the most ferocious plunderers. The Ungreas, whose profession is that of money-carriers, are of all castes, and generally athletic and well armed. Though extremely poor, they are remarkable for their honesty in conveying the largest sums. They conceal the money in their quilted clothes; and though rewarded for their services only with a small pittance, they will fight with the utmost desperation in defence of the property with which they are entrusted. In the northern and western parts of the province, is a class named Puggies, whose business it is to trace the steps of a thief, and they are so expert in the office, that, if set upon the pursuit early in the morning after the theft has been committed, before many people have been moving about the vicinity, they seldom fail to point out the village where the thief has taken refuge. The Dheras of Guzerat are similar to the Pariars of Malabar, and are obliged to live apart from the other inhabitants. They live on all kinds of carrion, and are much addicted to pilfering and intoxication. They are compelled by ancient custom to serve the state and travellers as carriers of baggage; and also to act as scavengers for the removing of filth from the roads and villages. The Koonbees, which is the name given in Guzerat to the Hindoos of the pure Sudra, or fourth caste, form the great body of the agricultural peasantry; and are supposed to have emigrated originally from Ajimeer, or Hindostan Proper. They hold portions of government land; and are called Patells, in distinction from the Gracias. They are peaceable, industrious subjects under every change of rulers; and, as they seldom repair to the cities, their manners are altogether simple and inoffensive. They rarely leave the village where their fathers lived and died, but continue in the same place, to plough the fields, and reap the harvest, and tend the cattle, while their women are employed in spinning cotton, grinding corn, and preparing the usual repast of milk, pulse, and other vegetables. Too large a proportion of the produce of their lands is collected for the government and subordinate chiefs; but still a sufficiency generally remains for the supply of their wants, which are extremely few and simple. In the more remote districts, particularly, their mode of living is remarkably primitive. A hut built of mud, and thatched with straw, is the ordinary habitation of the villager. A few earthen pots for cooking, a large jar of unburnt clay for holding grain, another of burnt clay, for holding water, and a glazed jug for holding oil, form the chief part of his furniture. A couple of yards of cotton cloth tied round the middle, and sometimes a turban on the head, composes the whole clothing of the men; and a long piece of similar cloth, put on in graceful folds, is the usual dress of the females.* They testify great hospitality to strangers, who are usually presented at the entrance of the villages with fruit, milk, butter, fire-wood, and earthen utensils; and sometimes compelled, at their departure, to take with them one day's provisions. They are a contented people, and their condition tolerably comfortable in seasons of peace; but they have no idea of liberty, and are subjected to every species of suffering in time of war. But

* It is a universal practice among all the Mahommedans of both sexes, and the Hindoo males throughout Guzerat, to smoke tobacco; except the Brahmins, who take snuff very freely.

wherever British influence extends, their comforts are increased, and their security better provided for. In the north-western quarters, many barbarous practices prevail among them; and among the Coolees and Rajpoots, particularly, besides what may be called the prescribed cruelties of their religion, it is not uncommon for many persons of both sexes to cut off their noses, as a security against the malignant influence of witches. The unnatural practice of putting to death the female infants, which prevailed among the Jahrejahs, a race of Rajpoots in the peninsula of Guzerat, was abolished in 1808, by the humane exertions of Jonathan Duncan, Esq. late governor of Bombay, and of Colonel Walker, British resident in the province;* and within the districts acquired by the East India Company, many other degrading customs are gradually disappearing. The province of Guzerat, in short, presents among its different inhabitants instances of the extremes of civilization, exhibiting all the rudeness of the pastoral and almost of the savage state, along with the wealth and luxury of commercial cities. It affords equally striking specimens of the extremes of population, which is thinly scattered over the western districts, but unusually crowded in the vicinity of Surat, and some of the other cities. The whole number of inhabitants in this extensive province is estimated at six millions, in the proportion of one Mahommedan to ten Hindoos. See Rennel's *Memoir of a Map of Hindostan:* Milburn's *Oriental Commerce;* Hamilton's *East India Gazetteer;* and Forbes's *Oriental Memoirs.* (*q*)

GWALIOR, Gualior, or Gualiar, is the name of a strong fortress of Hindostan, in the district of Gohud, and province of Agra. This fort stands on a hill about $1\frac{6}{10}$ mile long, 300 yards wide at its greatest breadth, and 342 feet high at its north end. The sides of this hill are nearly perpendicular, and a stone parapet is carried all the way round close to the brow of it. At the north end of the hill, and near the middle of the fort, are two remarkable pyramidal buildings of redstone, in the ancient Hindoo stile of architecture. The only gate to this fort is at the northern extremity of the east side, from which there is an ascent to the top of the rock by several flights of steps. The garrison is supplied with excellent water, from several natural cavities in the rock; and about half way up the rock, on the outside, there are many artificial excavations, containing the figures of men and animals carved out of the solid rock.

The town is situated on the east side of the hill. It is large and populous, and contains many good stone houses. The stone is obtained from the neighbouring hills, which surround the fort like an amphitheatre, at the distance of from one to four miles. They chiefly consist of schistus, with apparently a large portion of iron, and their surface is rugged, and nearly destitute of vegetation. The small river Soonrica rises to the eastward of the town, and beyond it is the tomb of Mahommed Ghous, a learned man; it is a handsome stone building, with a cupola covered with blue enamel. Within the inclosure of this monument is another tomb erected to the memory of Tan-Sein, a great musician. The leaves of the tree which overshadows this tomb, are supposed by the vulgar to give great melody to the voice when chewed. About 700 yards from the northern extremity of the fort, is a conical hill, having on its summit two high pillars joined by an arch, which is supposed to be of very ancient workmanship.

The town of Gwalior carries on a considerable trade in cloth with Chanderi, and also in indigo. About 14 miles from Gwalior, on the road to Narwar, is a mine of iron, near the village of Beerch, which is worked to advantage. Gwalior was always considered by the natives as impregnable, till it was taken by escalade by Major Popham, on the 3d August, 1780. In the time of the Mogul government, it was a state prison, where the obnoxious members of the family were secured, and a large collection of lions, tigers, and wild beasts, was kept here for their amusement. It was appropriated to the same purpose by Madajee Sindia, who, on account of its security, also made it a grand depot for artillery and military stores.

When the Mogul empire was dismembered, this fort came into the possession of the Ranah of Gohud, from whom it was taken by the Mahrattas. After the British took it in 1780, it was given up to the Ranah. Sindia invested the fort, and after a siege of many months, he succeeded in taking it by corrupting part of the garrison. In 1804, it was ceded to the British; but, by the treaty of 1805, it came into the possession of Dowlet Row Sindia. Distance from Agra 80 miles; from Delhi 197; and from Calcutta 480. East Long. 78° 14′, and North Lat. 26° 18′. See Hamilton's *Gazetteer.*

GYMNASTIC Exercises. See Athletæ.

GYMNOSOPHIST is a word of Greek origin, and literally signifies a philosopher who goes naked. It is particularly applied to the sages of India, who are understood to have wandered from place to place, either wholly without clothing, or only partially covered. Hence the *sapientes Indiæ* are described by Quintus Curtius, under the designation of *genus horridum et agreste.*

Though the Gymnosophists are usually considered as belonging exclusively to India, they were not in ancient times confined to that part of the world. There were likewise African Gymnosophists. These last inhabited a mountain in Ethiopia, near the river Nile; and they appear to have lived in celibacy and solitude, subjecting themselves to various penances and privations, after the manner of hermits or monks in more modern times. They were understood to hold an immediate intercourse with the immortal gods. If any one had killed his neighbour by accident, he had recourse to those recluses for absolution, and received it, upon the performance of certain ceremonies which they required. They were skilful in the medical art, and Lucan ascribes to them several important discoveries in astronomy. Indeed, it may be inquired, whether there were not Gymnosophists (using that term in a more general sense) in every nation, the early history of which has come down to us in any thing like detail, or with any measure of certainty; and whether the Brahmins of India, the Priesthood in Egypt, the Persian Magi, and the Druids of Great Britain, were not all branches of the same philosophical school, holding certain doctrines in common, though distinguished from one another by the degree of improvement to which they had respectively attained, or the political and moral circumstances of the countries to which they belonged.

One principal tenet of the Gymnosophists appears to have been that of the metempsychosis, or transmigration of souls; whether we understand by this term the passage of the soul from one human body to another, or the transmission of the immortal spirit through the bodies of different animals, till having been defæcated and refined in its progress, it enters at length into the immediate and beatific presence of the Supreme Divinity. The doctrine of the metempsychosis was afterwards taught with greater celebrity by Pythagoras; and, as the philosopher just named is known to have travelled into India, there is reason to believe that he borrowed it from the Gymnosophists. In many features of their character, however, the *sapientes Indiæ* appear to have resembled the stoics. They undervalued and despis-

* See Cormack's *Account of the Abolition of Female Infanticide in Guzerat.*

ed the goods of fortune, and lived chiefly in the woods and desert places, supporting themselves upon the spontaneous productions of the earth. Hence they are called, by Clement of Alexandria, *alobii*, or *hylobii*; and he relates of them, that they inhabit neither cities nor villages, but eat acorns, and drink water out of their hands. They abstained from marriage and the society of women. They held that every man was suffcient for himself, neither dependant upon others for the supply of his wants, nor requiring their assistance. They cherished a spirit of lofty independence. When Alexander the Great sent one of his captains to a body of the Gymnosophists, inviting them to a conference, they replied, that it was not their practice to visit any one, but that if the Macedonian king had any thing to communicate, they were ready to receive him. They maintained the lawfulness, and even the duty of suicide, and attached a degree of infamy to a lingering and anticipated dissolution. "Apud hos," says Quintus Curtius, "occupare fati diem, pulchrum; et vivos se cremari jubent. Quibus aut segnis ætas, aut incommoda valetudo est, expectatam mortem pro dedecore vitæ habent. Nec ullus corporibus, quæ senectus solvit, honos redditur. Inquinari putant ignem, nisi qui spirantes recipit." *De Reb. Gest. Alexand. Magn.* lib. viii. c. 9.

Apuleius *Florid.* lib. i. thus describes the Gymnosophists: 'They are all devoted to the study of wisdom, both the elder masters and the younger pupils: and what to me appears the most amiable thing in their character, is, that they have an aversion to idleness and indolence; accordingly, as soon as the table is spread, before a bit of victuals be brought, the youth are called together from their several places and offices, and the masters examine them what good they have done since the sunrise. Here one relates something he has discovered by meditation; another has learnt something by demonstration; and as for those who have nothing to allege why they should dine, they are turned out to work fasting." (*h*)

GYMNOTUS Electricus. See Electricity, and Plate CCXLVI. Fig. 2.

GYNANDRIA. See Botany.

GYPSIES. Towards the earlier part of the fifteenth century, the attention of various European nations was attracted towards a wandering tribe of people, entirely different in appearance and manners from the established inhabitants, and speaking a language peculiar to themselves. None could account for their origin; neither could the route by which they had been introduced be explained: they took up a temporary abode in places most congenial to their disposition, and were gradually dispersed throughout the continent, and among the principal islands. During their first introduction, and the periods immediately succeeding it, the strangers received various appellations, resulting either from corrupted dialects, or the opinions of those among whom they dwelt. But by common consent, conjoined with some imperfect traditions regarding their history, the name of Egyptians, or Gypsies, has been long bestowed upon them.

In so far as we are enabled to collect, these people have undergone no alteration with the lapse of centuries; they are a rude, illiterate, uncultivated race at this day; time and climate have been alike ineffectual in producing a change; they are the same in Siberia, in Turkey, in India, and in Europe: and if their vices have not increased, neither has there been any amelioration in their character. M. Olivier found a race of gypsies in Aleppo, and Lieutenant Pottinger saw tribes resembling them in Beloochistan. The gypsies are of a dark complexion, symmetrically formed, and rarely subject to deformity; they have beautiful white teeth, and the women fine black eyes, but the men are characterised by a scowling aspect. They are not remarkable for strength; they are swift of foot, but decidedly deficient in courage. The swarthiness of their colour is undoubted, and the earlier historians call them "black horrid looking men;" but the complexion of those who are kept cleaner than usual is evidently lighter: besides, there can be little doubt that an alteration in this respect may be slowly effected by the temperature of the atmosphere, or in the course of successive generations.

The gypsies testify an indifference to the quality of their food, unknown among the least civilized tribes of Europe. Carrion is a dainty to them; a murrain among cattle, whereby they may obtain abundance of flesh from animals dying of disease, is a joyful and profitable event; and they are even disposed to eat it almost raw. They have been accused of cannibal appetites; and as the existence of cannibals in several parts of the world is beyond dispute, we are not entitled to deny the fact with respect to gypsies. In the year 1782, after having for a length of time disturbed the tranquillity of Hungary, where they are numerously disseminated, many were brought to trial, and convicted of various crimes, among which were robbery, murder, and feeding on human flesh. It is recorded that they confessed having killed three people, and ate their bodies in great festivity, among other delicacies, at a wedding; that they preferred young persons from sixteen to eighteen years of age, and burnt their bones for fuel. The band to which these malefactors belonged, had subsisted 21 years, during which 84 individuals had perished by their barbarity. But the punishments inflicted on the criminals, were too shocking to admit of description. Thirteen were put to death at Frauenmark, in August; 15 at Kameza, in September; and at Esabrag 13 more, including 18 women who were beheaded. Many others were condemned, but respited, and 150 remained in chains. Yet whether these gypsies were actually guilty of such enormities, or whether they were the victims of persecution on slight grounds of suspicion, appears to us problematical. Amidst the numerous accusations of European cannibalism, few if any have been satisfactorily proved; and although the Asiatic gypsies are indirectly charged with the same depraved propensity, it is only on very slight evidence. Thus they have an immoderate desire for ardent spirits; and tobacco is so grateful, that they will be content to abstain from every thing else for a whole day, for a single leaf of it.

Gypsies have no settled abode, and never dwell in cities. They live in huts, or even in excavations of the earth, generally on the side of a hillock, that has a southern exposure. A roof is formed of rafters, overlaid with turf, and a woollen cloth is often drawn across the aperture left for a door. Some of the more miserable only shelter themselves in forests, or behind hedges, in the warmer climates. A fire occupies the middle of the hut, around which the children lie naked; and indeed the whole tribe, although delighting in finery, go very scantily clothed. But if a single gaudy article can be obtained, the rest is disregarded; whence a man is sometimes seen on the continent in an old red silk coat, or a woman adorned with glaring ribbons, while their other apparel consists of rags. Linen is a scarce commodity among them, for the females can neither sew nor spin.

None of the gypsies are agriculturists. Where they have, by unusual fortune, and by abandoning their nomadic life, become proprietors of spots of ground, the cultivation of it is left to others. Their own professions are, gold washing in Hungary, at which they are very expert, farriery, rude occupations in smith work, and, in Britain, they are for the most part employed in the lowest branches of that art. Their tools and materials are alike indifferent. Nothing is done but on a small scale; and it is observed, that the artificer always sits down cross-legged to his work, which is considered as denoting the eastern origin of his race. They were formerly employed abroad in the execution of criminals, wherein they displayed a skill in the art of torturing their fellow-creatures, corresponding with their own innate pusillanimity. Many dealt in horses, but they practised such ingenious deceptions, and to so great an extent, that a royal ordinance prohibited this part of their profession. Their females form a considerable portion of the dancing girls of India. They combine music with their allurements; and most of them, both in that peninsula and Turkey, as likewise in Spain, subsist on the wages of prostitution. Every where the character of their dances is the same; and, in Spain, one of them called Maguindry is prohibited under severe penalties. The men and women sometimes bring forward dramatic exhibitions, for the performance of which they are called before the houses of the wealthy. The women, as is well known, pretend to skill in divination, and tell the fortunes of the credulous from palmistry, physiognomy, or moles on the skin; hence the origin of the beautiful engraving of *La Zingara*. So long ago as the year 1531, we find an English statute narrating, "that before this time many outlandish people, calling themselves Egyptians, using no craft nor feat of merchandize, have come into this realm, and gone from shire to shire, and place to place, in great companies, and used great, crafty, and subtile means to deceive the people, bearing them in hand, that they, by palmistry, could tell men and women's fortunes, and so, many times by craft and subtilty, have deceived the people of their money, and also have committed many heinous felonies and robberies, to the great hurt and deceit of the people they have come among. It is singular, that at Tobolsk in Siberia, their practice and professions are the same. "They watch every traveller," according to Commodore Billings, "and pretend to explain the mysteries of futurity by palmistry or physiognomy. The peasant dreads their power, and, from motives of fear, contributes to their support, lest they should spoil his cattle or horses." Thus, in the western parts of Europe, and the eastern parts of Asia, at an interval of nearly three centuries, the gypsies are distinguished by corresponding features, scarcely modified by the people among whom they seek an asylum.

This tribe is utterly unacquainted with science and literature. The scanty knowledge of their forefathers remains with them unimproved. A few of those in Spain, however, pretend to knowledge in medicine or surgery; and the females in the neighbourhood of Calcutta visit that and other towns, and prescribe for the complaints of their own sex. They have no settled principles of religion; they are Turks with Turks, and Christians with Christians. It does not appear that they celebrate any religious rites, or entertain the common sentiments of mankind in regard to a future life, or places of reward and punishment. The son of a more civilzied Transylvanian gypsey having died at school, and being about to receive Christian burial, the officiating priest inquired, whether the survivors believed that the deceased would rise again at the last day? "Strange supposition!" they answered, "to conceive that a carcase, a lifeless corpse, should be reanimated, and rise again; it is no more likely to happen, in our opinion, than to the horse we flayed a few days ago." Their children, however, are circumcised in Turkey, and baptised in Europe.

Their marriages, which take place at a very early age, are void of ceremony, and rather resemble temporary connections than a union for life. One of their own number performs the part of priest, and thus gives it the sanction of publicity. The youth then forsakes his father, along with his bride, and if capable of mechanical exercises, he provides a pair of tongs, a stone for an anvil, a hammer and a file, to commence the profession of smith, after the fashion of his predecessors. In India a scene of riot and intoxication precedes the establishment of the parties, and certain mystical ceremonies attend the marriage. The men are extremely jealous of their wives, who are kept in strict subservience, and are in danger either of corporal punishment, or absolute dismissal, if they happen to displease them. Both sexes are extravagantly attached to their offspring; and, in some countries, it frequently happens that the readiest method of obtaining payment of the father's debts is by arresting his children. No education is given to the young, unless it be instruction in obscenity, and in the art of stealing dexterously. Infants of five or six months old are supplied with spirits in India, and their mothers, while indulging a fatal propensity to the same beverage, suckle them until they have seen as many years. In Europe these people are remarkably healthy, and escape those epidemical maladies which sweep away thousands around them; and even when they labour under dangerous diseases, they pertinaciously refuse medical assistance. They make loud lamentations at funerals, and carry the body of the leader of their horde with great respect to the grave.

The language of the gypsies, though it has necessarily undergone many changes from their successive migrations, and the corruptions unavoidable from living among others, is peculiar to themselves in Europe; but it contains many affinities with a dialect of particular castes in Hindostan. This fact receives the stronger corroboration, from having been first recognized by some young men, natives of the coast of Malabar, who were prosecuting their studies at Leyden. Numerous expressions were compared by them, and the same has since been carried to a greater extent by literary men residing in India. Etymologies are in general to be distrusted, for they frequently lead to the most ludicrous and absurd mistakes; but we cannot deny, on the other hand, that the affinities of languages spoken by nations separated far asunder, may be found so strong and decided, that we shall find it difficult to deny them a common origin. On this subject Grellman remarks, "with respect to the construction and inflection of the two languages, they are evidently the same; that of Hindostan has only two genders—the gypsey the same. In the former, every word ending in *j* is feminine, all the rest are masculine; in the latter it is the same. That makes the inflexions entirely by the article, and adds it to the end of the word; the gypsey language proceeds exactly in the same manner. Finally, likewise, excepting a few trifling variations, this identical similarity is evident in the pronouns." Many other instances of mutual correspondence may be produced, almost all tending to a similar purport, as may be seen at large in the writings of those authors who discuss this subject.

The gypsies of Europe acknowledge a chief or leader, who usually assumes the dignified title of wayvode or prince, duke, count, or lord, according to the countries frequented by them. The most exalted of these titles is given to one who presides over the gold washers in Hungary, and the dignity is elective, but with some regard to descent from a former wayvode, and also to the stature and apparel of the individual chosen, who is commonly about the middle age. He is merely lifted up three times with the loudest acclamations, amidst a numerous concourse of the tribe; his wife is treated with similar ceremony, while the dignity of both is recognized by all present. The titles assumed by these people are of ancient date: they appear in the fifteenth century; and in the commencement of the sixteenth, King James IV. of Scotland grants a pass and recommendation to the king of Denmark, in favour of the tribe of Anthony Gawino, an Earl from little Egypt. He specifies that this miserable train had visited Scotland by command of the Pope, and having conducted themselves properly, they wished to go to Denmark: He therefore solicited the extension of his royal uncle's munificence towards them; adding, at the same time, that these wandering Egyptians must be better known to him, because the kingdom of Denmark was nearer to Egypt! In Hindostan, the gypsies have a chief who has very little direct authority over them, but he controuls the establishment of sets who profess dramatic exhibitions, and draw a tribute from their profits. They even acknowledge a rude judicial procedure before a court of five persons, or a general assembly, and any individual, for petty offences, has to pass the ordeal of applying a hot iron to his tongue. If conviction follows, the culprit is generally sentenced to pay a fine in liquor, of which his judges participate; or, as a mark of the highest ignominy, he may be condemned to have his nose rubbed on the ground.

Almost in every country throughout the globe, the gypsies have long been the objects of reproach and detestation. From their first appearance, they have been wandering outcasts and universally refused a settlement in towns, or in their immediate neighbourhood. The dislike manifested towards them, though attended with less barbarous consequences, may be assimilated to the detestation which has accompanied the Jews since the destruction of Jerusalem. Those atrocious cruelties, however, that stain the annals of nations, cannot with confidence be charged on this nomadic tribe. If their crimes are numerous, they are of a petty description, directed against the property more than the persons of their fellow creatures. The gypsies have no where manifested virtuous principles, or any desire to excel; the depravity of the parents passes to the children, who inherit, along with it, the detestation of the people among whom they seek an abode. In foreign states, many attempts have been made to reclaim them, but there, as well as in our own island, they have been for the most part indiscriminately condemned to exile. Neither have the politic and patriotic views of the governments, thus directed, been attended with the success which they merited.

In the year 1782, the Empress Maria Theresa promulgated an edict, prohibiting gypsies from dwelling in tents, and enjoining them to settle in fixed abodes. They were forbidden to wander about, to allow their children to go naked, to deal in horses, and to wear cloaks, whereby thefts might be easily concealed. They were also commanded to abstain from feeding on carrion, to frequent the churches, and to conform to the manners of the inhabitants of the territory where they resided. Their usual name was to be abolished, and in future they were, instead of gypsies, to be called *new boors*, and occupy themselves in the active prosecution of agriculture. These regulations, wisely conceived, being ineffectual, severer enactments followed. It was decreed, that no gypsey should be permitted to marry, unless he could shew himself in a situation to maintain a wife and family; and that those who had children should be forcibly deprived of them, in order that the rising generation should have the benefit of a better mode of education. The latter part of this ordinance was carried into effect, and in certain districts, all the children above five years of age were conveyed away in waggons from their parents. But it is not evident that such compulsory measures were beneficial; and the failure of others in the eastern extremities of Russia, nearly at the same period, though more gentle, prove that it will be extremely difficult to reclaim the gypsies to habits of industry. Experience daily proves, that mankind, who have roamed at liberty, are averse to a settled residence, and that the controul of those living in society is an arduous undertaking, while their management is easily accomplished should they be only in an isolated state. With the diminution of their own hordes, a gradual incorporation will take place with those around them, and probably is insensibly doing so at this moment where they are least numerous. No accurate computation can be formed of the extent of the united tribes of gypsies dispersed throughout the world; for they are unequally distributed, and only partially known. Grellman conjectures, that those in Europe may amount to 700,000 or 800,000; of whom Twiss conceives 40,000 to belong to Spain: there are many in the Turkish empire, but few in the island of Britain, particularly north of the Tweed.

The history of the gypsies is an enquiry not less obscure than difficult; and it must be allowed, that even yet we have no conclusive authorities relative to its earliest period. Analogies certainly prove the eastern parentage of their tribes; but why they left their native soil, or how they penetrated into Europe and its more distant islands, we are unable to discover. It is commonly believed, that they migrated from Egypt; an opinion which has probably, received greater corroboration from their name than from other circumstances. But neither their size, complexion, manners, or appearance, correspond with those of any Eygptians described in ancient or modern history; hence, if we are to draw any argument from their name, we must say it arises from Egypt, being the last point of their departure from the East. Those observers who have most profoundly studied their history, find a striking resemblance between the gypsies and the natives of Hindostan: Should this hypothesis be correct, they may have reached the isthmus of Suez by the north of India, and crossed it into Egypt; a progress by no means impracticable, but which does not satisfactorily account for their immediate access to Europe. The time of their first appearance in this quarter of the globe is unknown; but towards the beginning and middle of the fifteenth century, they attracted general attention as a strange people. They are recorded to have frequented Germany in 1417; Switzerland in 1418; and they are spoken of as being in Italy in 1422. It is said that they were originally known in France by the name of Bohemians; and arrived at Paris on the 17th of August 1427. They travelled in hordes, generally of 70 or 100 persons, probably finding it expedient not to accumulate too much; and each horde had a leader, who assumed a title, which, however, has more the character of the West than the East. Rapidly spreading over Europe, they were at first believed to be pilgrims, chiefly from the Holy Land; and hence they both received protection and indulgence, and were treated with marks of veneration, wherever they went; but their real disposition speedily betrayed itself; they proved a lawless gang of depredators, deceiving the credulous, plundering their benefactors, and rendering themselves obnoxious to all civilized nations. Every arm was lifted against them; they were driven from place to place; and at length the very name of being a gypsey, was esteemed a crime deserving capital punishment. It is not unlikely, that the severity of the enactments directed against them had the effect of dividing and spreading their hordes still farther, to avoid the penalties of a permanent residence. But the barbarous and unsettled condition of the different European states was a powerful obstacle to the establishment of a vigorous police; and it is only in recent times, that the kingdoms, in which we dwell at peace, have been freed from vagabonds and beggars, who, invading the cottages of the peasantry, demanded alms in a manner that their inhabitants durst not refuse.

Gypsies are always included in the statutes respecting vagabonds; and in the year 1531, they were commanded at once to depart from England within sixteen days. The laws of Scotland exhibit repeated instances of the light in which they were subsequently viewed; for an ordinance of the Privy Council of 1603, converted to a perpetual act in 1609, decreed, that the whole race should quit the kingdom under pain of death. Nevertheless they found means to evade compliance; they continued roving about the country; and as is well known, one of them, having seduced the affections of a Countess of Cassilis from her husband, persuaded her to elope with him. In the criminal records, several of the same name as this adventurer appear to have been brought to trial for petty offences, and for being found in Scotland. Four gypsies, named Faa, were condemned to be hanged in 1613, though they seem to have had permission to remain. Two more of this name were tried in 1616; and in 1624, Captain John Faa, and five other men of his name, were sentenced to death. Their execution was followed by the condemnation of Helen Faa, widow of Captain John, Lucretia Faa, and nine females more, all to be drowned for being reputed Egyptians, for remaining in the kingdom, and having committed petty thefts. But this barbarous sentence was commuted to perpetual banishment. The terror of these trials quieted Scotland for nearly a century; and excepting a few itinerant gypsies, universally denominated tinkers, none are now to be seen. They are also gradually disappearing from England, where they seem inclined to be turbulent; and some years ago, we believe, that on the apprehension or punishment of one of their gang, they threatened to set fire to the town of Norwich. In a country so industrious as Britain, the residence of men who live in a state of idleness cannot be permanent; and they will either depart, or their habits will be assimilated to those around them, while they themselves are slowly absorbed in the great mass of the people.

See Peysonnel *Observations sur les peuples barbares qui ont habité les bords du Danube;* Thomasius *De Cingaris;* Muratori *Rerum Italicarum Scriptores* tom. xviii.; Swinburne's *Travels in Spain;* Twiss's *Travels in Spain; Asiatic Researches*, vol. vii.; Grellmann's *Dissertation on the Gypsies;* Laborde's *View of Spain;* Olivier *Voyages*, tom. ii.; and Pottinger's *Travels*. See also *Free* MASONRY. (*c*)

GYPSUM. See MINERALOGY.

GYRATION, CENTRE OF. See MECHANICS.

# H.

HABEAS CORPUS, is a writ in the English law, of which there are various kinds, for removing prisoners from one court into another, for the more easy administration of justice. Such are the *habeas corpus ad respondendum*, *satisfaciendum*, *prosequendum*, *testificandum*, *deliberandum*, &c. when a prisoner is removed from an inferior court to be charged with a new action in the courts above; or when he is to be charged with process of execution; or when it is necessary to remove a prisoner in order to prosecute or bear testimony in any court, or to be tried in the jurisdiction wherein the fact of which he is accused was committed. There is also the common writ *ad faciendum et recipiendum*, otherwise called an *habeas corpus cum causa*, which issues out of the courts of Westminster Hall, commanding the inferior judge to produce the body of the defendant in a process, together with the day and cause of his caption and detainer, to *do and receive* whatsoever the king's court shall consider in that behalf.

But the most important writ of this kind, and the most efficacious for vindicating the personal liberty of the subject in all cases of illegal confinement, is that of *habeas corpus ad subjiciendum*. This is a high prerogative writ, and therefore, by the common law, issuing out of the court of King's Bench, not only in term time, but also during the vacation, by a *fiat* from the chief justice, or any other of the judges, and running into all parts of the king's dominions. Like all other prerogative writs, it must be applied for by motion, and does not issue of mere course, without shewing some probable cause why the extraordinary power of the crown is called in to the assistance of the party. And this is the more reasonable, because, when once granted, the person to whom it is directed can return no satisfactory excuse for not bringing up the body of the prisoner. This also, it will be observed, induces an absolute necessity of expressing, upon every commitment, the reason for which it is made; in order that the court, upon an *habeas corpus*, may examine into its validity, and act according to the circumstances of the case.

The law of England has always been extremely careful in asserting and preserving the personal liberty of individuals, which ought never to be abridged at the mere discretion of the magistrate, without the explicit permission of the laws. The great charter provides, that no freeman shall be taken or imprisoned, but by the lawful judgment of his equals, or by the law of the land; and many subsequent old statutes expressly direct, that no man shall be taken or imprisoned by suggestion or petition to the king, or his counsel, unless it be by legal indictment, or the process of the common law. The writ of *habeas corpus* affords an ample and effectual remedy in all cases of illegal confinement; yet this remedy was in danger of being rendered nugatory during the early part of the reign of Charles I. the court of King's bench having determined, that they could not upon an *habeas corpus* either bail or deliver a prisoner, though committed without any cause assigned, in case he was committed by the special command of the king, or by the lords of the privy council. This illegal judgment drew on a parliamentary enquiry, and produced the petition of right, 3 Car. I. which enacted, that no freeman shall be imprisoned or detained without cause shewn, to which he may make answer according to law. The evasions of this enactment, however, which were attempted in the following years, particularly in the case of Mr Selden, gave rise to the statute 16 Car. I. c. 10. § 8. whereby it was provided, that if any person be restrained of his liberty by order or decree of any illegal court, or by command of the king's majesty in person, or by warrant of the council board, or of any of the privy council, he shall, upon demand of his counsel, have a writ of *habeas corpus*, to bring his body before the court of King's Bench or Common Pleas, who shall determine whether the cause of his commitment be just, and thereupon do as to justice shall appertain. But other abuses now crept into daily practice, which in some measure defeated the benefit of this great constitutional remedy; and in the case of Jenks, who in 1676 was committed by the king in council for a turbulent speech at Guildhall, new shifts and devices were made use of to prevent his enlargement by law. These abuses gave birth to the famous *habeas corpus act*, 31 Car. II. c. 2. which has frequently been considered as another *magna charta* of the kingdom; and by which the methods of obtaining this writ are so plainly pointed out and enforced, that, so long as this statute remains unimpeached, no subject of England can be long detained in prison, except in those cases in which the law requires and justifies such detainer.

Sometimes, when the state is in real danger, a temporary suspension of the *habeas corpus* act is thought necessary; but, fortunately, it is not left to the executive power to determine when the danger of the state is so great as to render this measure expedient. For the Parliament only, or legislative power, whenever it sees proper, can authorise the crown, by suspending the *habeas corpus* act for a short and limited time, to imprison suspected persons without giving any reason for so doing. This, however, is an experiment which ought never to be resorted to, except in cases of extreme emergency. See Blackstone's *Comment.* B. III. ch. 8, and Jacob's *Law Dict.* by Tomlins, in which the reader will also find the substance of the provisions contained in the *habeas corpus* act. (*z*)

HABIT. See Moral Philosophy, and Association of Ideas.

HACKNEY. See Middlesex.

HADDINGTON is a royal burgh of Scotland, and the county town of East Lothian or Haddingtonshire. It is situated on the small river Tyne, and consists of four streets which cross each other nearly at right angles. One of these has two branches, viz. the Fore and the Back Street, the first of which crosses the place of intersection. The streets are in general spacious and clean. The houses, particularly those in the Fore Street, are neat and well built; and in the suburbs are some elegant little villas. At the end of the Fore Street, at its junction with the Back Street, is a neat town house, erected from the designs of the late Mr Adam. The old abbey, which contains the parish church, is one of the principal ornaments of the town. This venerable pile was formerly the church of the Franciscan monastery, and was erected during the reign of Alexander II. In February 1355-6, the town and monastery, along with the church of the Minorites, were burned by Edward III. The parish church, which has lately been much improved and embellished, occupies the west end, and the rest of the building is in ruins. In the aisle, which forms the burying-place of the Maitland family, is a marble statue of the Duke of Lauderdale lying on a bed of state, and also the monument erected to John Maitland, Baron of Thirlstane, Lord High Chancellor of England, which contains an inscription from the pen of James VI. The Episcopalian chapel, built by private subscription, is neat and commodious. About a $\frac{1}{4}$ mile to the east of the town, near the suburb called Nungate, are the ruins of a nunnery, founded in 1178 by Adda, widow of Prince Henry, and mother of Malcolm IV. The bridge over the Tyne, which connects this suburb with the town, is built of stone, and consists of three arches. Several remains of the ancient fortifications of the town are still visible. Haddington had formerly a house of dominicans or black friars, who were introduced into Scotland in the reign of Alexander II.

Haddington sends a member to parliament along with Jedburgh, Dunbar, Lauder, and North Berwick. It is governed by a provost, three bailies, a dean of guild, a treasurer, and 12 councillors, and has seven incorporated trades. The principal manufacture carried on in Haddington was one of coarse woollen cloth; but it has some time ago been abandoned. The manufacture of starch was attempted by Mr Wilkie, jun. of Gilchriston, a public spirited individual, but it did not succeed. A new flour mill, driven by steam, has been built in the Nungate; and an extensive distillery is at present erecting on the bleachfield by Mr Dunlop, one of the partners of the distillery at East Linton. The town has also suffered considerable injury, from the removal of the extensive barracks in its immediate vicinity. The country around Haddington is extremely rich and beautiful, and is ornamented with many gentlemen's seats, the principal of which are Amisfield, one of the seats of the Earl of Wemyss; Clerkington, the seat of Mr Hepburn; Leadington, the seat of Lord Blantyre; Coulston, the seat of Lord Dalhousie; Alderston, the seat of Mr Stewart; and Letham, the seat of Mr Buchan Hepburn.

The following is the population of the burgh and parish in 1811.

| | |
|---|---|
| Number of inhabited houses | 671 |
| Do. of families | 1041 |
| Do. employed in agriculture | 379 |
| Do. in trade and manufactures | 389 |
| Males | 2002 |
| Females | 2368 |
| Total population | 4370 |

See *Statistical Account of Scotland; Transactions of the Antiquarian Society of Scotland*, vol. i.; and Chalmers' *Caledonia*, vol. ii. p. 412.

HADDINGTONSHIRE. See Lothian, *East*.

HADLEIGH, or Hadley, is a market-town of England, in the county of Suffolk, situated on the river Breton. Its principal ornament is its church, which is a handsome structure with a spire steeple, situated in the middle of the town. The altar piece of the church is very handsome. Guthrum or Gormo, the Danish chieftain, who was defeated by Alfred, embraced Christianity, and reigned over the East Angles for 12 years, was interred here in 889. The tomb, however, which is shewn as his, is supposed by Mr Gough to be of much later date. Twelve alms-houses for 24 aged persons were founded here in 1497 by William Pykenham, dean of Stoke College, who was rector of Hadleigh. This town formerly carried on a great trade in cloth; but its principal business is now that of spinning yarn for the weavers of Norwich. In 1811, the town and parish contained 509 inhabited houses, 529 families, and a population of 2592. See *Beauties of England and Wales*, vol. xiv. p. 211.

HADRAMAUT. See Arabia.

HADSJAR. See Arabia.

HAERLEM, or Haarlem, a town in the United Provinces, 12 miles west of Amsterdam, and $15\frac{1}{2}$ north of Leyden, is a place of considerable antiquity, and has experienced many vicissitudes in its history. In 1249, the citizens, having signalized themselves in the crusades, were rewarded with great privileges by William, king of the Romans, and Comte of Holland. At different times, especially in 1347 and 1351, it was almost entirely consumed by fire. In 1492, it was seized and pillaged by the faction of the Caes-en-brool, but was recovered by Albert, duke of Saxony, who punished the insurgents, and deprived the inhabitants of their privileges. At the request of Philip II. of Spain, it was erected into a bishop's see by Pope Paul V.; but, in 1571, the citizens embraced the Protestant faith, and submitted to the Prince of Orange. It was besieged in 1572 by Frederick of Toledo, son of the Duke of Alva, and for the space of eight months made a most desperate resistance. Even the women of the place formed themselves into regular battalions, and shared in all the duties of the garrison. At length, worn out by famine and fatigue, they agreed to surrender, upon condition that the lives of the garrison and of the citizens should be spared; but the articles of capitulation were perfidiously violated, and two thousand of the soldiers and inhabitants were massacred in cold blood. In 1577, it was finally united with the States.

Haerlem is a large and handsome town, well built, and well paved. Its streets are broad and regular; and, like the other towns of Holland, it abounds in canals, bridges, and trees. The buildings most worthy of notice are the palace, the public library, and the church. The last is a very large structure, crowded, as is common in that country, with square wooden monuments, without any name, but having the arms of the deceased painted on a black ground, and the date of the death in gold letters. Its principal ornament is the organ, which is accounted the finest in the world, and which occupies the whole west end of the nave. It is supported by eight marble columns, between two of which in the centre is a noble emblematical alto-relievo, with figures as large as life. It was built in 1738, and has 8000 pipes, the largest of which is 32 feet in length, and 16 inches in diameter. There are 60 stops or voices, four separations, two shakes, two couplings, and twelve bellows. There is a pipe, which imitates the sound of the human voice, but it generally disappoints the expectations of strangers. The power and variety of tone possessed by this instrument is said to be truly astonishing. Some of its notes are so delicate as scarcely to exceed the warblings of a small singing bird; and others so loud, as to shake the massy pile in which it stands. "When the whole strength of the organ is exerted," says Mr Fell, "never did I hear, or could conceive, sounds more godlike. The swelling majesty of each gigantic note seems of more than mortal birth, and the slightest sounds enchant the ear. Solemnity, grandeur, delicacy, and harmony, are the characteristics of this noble instrument." It is played on two days of the week, for an hour each time; and the church is, on these occasions, the resort of the first company of the place. Haerlem is still more justly celebrated as the birth-place of Laurence Costar, who is said to have invented the art of printing, and the site of whose house is still pointed out to strangers by an inscription. He is said to have made the discovery by cutting the initial letters of his name upon a piece of bark, and using it as a seal; and specimens of the infancy of the art are preserved in the town-house. An academy of sciences was founded in 1752; and there is an elegant museum of natural history, formed by Dr Van Marum, superior to any other cabinet in Holland. The articles are in an excellent state of perservation, and arranged with scientific taste. The insects of the *Papilio* tribe are said to be particularly numerous, and many of them of the rarest description. There is an institution founded by Peter Teyler Vander Hulst, a rich merchant of Haerlem, who bequeathed the whole of his fortune for the improvement of knowledge, and the relief of the poor. Its annual revenues are said to have amounted, before the revolution, to the sum of 100,000 florins; but, instead of being applied to objects of science, they were allowed to accumulate, and are suspected to have been secretly appropriated, during the ascendancy of the French republic, to the urgent necessities of the state. The Stadthouse is a magnificent building at one end of the market-place, and contains a number of valuable paintings, among which is the first piece in oil, by Eyert, in 1437, which was sold during the siege in 1572 for a few stivers, and is now valued at 2000*l*. Haerlem is not a place of much trade; but is celebrated for its flourishing manufactures of velvets, damasks, fine linens, dimities, satins, worsted stuffs, ribbons, &c. which employ a number of workmen, and supply a profitable branch of traffic with Germany and Brabant. Its bleacheries, also, are famous for the delicate whiteness which they give to linen cloths, which has been attributed to a peculiar quality in the waters of the lake of Haerlem, incapable of imitation by any chemical process hitherto discovered. Great quantities of beer are exported to Friesland, &c.; and a gainful trade is carried on in flowers, one of which, a hyacinth, seen by M. Dutens in 1771, was valued by its owner at 10,000 florins. In the neighbourhood of the town are several handsome villas, and a wood of considerable extent full of delightful walks. About three miles distant is an extensive lake, called Haerlem Meer; sometimes, also, the Sea of Leyden, generally ten feet in depth, and containing a surface of fifteen square leagues. The population of Haerlem is 30,000. East Long. 4° 38′ 19″, North Lat. 52° 22′ 56″. See Trotter's *Memoirs of Fox;* Fell's *Tour in Holland;* Carr's *Tour in Holland;* and Owen's *Travels*, vol. i. (*q*)

HAGUE, a town in Holland, and the seat of the Dutch government, 10 miles south-south-west of Leyden, 14 south-west of Amsterdam, and about 3 from the coast. It is generally termed by geographers a village, because it has no municipal rights, and is not surrounded with walls; but it contains at least 38,000 inhabitants, and is one of the most elegant cities in Europe. It formed originally a part of the domains of the Counts of Holland, under the name of Graven Haag, Counts Hedge, which may perhaps account for its humble appellation of village. William II. Comte of Holland, removed his court from Gravesande to this place in 1250; from which time it has always been the seat of government, and in a political sense the metropolis of the United States. It stands in a drier soil, and a more elevated situation, than most other towns in Holland; and its atmosphere is therefore accounted more pure and healthful. The environs are delightful; and the approach to it extremely beautiful. The road, shaded on both sides by lofty rows of trees, is sufficiently broad to admit four or five carriages abreast, and so level, that not the smallest inequality of surface is to be perceived. On one side flows the canal covered with boats, and ornamented by numerous handsome villas on its banks; and directly in view of the traveller appear the lofty edifices of the Hague, with the beautiful forest scenery on the right of the town. The streets are generally spacious, and the meanest of them extremely clean. They are decorated with trees, canals, and tasteful bridges. They are paved with a kind of light-coloured bricks, which have a gay appearance, and which are so closely joined together, that no interstices can be perceived to harbour any species of dirt. The Voorhout, which is accounted the principal street, is about half a mile in length, with a mall in the middle, and contains a number of elegant buildings, in the purest style of architecture. But the Vyverburg is the most beautiful part of the city, and forms an oblong square, with a line of magnificent buildings on one side, and a large basin of water on the other. The palace of the Stadtholder consists chiefly of old buildings, erected at different periods, without any regularity of design, and is surrounded by a canal, with drawbridges. The French church is noted as being the burying-place of several Counts of Holland; and in its vicinity is a fine garden in imitation of that of Vauxhall. To the east and south of the town are many beautiful meadows and handsome country seats; and the trees are so disposed as to give the country the appearance of being better provided with wood than it is in reality. On the west side, leading to the fishing village of Scheveling, is a beautiful avenue, nearly two miles in length, and 20 paces in breadth. It runs in a perfectly straight line, and is shaded on each side by oaks, beeches, and limes of an astonishing size, so closely and skilfully planted, as to have the appearance of an impervious forest. The utmost care is taken to preserve this magnificent grove from injury; and cautions are fixed up at short distances, denouncing the severest penalties against offenders. On the north side, about a mile from the town, is a noble wood, about two English miles in length, and nearly one in breadth, and full of the finest walks and most pleasing views. The palace called Maison de Bois, a house of retirement for the Stadtholder, has nothing remarkable in its appearance or situation, but resembles the residence of a plain country gentleman. During the time of the Batavian republic, it was converted into a receptacle for the national cabinet of paintings; and, to the disgrace of the government, one suite of its apartments was occupied by the keeper of a tavern and brothel. The gardens belonging to this palace are kept with great care as a public promenade; but they are laid out in the worst taste. Every thing is unnatural and artificial, stagnant canals, puerile bridges, flower-beds of every conceivable form, and trees cut into the most fantastic shapes. One of the principal curiosities at the Hague was the prince's cabinet of natural history, and museum of rare productions, which contained an excellent selection of shells, insects, and birds, besides a great variety of toys from the East Indies. It had been removed to Paris; but is now probably restored along with the other pillaged property of the nation. The only species of trade of any consequence carried on at the Hague, consisted in the publication of continental productions, particularly of French books; but this literary traffic was completely extinguished by the revolution; and from the absence of the court, the city was falling rapidly into decay. By the recent restoration of the old government, its empty palaces have been re-occupied; and its former affluence and splendour may be expected to return. East Long. 4° 18′ 47″, North Lat. 52° 4′ 50″. See Trotter's *Memoirs of Fox*; Fell's *Tour in Holland*; Owen's *Travels*, vol. i.; and Sir J. Carr's *Travels in Holland*. (*q*)

HAIL. See METEOROLOGY.

HAINAN, ISLAND OF. See CHINA.

HAINAU. See HANAU.

HAIR. See ANATOMY; and Gordon's *System of Human Anatomy*, vol. i. See also PLICA POLONICA.

HALBERSTADT, is an ancient town of Prussia, and capital of the principality of the same name. It is situated in the circle of Lower Saxony, on the small river Holtzemme. The principal public edifices and curiosities are, the cathedral, from the summit of which there is a fine view of the town, the court of St Peter's, the church of Notre Dame, and its organ. The palace now forms the town-house and excise-offices. There is here a literary society, which has published several journals of merit; and there are excellent libraries belonging to the cathedral, to the church of Sta Maria, the church of St Martin, and that of the Franciscans. The cathedral library contains a manuscript of Priscian upon parchment, and several annotations in the handwriting of Luther. The Temple of the Muses, belonging to M. Gleim, one of the celebrated German poets, is worthy of being visited. The principal manufactures of this town are those of woollen and linen goods, gloves and pipes, paper and wax. There is here also a work in which cobalt is prepared. The mountains of Spiegelberge, about half a league from this town, are deserving the notice of travellers. They have been laid out in the English style of landscape-gardening, by the late Baron Spiegel. The village of Stropke, about $1\frac{1}{2}$ leagues from Halberstadt, is celebrated for the skill with which its peasantry play at chess. Halberstadt was burned in 1179 by Henry the Lion, and a remarkable diet was held there by Lotharius II. in 1134. In 1203, it was surrounded by walls and ditches. By the treaty of Tilsit it was annexed to the kingdom of Westphalia; but we believe that it has now reverted to the Prussian monarchy. Breyhahn, the supposed inventor of beer, was born in this town; and his house, containing an inscription in honour of him, is still shewn. The population, which now amounts to 11,700, is composed equally of Catholics and Calvinists. East Longitude 11° 3′ 33″, North Latitude 51° 53′ 55″.

HALES, STEPHEN. See BOTANY, p. 30.

HALF-NOTE, *Elementary*, in music, according to several writers, has the ratio $\frac{15}{16}$, $=57\Sigma+f+5m$, and is the SEMITONE-*major*, which see.

HALF-NOTE, *Finger-key*, or artificial, is of very different magnitudes in the different modes of tuning, and places in the scales of keyed instruments. The number of f's in our notation, of any musical interval (by Σ, f and m), shews its number of these half-notes; and is fully explained in our article FINGER-KEY *Intervals*.

HALF-NOTE, *Greater*, of Holden, has the ratio $\frac{15}{16}$, $=57\Sigma+f+5m$. See SEMITONE *Major*.

HALF-NOTE, *Isotonic* or mean, is $\frac{1}{12}$th of the octave, $=1\div\sqrt[12]{2}$, $=51\Sigma+f+4\frac{5}{12}m$, or $51.003276\Sigma+f+4m$. See MEAN SEMITONE.

HALF-NOTE, *Lesser*, of Holden, has the ratio $\frac{24}{25}$, $=36\Sigma+f+3m$. See SEMITONE MINOR.

HALF-QUARTER *Tone*, of the Diacomatic genus, according to Feytou, is $\frac{1}{8}$ T, $=13\Sigma+\frac{1}{4}f+1\frac{1}{8}m$, $=13.038398\Sigma+m$, its common log. being .9936059,3469. Mr Hoyle and others call this interval a *comma*.

HALF-STOPS *on the Organ*, are those ranges of pipes which do not go through the whole compass of the instrument, from the treble to the bass; as the *cornet* and the *sesquialtera* stops, the *dulciana*, *basoon*, &c. stops.

HALF-TONE of the ancients, had the ratio $\frac{243}{256}$, $=46\Sigma+f+4m$; which is now called the LIMMA. See that article.

HALF-TONE *of Brougham*, has the ratio $\frac{11}{12}$, $=76.897955\Sigma+f+7m$; its common log. $=.9616713,1976$, and it is the hemitone major of Ptolemy's *chromaticum intensum*.

HALF-TONE, *Chromatic Tonicum*, is $\frac{1}{2}$T, $=2\sqrt{2}\div3$, $=52\Sigma+f+4\frac{1}{2}m$, $=52.0039312\Sigma\times f+4m$; its common log. $=.9744237,3877$, $=084962\times\text{VIII}$, $=4.74070\times\text{C}$, $=\frac{1}{2}\text{VIII}+\Sigma+\frac{1}{12}m$. It is the hemitone of the soft diatonic, and the chromatic diesis of Hoyle.

HALF-TONE, *mean*, of Sauveur, is $\frac{1}{12}$VIII, $=1\div\sqrt[12]{2}$, $=51.003276\Sigma+f+4m$. See *Mean* SEMITONE.

HALF-TONE, *mean*, of Dr Smith, is $\frac{1}{4}$III, $=\sqrt{2}\div\sqrt[4]{5}$, $=49\frac{1}{4}\Sigma+f+4\frac{1}{4}m$, $=49.251966\Sigma+f+4m$; its common log. $=9757724,9675$, $=.080482\times\text{VIII}$, $=4.490705\times\text{C}$: it is sometimes called the mean half note.

HALIFAX, is a populous market town of England, in the west riding of Yorkshire. It is situated on the western slope of a gentle eminence, washed by a branch of the river Calder, and is surrounded on all sides with high hills. The town is about three quarters of a mile long from west to east, but it is narrow and irregular in its breadth. The houses are in general neat and well built, and the town has a singularly variegated appearance, from the mixture of brick and stone buildings, and from the great number of small inclosures surrounded with stone walls. The church, which is a large Gothic structure, stands near the east end of the town. It is 64 yards long, and 20 broad, and is supposed to have been built in the reign of Henry I. The tower of the church, which is well proportioned, is said to be 117 feet high. Within the church are two chapels, one on the north, and the other on the south side. This church having been found too small, an elegant and spacious new church has lately been erected. The cloth hall, or piece hall, erected for the convenience of the manufacturers, is a large and elegant edifice of freestone, in the form of an oblong square. It covers an area of 10,000 square yards, and has 315 separate rooms for the reception of goods. It is generally open from 10 to 12 o'clock, and goods to the amount of 50,000*l.* are often exposed to sale at a time.

The parish of Halifax is one of the largest in England. It covers a space of 150 square miles, and has 13 chapels. It contains no fewer than 26 villages, whose united population, according to the census of 1811, is 73,515. The chief manufactures carried on in the parish are, those of shalloons unpressed, and dyed of a scarlet colour, which are sent to Turkey and the Levant; tammies, duroys, calamancoes, everlastings, russets, figured and flowered armines, says, moreens, and shags, kerseys, half thicks, serges, houlies, baize, broad and narrow cloths, coatings, and carpets. Several cotton manufactories have also been erected here. The trade of this town is greatly facilitated by a navigation from Sowerby bridge, in the neighbourhood of the town, along the Calder, to Hull, and will receive additional advantages from the Rochdale canal, which will connect the Calder at Sowerby bridge with the Bridgewater canal at Manchester. Excellent wool cards are also manufactured here. Great quantities of the freestone found in the neighbourhood are sent to London.

Gough, in his additions to Camden, informs us, "that the inhabitants within Hardwicke forest claimed a right or custom from time immemorial, that if a felon be taken with goods to the amount of 13½d. stolen within their liberty, after being carried before the lords bailiff, and tried by four frith-burghers, from four towns within the said precinct, he was, on condemnation, to be executed on the next market-day, after having been set in the stocks first; and after his execution, a coroner was to take the verdict of a jury, and sometimes of those who condemned him." The instrument used in these executions was one exactly the same as the modern guillotine, which was freely used against the robber of tenter grounds: (See Guillotine.) The last execution under the "Halifax gibbet law," as it has been called, took place in 1650. The bailiff was afterwards threatened with prosecution, if he should repeat them. According to the census of 1811, the township of Halifax contains.

| | |
|---|---|
| Inhabited houses | 2151 |
| Number of families | 2313 |
| Do. employed in agriculture | 8 |
| Do. in trade and manufactures | 2261 |
| Males | 4151 |
| Females | 5008 |
| Total population | 9159 |

See *Beauties of England and Wales*, vol. xvi. p. 742.

HALIFAX, is the principal town of the county of the same name in Novia Scotia, one of the British possessions in North America. It is situated on the Bay of Chebucto, which is very spacious, and is able to contain, in perfect security, 1000 of the largest vessels. The town, which is about two miles long, and one-fourth of a mile broad, is situated on the west side of the harbour, on the declivity of a commanding eminence, elevated 236 feet above the level of the sea. In consequence of the streets intersecting each other at right angles, the houses are arranged into oblong squares. The Royal Naval Yard, supplied with military stores of all kinds, stands at the north end of the town. The accessible nature of the harbour, and its proximity to the principal interior settlements of the province, render it the fittest place in British America for a seat of government. Halifax is entrenched with forts of timber. The country around the town is rocky, and the soil unfit for cultivation. The imports of Great Britain, alone, into the single port of Halifax, amounted in 1810, to 600,000*l.* In 1790 and 1791, the whale fishery from the port of Halifax employed 28 sail of ships and brigs from 60 to 200 tons burthen. The principal exports from Halifax are the fish caught upon its coasts, great quantities of which are sent to the West India Islands. The amount of tonnage employed in the trade to and from the West India islands, and entered at the custom-house of Halifax, was, in 1792, 6489½ tons outwards, and 6571,1-4 tons inwards. Roads are opened from Halifax to all the settlements in the province. Population, 1000 houses, and 8000 inhabitants. Some accounts state the population so high as 15,000 or 16,000. West Long. 63° 35′ 45″, North Lat. 44° 44′. See Morse's *Geography*; Raynal's *History of the East and West Indies*; Gray's *Letters from Canada and* Nova Scotia.

HALIOTIS. See Conchology.

HALLE, is a town of Prussia, in the duchy of Magdeburg. It is situated on an agreeable plain on the river Saale. This town is divided into four quarters, and contains three Lutheran churches, and also places of worship for the Calvinists and the Roman Catholics, and a synagogue for the Jews. The principal edifices and curiosities of the town are, the cathedral; the red tower, which rises 268 Rhenish feet; the church of St Ulrice, where there is a fine monument erected to the celebrated Bulle d'Or of the Emperor Frederick II.; the orphans, physician Hoffman; the hotel de ville, which contains the hospital; the amphitheatre of anatomy, situated in the place d'Armes; the public library; the ruins of the chateau of Giebichenstein, from one of the windows of which the Landgrave of Thuringia threw himself, and received the title of the Leaper; and the ruins of the chateau of Moritzbourg. The orphans' hospital was built in 1698 by professor Franke, and contains a collection of artificial and natural curiosities, and a library. The university of Halle, formed out of a military academy, was established in 1699. It has a good library, and a cabinet of natural history. In the year 1802, it had 634 students. This town owes its celebrity to the fine salt springs in its neighbourhood. There are four of these which are very productive, lying on the Saale, in the lower part of the town, called the Vale of Saale. These salt springs furnish water, of which from 16 to 20 ounces yield from 3 to 3½ ounces of salt. They give work to 111 boiling houses. Each of these produces annually about 1200. The possessors of these springs are called Pfaenner, and the workmen Hallores. They are the descendants of the ancient Wends, and still retain their dress and manners.

Canstein's printing-office for the Bible is a very large establishment. In 1800, the number of copies printed amounted to 1,793,534 Bibles, exclusive of 877,999 copies of the New Testament, 1600 Psalms, and 52,500 copies of Jesus Sirach. The other articles of manufacture are, worsted and silk stockings, starch, flannels, buttons, linen, tobacco pipes, china ware, ribbons, and red and yellow Turkey leather. Population 20,000, including 1195 Halleres, or manufacturers of salt. East Long. 11° 58′ 2″, North Lat. 51° 29′ 5″.

HALLER, Albert de, a physician and professor of the last century, celebrated for the excellence and voluminousness of his writings. He was born at Berne, in Switzerland, on the 18th of October 1708. His father was Emmanuel Haller, advocate and chancellor of the county of Baden. His early education was committed to one Abraham Baillodz, a fanatical and severe preceptor, not well qualified for training with advantage a mind of Haller's sensibility. Yet he very early discovered an unparalleled assiduity in the pursuit of knowledge. At five years of age, having already learned to write, he arranged for himself, in alphabetical order, all the words that were taught him. In a little after, he compiled dictionaries in the Hebrew, Chaldee, and Greek languages, to which he often had recourse in his advanced years. At the age of ten, he composed German and Latin verses, the merit of which astonished his teachers. He ridiculed, in a Latin satirical poem, the pedantry of his private tutor, from whose severity he had suffered. At the age of twelve, he extracted from the dictionaries of Moreri and Bayle, 2000 articles of biography of the most celebrated men. When he was thirteen he lost his father, whose death left him in a great measure destitute of the resources of fortune. Being intended for the church, he finished his studies at the public school. On one occasion, having got a passage to translate into Latin, he attracted the admiration of the professors, by giving a translation of it into excellent Greek. Having finished his literary studies at the age of fourteen, he was led, by his ardour for learning, to pay a visit to Dr Newhams, an able physician at Bienne, whose son was one of his school companions. This gentleman gave him some instructions in the Cartesian system of natural philosophy. That pursuit, however, did not engross his whole attention. He continued to cultivate polite literature, and to exercise his talent in composing verses. The house in which he lived at Bienne having caught fire, he had only time to save his poems before it was burnt down. These poems he revised in less than twelve months after; and, reflecting on the satirical strain in which they were written, he committed them to the flames, with the exception of a few, which were left to attest his poetical talent, without reproaching the goodness of his heart.

After indicating talents which qualified him for making a conspicuous figure in any pursuit, he embraced the medical profession. Towards the end of the year 1723, he began his professional studies at Tubingen, under Camerarius and Duvernois, at that time celebrated teachers of anatomy and medicine. While at Tubingen, he occasionally joined in the convivial parties of his fellow-students; but was on one occasion so powerfully shocked by the abandonment of reason exhibited in these indulgences, that he formed a resolution, which he kept for the remainder of his life, to leave off entirely the use of wine. As Boerhaave's *Institutions* were used as a medical text-book at Tubingen, Haller had an opportunity of appreciating the genius of this author, which induced him to repair to Leyden to profit by his lectures. These two great men, having met in this manner, immediately perceived each other's merits. Boerhaave was then teacher of medicine and botany, and Albinus demonstrator of anatomy at that celebrated school. Both of these professors treated him with great distinction, and excited in his mind a powerful emulation. The superb museum of Ruysch, at Amsterdam, which he often visited, contributed at this time to animate and guide his studies. At the age of 19, he took the degree of Doctor of Medicine at Leyden. The subject of his thesis was one which he had discussed with Duvernois at Tubingen, the refutation of a position advanced by Professor Coschwitz, of Halle, that there were two salivary ducts in the posterior part of the tongue, which this author claimed as his discovery. Haller shewed that these supposed ducts were two veins. His works contain the plates by which this point was elucidated.

In 1727, he visited England, where he became intimately acquainted with Sir Hans Sloane, the president of the Royal Society, and Douglas and Cheselden, two of its distinguished members. He also spent some time at Oxford. He went next to France, where he formed an acquaintance with Geoffroy, Antoine and Bernard de Jussieu, Petit, and Ledran, and attended the lectures of the celebrated Winslow. A person who lived in an adjoining house having found him engaged in private dissection, denounced him to the minister of police, in consequence of which he was obliged to remain for some time in concealment. Dissections must have been conducted in that city with much greater difficulty than they are now. Paris has furnished for some time the amplest field in the world for this mode of pursuing professional knowledge: and, however much some may affect to connect this fact with the careless licentiousness of the French nation, it exhibits a bright contrast to the feelings so prevalent in our own country relative to the remains of the deceased. Like all the prejudices of savage ignorance, these feelings appear to the persons who cherish them sacred and refined, though they senselessly oppose an obstinate barrier to the dissemination of the most important knowledge.

Haller went next to Basle, where he applied himself to the study of geometry under the celebrated Bernoulli, and for a short time he filled, with great credit, the anatomical chair during a temporary illness of Professor Mieg. He returned to Berne in 1729, to practise as a physician. Those who were previously established there, detracted from his professional character, by representing him as blindly attached to delusive theories, and had even the address to prevent him from obtaining the appointment of physician to an hospital, for which, in 1734, he was a candidate. Two years after, however, he succeeded in that object, and discharged the duties of the office with great credit.

The celebrity of his talents for anatomy induced the republic of Berne to form an anatomical theatre, and appoint him their professor. About this time he cultivated various elegant studies. He pronounced an oration before a public litterary assembly, in which he asserted the general superiority of the ancients to the moderns. He published a collection of German odes and poetical epistles, which evinced the refined taste and delicate sensibility of the author, were admired in every part of Europe, and soon translated into various languages. The piece which gave greatest satisfaction was one devoted to a descriptive account of the Alps, and the manners of their inhabitants. Possessing, among his other accomplishments, an extensive acquaintance with biography and civil history, he received the charge of the public library at Berne. He drew up a *catalogue raisonnée* of the books, and arranged, in luminous order, a collection of more than 5000 medals belonging to it.

In 1736, he was invited, by the regency of Hanover, to fill the chair of anatomy, surgery, and botany, in the University of Gottingen, now for the first time instituted. He embraced this opportunity of devoting himself with more decided advantages to the improvement of science. He celebrated, in an ode, the inauguration of that university, and gave a competent share of praise to George II. King of Britain, for the zeal with which he promoted science in every part of his dominions. These included the American colonies, which were then illuminated by the genius of Franklin. At his entrance on his official duties at Gottingen, Haller was subjected to domestic discouragements of a trying nature. The carriage in which his wife and three children travelled from their native country to this new situation was overset on the road, and his wife received an injury, of which she died soon after arriving at the end of her journey. He applied himself, however, with great zeal, to his academical duties, encouragd by the increasing esteem of his colleagues, and by the assistance of his countryman Huber. He published, in 1739, his *Lectures on Boerhave's Institutions*, on which he had annually commented to his pupils. In this work, we find some germs of those more extended undertakings in physiology, which laid the foundation for so great a share of his future fame.

Having, among his other pursuits, cultivated that of botany, he published, in 1742, his *Enumeratio Stirpium Helveticarum*, in two folio volumes, which were embellished with numerous elegant engravings. The arrangement of this work rather presents us with a view of the gradations which take place in the external characters of plants, than a distribution fitted for permanent reference. Differences of opinion have even been entertained on the number of classes which Haller admitted, some reckoning them 13, others 15. In the following year, he published a systematic account of the plants in the botanic garden of Gottingen, which was republished nine years after in a more complete state, and contained a description of some new species. In 1749, he published, in one work, a collection of insulated remarks in botany, which he entitled *Opuscula Botanica*. Haller's great merit consisted in the versatility of his genius, which enabled him to pass rapidly from one subject to another, excelling equally in all. From the year 1743 to 1753, he published annually a fasciculus of anatomical plates of the most remarkable dissections which occurred in the course of his labours. These were admired for the minute explanations and learned notes which accompanied them.

In 1745, he published an ingenious argumentative discourse, *De Fœtibus Monstruosis*, in which he maintained that the original germs were in such instances defective, in opposition to the opinion that monstrosity was the effect of a derangement in the evolution of a germ originally perfect.

In 1746, he announced his experiments on respiration, in which he established the identity of office of the two layers of intercostal muscles, and the whole of the doctrines regarding the mechanical part of that function which have ever since been maintained, in opposition to the vague and erroneous notions which previously prevailed.

Haller, like most other eminent men of the medical profession, was engaged in some warm disputes. Dr Hamberger, Van Swieten, De Haen, Albinus, and Lamettrie, were his antagonists. In these, however, he generally displayed moderation. In the second edition of his *Essay on Respiration*, instead of accumulating rejoinders, and exposing afresh the weakness of the arguments of Hamberger, he suppressed every harsh expression which the first edition contained. He had some physiological discussions with Dr Whytt of Edinburgh, Lamure, Lecat, and Lorry, in the course of which candour and mutual respect were on all sides observed.

The subject on which he displayed greatest originality was irritability, which he considered as a property of animated bodies distinct from sensibility, and residing in different organs. On this subject, Dr Whytt of Edinburgh maintained with him a learned and instructive controversy. The latter undoubtedly had the superiority in argument, without prejudice to the genius which Haller displayed in the developement of his theory, and the command of temper with which he conducted the controversy.

In 1649, he published his *Primæ lineæ Physiologiæ*. This work maintained the pre-eminence as a text-book in this department long after a multitude of improvements had been made in the science. In the composition of it he did not indulge in theory, but exhibited facts with a rigorous exactness. He published new editions of various works in medicine, as well as in natural science. It is in the prefaces to these works and to his own that he communicates knowledge in the most striking and engaging manner. They are collected in one volume, entitled *German Opuscula*.

Betwixt the years 1747 and 1756, he was employed in publishing a collection of dissertations, composed by various authors, on anatomy in eight volumes, on surgery in five, and on the practice of medicine in seven.

Besides the works now mentioned, Haller published various physiological dissertations betwixt the years 1736 and 1753, which were of themselves sufficient to confer on him a high degree of celebrity. Among these, was one on the circulation by which the substance of the heart is supplied with blood for its own nutrition; one on the form of the Eustachian valve at different periods of life; and one on the *membrana decidua* of the fœtus.

At Gottingen, he exerted himself in the formation of various useful institutions; such as the College of Surgeons, the Gottingen Society, a lying-in hospital subservient to the obstetrical branch of education, an anatomical museum, and a seminary for instructing artists in painting objects of anatomy, botany, and natural history.

These exertions procured for M. de Haller a high degree of honourable fame. He was elected member of almost all the academies of Europe. It deserves to be mentioned, that the Academy of Upsal had the honour of taking the lead. A learned society, which shews no tendency to precipitate admiration, deserves great credit when it early distinguishes the buds of a just celebrity, and by its notice cherishes exertions which might otherwise in some measure languish. When on a visit to Berne, he was elected a member of the sovereign council of that republic.

George II. took a lively interest in the splendid success of Haller. In 1739, he appointed him his first physician as elector of Hanover; he gave him the title of aulic counsellor; and in 1749, procured for him letters of nobility from the Emperor of Germany, creating him baron. Haller always, however, declined the title.

More than one seminary of learning aspired to the honour of numbering him among their teachers. Dillenius, professor of botany at Oxford, having before his death, which happened in 1747, expressed a desire that he should be chosen his successor, an invitation was given him to fill that vacancy. The following year he was invited to succeed Albinus at Utrecht as chancellor to the university; and soon after, the King of Prussia offered him an eligible establishment at Berlin, with the presidentship of the Academy. But Haller did not so far indulge a roving ambition, as to accept of any of these honourable appointments. He thus testified a grateful attachment to that university, the founder of which was the earliest to give him the honours best suited to gratify his wishes, and to afford scope for the full exercise of his great talents. He determined not to leave Gottingen for any place except his native country.

In 1753, finding his strength unequal to the labours of his situation, conjoined with the execution of the plans of writing which he meditated, he resolved to return to Berne, to pass the remainder of his life. The seventeen years which he had spent at Gottingen, though brilliant in the eyes of Europe, and attended with much gratification to his own mind, were also marked with traces of affecting domestic vicissitudes. Two years after he had lost his wife in the manner already related, he married a second, who died a few months after marriage. He then married a third, who was his companion for the rest of his days. For thus consoling himself twice, after the death of the individual bound to him by the closest ties, he was subjected, as usually happens, to the censure of weak and vain persons, who affect a character for sensibility, because their taste leads them to admire consistency in unhappiness in an object to which, with the eyes of critical amateurs, they occasionally turn their attention, and who demand, for the gratification of that preposterous selfishness, that the most worthy characters should be involved in permanent bitterness, bereft at once of self-command and consolation. Haller was not chargeable with that harsh apathy of which the ancient Stoics are sometimes accused. He allowed the tides of sensibility on proper occasions to overflow; but, with the most rational of that sect, he set bounds to this indulgence; considering protracted tears as equally unbecoming with inordinate laughter. In an elegant poem, entitled *Doris*, he expressed the tenderest attachment to his first wife, and his sincere grief after her decease. In another monody within three years, he celebrated his second; and with the third, he spent many years in the enjoyment of the most respectable state of domestic happiness.

On his return to Berne, he was received by his countrymen with genuine affection and delight. He had the fortune to obtain the honourable situation of governor of the town-house, which was awarded by lot.

In a year after his return, he published his *Opuscula Pathologica*, a work containing some curious facts in morbid anatomy. It contained also a description of a singular epidemic which had appeared in Switzerland, a sort of bilious pleurisy, in which venesection was unfavourable. He made experiments on the medical power of electricity in deafness, a subject which then excited much attention in Europe, and he pronounced it wholly ineffectual. He sometimes made botanical excursions, sometimes dissected animals, and published ingenious accounts of such physiological results as he obtained; for example, the growth of the bones, the structure of the brain and eyes of fishes, the anatomy of the chick *in ovo*, and the general subject of generation. One of his conclusions on this last subject was, that the female has by far the greatest share in the production of the fœtus.

The most complete work of Haller, and that which will always be most perused, was his great System of Physiology in eight quarto volumes, which he began in 1757 and finished in 1766. This work contains a complete account of all the facts then known on this extensive subject, minute anatomical descriptions of the structure of the organs, and a detail of the systematic opinions of former authors. By this work he for ever rescued physiology from the degradation of being the sport of vain hypothesis: he divested it of the spurious riches with which fancy had decorated it, and in their stead exhibited a collection of facts, which was at once solid and extensive, and led the way for the accumulation of further results of observation and experiment, from which just theories might gradually arise.

In 1772, 1773, and 1774, he amused himself by publishing, in the form of three romances, his thoughts on the degrees of happiness to be enjoyed under different forms of political government. In the first, entitled *Usong*, he delineated the happiness arising from the administration of a virtuous and judicious despotic monarch, who encourages justice and morality. In the second, *Alfred*, he represented that of a limited monarchy, in which the nobles and people preserve their right to a share in the management of the public interests; and the king, while he regulates the state, pays respect to established forms, consults systematically the public voice, and exerts himself to maintain that constitution by which his own power is at once prevented from becoming lawless, and assisted in the dispensation of national benefits. In the third, entitled *Fabius and Cato*, he described a well-regulated aristocracy. Where it is dangerous to insist on the desirableness of a complete change of government, it is wise to endeavour to stimulate to virtue those in whose power the destinies of the human race are placed. At the same time it is a beneficial exercise of a philosophical talent to speculate on the most eligible forms for those communities which have as yet no established government, or for those eras of revolution in which the persons qualified to judge of what is best, and possessed of power by their union to adopt it, are perfectly disposed to embrace such institutions as would contribute most effectually to the perpetual welfare of society. On this speculation Haller did not enter farther, than by shewing himself partial to an aristocracy like that of his native country; nor did he so far complete his plan, as to paint the advantages of the best state of a democracy.

Haller drew up several articles for the French Encyclopedie: and he long guarded the interests of general literature, by writing in the German review at Gottingen. The articles of which he was the author in that work amounted to 1500.

His last works were, his *Bibliotheca Botanices, Anatomicæ, Chirurgiæ et Medicinæ Practicæ*. In this extensive and well digested list of authors, he points out in the amplest manner, and with a luminous arrangement, the sources from which he derived his knowledge, and from which it might be obtained by others. It is written in the order of time, in subdivisions corresponding to the different epochs and schools of systematic opinion, and to each subdivision a short descriptive sketch of the period or sect in these sciences is prefixed. It thus exhibits an interesting history of the advances of science, accompanied by a full enumeration of the literary monuments which serve for the records of knowledge and opinion. His *Bibliotheca Medicinæ* was not completed. He had it also in view to form a similar work on Natural Philosophy.

The republic sometimes conferred on him temporary offices, which his philosophical talents enabled him to fulfil with distinguished advantage; and he was always ready to employ these talents for the public good. While he was governor of the canton of L'Aigle, he essentially benefited the resources of the state, by improving the manufacture of salt. He exerted himself for the establishment of a house for the maintenance and education of orphans and the children of decayed citizens, and also a school for the education of the children of the more opulent classes, in which the acquisition of useful knowledge was preferred to the objects of a scholastic discipline. By his influence, the situation of the clergy of the Pais de Vaud, which had been wretched and degrading, was rendered comfortable and respectable.

The university of Gottingen, and its patron the King of Britain, solicited him to return to that place, offering him the chancellorship on the death of Mosheim. The King of Prussia offered to make him chancellor of the University of Halle, and the Empress of Russia made tempting proposals to induce him to go to Petersburg. But he preferred remaining in the bosom of his native country, which at this time testified its respect for his character, and its desire of retaining him, by voting to him a competent annual salary. In 1776, he received the order of the Polar Star from the King of Sweden.

The Emperor of Germany, in the course of his last travels, visited Haller, and found him labouring under an accumulation of infirmities which he evidently could not long support. On his return to Vienna, he sent him some bottles of wine of uncommon excellence, with a quantity of the best bark; but Haller, before he had it in his power to set the due value on this simple tribute of private friendship from that monarch, had paid the debt of nature. The emperor received the news of his death with unfeigned grief; and afterwards, in order to secure an honourable relict, and a useful memorial of the studies of this great man, he purchased his library, and had it conveyed to Milan.

His disease was a form of retrocedent gout, affecting the region of the bladder, and was accompanied with so much inconvenience that he was obliged to confine himself at home. He published among the memoirs of the Society of Gottingen, an account of its progress, and of his personal experience of the effects of opium and other remedies. In the midst of this distressing illness, he published a second edition of his great work on physiology.

M. Rosselet, his physician, told him, at his own desire, his opinion of the exact time at which he was likely to die. In his last moments he was perfectly collected, and, with his hand on his pulse, coolly remarked to M. Rosselet that it had now ceased to beat.

He had eleven children, eight of whom he lived to see established, 20 grand-children, and before his death two great-grand-children. His eldest son, Gottlieb Emanuel, was afterwards an eminent citizen of Berne, and distinguished for his historical learning.

Haller was of the Protestant religion, and sincerely attached to his religious principles. La Mettrie, in dedicating to him a work in support of materialism, created in him the utmost horror and distress, by affecting to represent his discoveries as the most valuable proofs of this doctrine. His mode of life was rigidly sober. His only beverage was water, and he delighted to represent the unfitness of the climate of Berne for the culture of the grape as a signal advantage conferred by nature on his country.

Haller was exceeded by none of his contemporaries in the extent of his general information. He was well acquainted with most of the languages of Europe, and corresponded with the utmost facility with the literati of France, England, Italy, Holland, Denmark, and Sweden, in their respective native languages.

A more industrious literary life than that of Haller cannot be imagined. Every moment of his time was occupied. The reading of new books, and the composition of the lighter species of memoirs, and articles for reviews, were his only pastimes. During a long state of delicate health his bed was in his library, where he sometimes spent months without ever going out. There he eat his meals, and, with the society of his family and his books, he concentrated within this narrow space all that he held most dear on earth. He communicated to those around him a taste for scientific pursuits. His house was a sort of sanctuary of the sciences. He was assisted by his pupils, who had the range of his library and his theatre. His wife acquired the art of drawing and painting, for the purpose of rendering herself useful to him. His children, friends, and fellow citizens, all regarded it as their duty to contribute to his labours. His uncommon sensibility subjected him to quick alternations of pain and pleasure. He rarely joined in general social parties. When he did, he often rendered himself extremely agreeable; his conversation, however, was always that of a man of learning; even on trifling subjects, he displayed profound sense, and a spirit of application. He was above the ordinary size,—his eyes were lively,—and his countenance noble and expressive.

He was probably the most voluminous writer after Galen. His Latin style is sometimes dry, complicated, and not readily understood by persons unaccustomed to it: but the profundity of views, the well connected strain of reflection, and the great erudition with which his works are replete, never fail to reward the reader. Various as the subjects were which occupied his pen, he shews a consistency of doctrine, and a unity of views and of method, which characterise solidity of judgment, and announce a commanding genius. His works on medical science will long continue to be read with profit, when the labours of many others, which have attracted the notice of the day, are reduced, by the cool decision of posterity, to their just rank —that of being regarded as the errors of exuberant fancy, imposing on the age in which they appeared, by laying premature and peremptory claim to the credit of regular scientific systems. See Vicq d'Azyr's *Eloges;* Henry's *Life of Haller; and* Haller's *Bibliotheca Anatomiæ.* (H D.)

HALLEY, Edmund, a celebrated astronomer and natural philosopher, was born at Haggerston, in the parish of St Leonards, Shoreditch, London, on the 8th November 1656. His father, who was an opulent citizen and soapboiler, sent him to St Paul's school, where, under the care of the learned Dr Gale, he made rapid advances in his classical studies, and acquired such a taste for elementary astronomy, that he amused himself in making dials, and observed the change in the variation of the needle at London in the year 1672, the year before he left school. From this seminary, which he left in 1673, he went to Queen's College, Oxford, where he was entered a gentleman commoner, and where, with the aid of a good collection of instruments which his father had purchased for him, he devoted himself almost exclusively to the study of mathematics and astronomy. In the year 1676, he published his first paper in the Philosophical Transactions, entitled "*A Direct and Geometrical Method of investigating the Aphelia, the Eccentricities, and the Proportions of the Orbits of the Primary Planets, without supposing the equality of the Angle of Motion at the other focus of the Planet's Ellipsis;*" and he continued to employ himself in astronomical observations. Although he had long entertained a plan of forming a complete catalogue of the fixed stars, yet he abandoned this scheme upon hearing that Flamstead and Hevelius were occupied in the same pursuit. He resolved, however, to form a catalogue of the stars of the southern hemisphere; and, by the influence of Joseph Willamson, Secretary of State, and Sir J. Moore, Surveyor of the Ordinance, Charles II. was prevailed upon to send Halley to St Helena, in order to accomplish this desirable object. He arrived on the island in February 1677, after a voyage of three months; and though he was much interrupted by the frequent fogs which hover over it, yet, by the most unremitting industry, he at last executed his plan, which he published in 1679, under the title of *Catalogus Stellarum Australium.* This work was presented, on his return from St Helena, in November 1678, to Charles II. who gave him a mandamus to the University of Oxford for the degree of A.M. Halley had rewarded the kindness of his patron by forming a new constellation, under the name of *Robur Carolinum.* During his stay at St Helena, he had the good fortune to observe the transit of Mercury over the sun's disc.

In the year 1678, Halley was elected a Fellow of the Royal Society of London; and, in consequence of the dispute between Hevelius and Hooke respecting the use of telescopic sights, he went to Dantzic in 1679, for the purpose of settling the controversy, by examining the method of observation employed by the Polish astronomer. He remained at Dantzic from the 26th of May till the 18th July, and returned to England deeply impressed with a conviction of the wonderful perfection of Hevelius's instruments, and of the great accuracy of his observations.

In the year 1680, Halley set out for Paris, accompanied by his friend Mr Nelson, with the view of performing the grand tour of Europe. In crossing the English channel, he obtained a view of the great comet upon its return from the sun; and having been fortunate enough to observe its descent towards that luminary, he was able to complete his observations at the Royal Observatory of Paris, which was then under the direction of Dominique Cassini. From Paris he went to Italy, where he spent the greater part of the year 1681; but his private affairs obliged him to return to England about the end of the year.

Soon after his arrival in London, Halley married the daughter of Mr Tooke, auditor of the Exchequer, and took up his residence at Islington, where he put up his astronomical apparatus, and pursued with ardour his favourite study. With this amiable woman Halley lived 55 years, but was not blessed with any family.

In the Philosophical Transactions for 1683, he published his *Theory of the Variation of the Magnetical Compass*—a paper of singular merit, in which he endeavours to shew, that the "whole globe of the earth is one great magnet, having four magnetical poles or points of attraction, near each pole of the equator two; and that, in those parts of the world which lie near adjacent to any of these magnetic poles, the needle is governed thereby, the nearest pole being always predominant over the more remote."

Our author's studies were now somewhat interrupted by domestic misfortunes. His father had suffered greatly from the fire in London; and having imprudently entered into a second marriage, he was reduced comparatively to a state of poverty. His son, however, speedily resumed his usual occupations; and, in the year 1684, his attention was directed to the subject of Kepler's sesquialterate proportion, from which he concluded that the centripetal force must be inversely as the square of the distance. He found himself unable, however, to establish this by geometrical principles; and having applied in vain for assistance to Dr Hooke and Sir C. Wren, he at last made a visit to Cambridge, in order to consult Mr Newton. This illustrious mathematician communicated to Halley 12 theorems which he had written upon the subject, containing his theory of gravitation. Halley was so delighted with the developement of this great discovery, that he prevailed upon Newton to complete his *Principia*, which was actually published in 1686, under the immediate care of Dr Halley, who prefixed to it a discourse of his own, and complimented Newton in an elegant copy of Latin verses.

In the year 1685 Halley had been appointed clerk to the Royal Society, and was the principal person employed in the publication of its Transactions.

In 1686, he published a paper, entitled *An Historical Account of the Trade Winds and Monsoons, observable in the Seas between and near the Tropics*, with an attempt to assign their physical cause; and in 1687, appeared his *Estimate of the Quantity of Vapour raised out of the Sea by the warmth of the Sun*, which gave so much satisfaction to the Royal Society, that they requested him to pursue the subject. He accordingly published in 1691, his paper *On the Circulation of the Watery Vapours of the Sea, and the Origin of Springs*; in which he first pointed out that fine provision of nature, by which a constant circulation of water is kept up between the atmosphere and the ocean. Halley published in 1687, his paper *On the Numbers and Limits of the Roots of Cubic and Biquadratic Equations*. In 1688, he published a correct ephemeris for that year; and in 1691, appeared his paper *On the Time and Place of Julius Cæsar's Descent upon Great Britain*, in which he considers it as demonstrated that Cæsar landed in the Downs, a little to the northward of Dover cliffs, on the 26th of August, 55 before Christ. In consequence of having had the good fortune to observe the transit of Mercury when he was at St Helena, Halley directed his attention particularly to this class of phenomena; and in 1691, he published a paper *On the visible Conjunctions of the Inferior Planets with the Sun*, in which he has calculated all the transits of Mercury from A. D. 1605 to 1799, and all those of Venus from 918 to 2004. He was fully aware at this time of the great advantages which astronomy would derive from the observation of these phenomena; and he remarks, that "the principal use of these conjunctions is accurately to determine the distance of the sun from the earth, or his parallax, which astronomers have, by several methods, attempted in vain, while the smallness of the angles sought do easily elude the nicest instruments; but in observing the ingress of Venus into, and egress from, the sun, the space of time between the moments of the internal contacts may be obtained to a second of time, that is, to $\frac{1}{15}$ of a second, or 4‴ of the observed arch, by means of an ordinary telescope and clock that goes accurately for 6 or 8 hours." Halley had, however, been anticipated in this ingenious remark by our countryman James Gregory. See our life of JAMES GREGORY.

In consequence of Dr Bernard's resignation, a vacancy too place in the Savilian professorship of Astronomy at Oxford. Dr Halley was naturally considered as well qualified for the chair, and became one of the candidates. Dr David Gregory, however, was the successful competitor; and Halley is known to have lost the office solely from his adherence to the principles of infidelity. Mr Whiston informs us, "that Bishop Stillingfleet was desired to recommend him at court; but hearing that he was a sceptic and a banterer of religion, the Bishop scrupled to be concerned, till his chaplain, Bentley, should talk with him about it, which he did. But Halley was so sincere in his infidelity, that he would not so much as pretend to believe the Christian religion, though he thereby was likely to lose a professorship, which he did accordingly, and it was then given to Dr Gregory."

In 1692, Mr Halley resigned his situation as assistant-secretary to the Royal Society, and in 1696, when five different mints were established for the recoinage of the silver specie, he was made comptroller of the office at Chester. In 1692, Mr Halley published a singular paper *On the Cause of the Change of the Variation of the Magnetic Needle; with an Hypothesis of the Structure of the Internal Parts of the Earth*. In order to account for the change in the variation of the needle, he supposes that there is an interior globe within the earth, separated from the external sphere by a fluid medium; that they revolve about the same diurnal axis nearly in 24 hours, the outer sphere moving either a little slower or faster than the internal ball; that the magnetic poles, both of the external shell and the included globe, are distant from the poles of rotation; and that the variation arises from the change in the relative distances of the external and internal poles, in consequence of the difference of their daily revolutions. The whole of this paper, though marked by the ingenuity of its author, is characterised by an extravagance of speculation, in which he was not accustomed to indulge. He even goes so far as to say, that there may be several internal spheres separated by atmospheres, the concave side of each shell being made up of magnetical matter; and he considers it as by no means improbable, that these different spheres may be occupied by living beings. The concave arches," says he, "may, in several places, shine with such a substance as invests the surface of the sun; nor can we, without a boldness unbecoming a philosopher, adventure to assert the impossibility of peculiar luminaries below, of which we have no sort of idea."

Till the year 1698, Dr Halley continued to enrich the Philosophical Transactions with various memoirs on the price of annuities on lives; on the foci of lenses; on the roots of equations, and on different subjects in mathematics, meteorology, antiquities, astronomy, and optics. He now, however, conceived the design of making an extensive voyage, to determine the variation of the needle in different parts of the world. For this purpose, King William appointed him captain of the Paramour Pink, in which he set sail on the 20th of October 1698. Having sailed along the African coast, he crossed to the coast of America, going some degrees south of the line. His crew having begun to lose their health, and his officers to become mutinous, he proceeded to the West Indies to get them exchanged; and when he found this impracticable, he returned to England, where he arrived early in July 1699. When his lieutenant had been tried and cashiered, he again set sail on the 16th of September 1699, and after having made observations at St Helena, the Brazils, Cape Verd, Barbadoes, Madeira, Canaries, the Coast of Barbary, he proceeded in a southerly direction till he was stopped by the ice in the south latitude of 53°. Having thus accomplished the object of his voyage, he returned to Britain, and anchored in Long Reach on the 7th of September 1700. From this voyage he received the title of Captain in the Navy, and, through the influence of Queen Caroline, he enjoyed half pay during the remainder of his life. The results which Dr Halle obtained during this voyage were published in 1701 in his general chart, which exhibits the variation of the needle in all the seas frequented by navigators.*

In 1701, Mr Halley was sent by the King to observe the course of the tides in every part of the English Channel, and to ascertain the geographical positions of the principal headlands. This task was accomplished in 1702, and the results were published in a large chart of the English Channel.

The Emperor of Germany having resolved to form a commodious harbour in the Adriatic, Halley was sent by Queen Anne to inspect the two ports on the coast of Dalmatia. He set out on the 22d of November 1702, and went to Istria by the way of Holland and Germany; but, in consequence of the opposition which the Dutch made to the scheme, it was laid aside. The Emperor, however, when he saw him at Vienna, made him a present of a rich diamond ring from his own finger, and gave him a letter of recommendation written in his own hand to Queen Anne. No sooner had he returned to England, than he was a second time dispatched to Germany on the same errand. In passing through Hanover, he supped with the Electoral Prince, afterwards King George I. and his sister the Queen of Prussia; and after having been presented to the Emperor on the evening of the day on which he arrived at Vienna, he set out with the chief engineer for Istria, when the fortifications of Treiste were, by his advice, repaired and enlarged.

Upon his return to England in November 1703, he succeeded to the Savilian professorship of geometry at Oxford, which was vacant by the death of Dr Wallis; and the university at the same time conferred upon him the honorary title of doctor of laws. As soon as he settled in this new situation, he began, in conjunction with his colleague Dr Gregory, to publish the works of the ancient geometers, in pursuance of the plan recommended by Sir Henry Saville. He translated from the Arabic into Latin, *Apollonius de Sectione Rationis*; (See ANALYSIS. vol. i.) and he restored the two books of the same author, *De Sectione Spatii*, from the account given by Pappus. This work appeared in 1706. Dr Halley assisted also in preparing for the press, the Conics of Apollonius; and he supplied the whole of the 8th book which had been lost. This work appeared in 1710; and contained also Serenus *On the Section of the Cylinder and Cone*, which was printed from the original Greek, with a Latin translation. In 1708, Dr Halley published the *Miscellanea Curiosa*, in 3 vols. 8vo, which contained several original articles by himself.

On the death of Sir Hans Sloane in 1713, Dr Halley was appointed secretary of the Royal Society. In 1716, he published his paper *On the art of living under water*, which contains an account of his diving bell, and of the experiments which he made with it at great depths in the sea: (See DIVING BELL, vol. viii. p. 11, 12.) At the death of Mr Flamstead in 1719, Dr Halley was appointed astronomer royal; and though he had now reached the 64th year of his age, he entered upon the duties of his new office with a degree of juvenile ardour; and without the help of an assistant, he continued for 20 years to make celestial observations with the most surprising and unremitting assiduity. In the space of 9 years, a period of the moon's apogee, he made no fewer than 1500 observations on the moon's right ascension, the object of which was to determine the inequalities of her motion, and to furnish navigators with the most correct means of finding the longitude at sea. He gave an account of this plan in the *Phil. Trans.* for 1731, in his *Proposal for finding the Longitude at Sea within a Degree, or 20 Leagues.* In an appendix to the second edition of Street's Caroline Tables, Halley had suggested this method of finding the longitude so early as 1683 and 1684; and he now shews, from a comparison of the lunar tables with accurate observations, that the longitude may always be determined to within 20 leagues under the equator, and 15 leagues in the British Channel.

Dr Halley was constantly employed in perfecting his tables of the planets. They were drawn up in 1725; but he was unwilling to publish them till they were made as perfect as he could. In 1729, he was elected a foreign member of the Academy of Sciences at Paris. In 1737, he was seized with a paralytic affection in his right hand; but this did not prevent him from attending the Royal Society Club every Thursday. His disorder, however, gradually increased; and he died on the 14th January 1742, in the 86th year of his age. He was buried in the church-yard of Lee, near Blackheath. Dr Halley's *Tabulæ Astronomicæ* were published in 1749. They were for a long time the most complete and accurate; but they have long since been superseded by others more correct and valuable.

There are few individuals who have been so distinguished as Dr Halley, both for their industry and their genius. He was the author of no fewer than 78 papers in the *Philosophical Transactions*, upon almost every branch of natural philosophy; and a great number of these are remarkable for their originality, and for the new and ingenious views which they unfold. The name of Halley, however, is not associated in the history of science with any brilliant effort, or any striking discovery. His reputation was widely extended, both as a profound philosopher, and as a man of taste; and almost every department of physical science received some improvement from his labours. The upright character of Halley was strikingly displayed in his refusal to assume the mask of religion, when it would have conducted him to a professorship in Oxford. But while we admire this example of sincerity and disinterestedness in

* The original journals of Dr. Halley's two voyages were published by the late Alex. Dalrymple, Esq. in 1775, in a thin quarto volume.

his unbelief, we cannot but feel that a stain is left upon his reputation, when history records that he was a "banterer of religion." In an age when a philosopher like Newton was an open defender of Christianity, it was indelicate in a philosopher like Halley to assume in public the character of an infidel.

HALO, or CORONA, is a luminous circle, sometimes containing all the prismatic colours, which occasionally appear about the sun and moon, and other luminous bodies.

In the northern regions of the globe, the sun and moon frequently appear surrounded with halos, or coloured circles, having their diameter about 44° or 92°. When a horizontal white circle intersects these halos, *parhelia* or brighter spots appear near their intersections, and also portions of inverted arches of various curvatures. In the horizontal circle, there are often *anthelia* or bright spots nearly opposite to the sun.

In order to lay before our readers a pretty full account of this curious class of phenomena, we shall begin with describing the most interesting halos that have hitherto been observed, and then give an account of the theories which have been employed to explain them. As the most minute accuracy is necessary in the description of the phenemena, we shall generally give it in the words of the observers themselves.

On the 20th March 1629, Scheiner observed at Rome a singular halo, which Huygens describes in the following manner from the writings of Descartes and Gassendi:

"A is the place of the observer at Rome, B the vertex or point over his head, C the true sun, AB a vertical plane passing through the observer's eye, the true sun and the vertex B, which are all projected in the straight line ACB (Plate CCLXXXVII. Fig. 1.) About the sun C, there appeared two concentric rings not complete, but diversified with colours. The lesser and inner of them, DEF, was fuller and more perfect; and though it was open from D to F, yet these ends D and F were perpetually endeavouring to unite. Sometimes they did unite and complete the ring, and then opened again. The other exterior and fainter, and scarce discernible circle, was GKI; it had a variety of colours, but was very inconstant. The third circle KLMN was very large, and all over of a white colour, such as are often seen with paraselenæ about the moon. This was an eccentric circle passing through the middle of the sun, at first entire, but towards the end of the appearance it was weak and ragged, and scarce discernible from M towards N. In the common intersection of this circle, and of the outward iris GKI, there broke out two parhelia N and K, not entirely perfect; K was somewhat weak, bnt N shone brighter and stronger. The brightness in the middle of them both resembled that of the sun; but towards their edges, they were tinged with colours like those of the rainbow. They were not perfectly round and even at their edges, but uneven and ragged. The parhelion N was a little wavering, and sent out a spiked tail NP, of a colour somewhat fiery, which had a continual reciprocation. The parhelia at L and M, beyond the zenith B, were not so bright as the former, but rounder, and white like the circle which they were placed in. They resembled milk or clean silver. The parhelion M was almost quite extinct at half an hour past two o'clock, excepting that some faint remains would revive now and then, and the circle itself vanished in that place. The parhelion N disappeared before K did, and while M became fainter K grew brighter, and vanished last of all." This has been generally called the Roman Phenomenon.

On Sunday February 20th 1661, new style, Hevelius observed at Dantzic a very curious halo, which he thus describes in the appendix to his *Mercurius in Sole Visus*, page 174. "A little before 11 o'clock, the sun being towards the south, and the sky very clear, there appeared seven suns together in several circles, some white and some coloured, and these with very long tails, waving and pointing from the true sun, together with certain white arches crossing one another. 1st, The true sun at A (Fig. 2.) being about 25° high, was surrounded almost entirely by a circle whose diameter was 45°, and which was coloured like the rainbow with purple, red and yellow, its under limb being scarce $2\frac{1}{2}°$ above the horizon. 2d, On each side of the sun at B and C, towards the west and east, there appeared two mock suns, coloured especially towards the sun, with very long splendid tails of a whitish colour, and terminating in a point. 3d, A far greater circle YXHVZ, almost 90 degrees in diameter, encompassed the sun and the former lesser circle GBIC, and extended itself down to the horizon. It was very strongly coloured in its upper part, but was somewhat duller and fainter on each side. 4th At the tops of these two circles at G and H were two inverted arches, whose common centre lay in the zenith, and these were very bright and beautifully coloured. The diameter of the lower arch QGR was 90°, and that of the upper one THS was 45°. In the middle of the lower arch at G, where it coincided with the circle BGC, there appeared another mock sun; but its light and colours were dull and faintish. 5th, There appeared a circle BEFDC much bigger than the former, of an uniform whitish colour, parallel to the horizon at the distance of 25°, and 130° in diameter, which arose as it were from the collateral mock suns B and C, and passed through three other parhelia of an uniform whitish colour like silver: one at D, almost 90° from the true sun, towards the east; another at E, towards the west; and a third at F, in the north, diametrically opposite to the true sun, all of the same colour and brightness. There passed also two other white arches EN, DP, of the greatest circle of the sphere through the eastern and western mock suns E, D, and also through K, the pole of the ecliptic. They went down to the horizon at N and P, crossing the great white circle obliquely, so as to make a white cross at each parhelion; so that seven suns appeared very plain at the same time; and if I could have seen the phenomenon sooner from an eminence, I do not question but I should have found two more at H and I, which would have made nine in all; for there remained in those places such marks, as made this suspicion not improbable.

This most delightful and extraordinary sight lasted from 30 minutes past 10 to 51 minutes past 11; though it had not the same appearance all the while, but sometimes one and sometimes another. It appeared in the perfection of this description at about 11 o'clock, and then degenerated by degrees. The northern mock sun at F vanished first of all, together with a part of its circle; the other parhelia with their arches lasted till 10 minutes past 11, then the eastern mock-sun, and after that the western, vanished with both the crosses. Soon after this the collateral parhelia C, D suffered several changes; sometimes one was brighter than the other in light and colours; and sometimes fainter and darker. For at 18 minutes past 10 the eastern parhelion at C vanished, while the western parhelion at B remained very conspicuous; and 24 minutes past 11, the eastern one was very bright again, and remained so, while the western one disappeared at 40 minutes past 11; although this western one had almost always the longer tail. For the tip of it was frequently extended for 30 degrees, and sometimes 90, as far as the parhelion E; but the tail of the eastern one C was scarce above 20 degrees. At 30 minutes past 11, the great vertical circle YXHVZ was destroyed; but the inverted arches H and G, together with the collateral parhelia B and C, continued to the last.

The scheme of this phenomenon is drawn in the same manner as the constellations are drawn upon an artificial globe, to be received by the eye on the outside of it. For by this means every thing is represented much clearer and distincter. Nevertheless, the place of the observer was nearly under the zenith, within the circle parallel to the horizon; so that the true sun appeared to him in the meridian, the mock sun F in the north, and the other two at D and E on each hand. But if you desire to have this extraordinary phenomenon represented a little plainer: upon an artificial globe, whose pole is elevated to our altitude at Dantzic, with the centre A in the 2d degree of Pisces, where the sun then was, and with a semi-diameter of $22\frac{1}{2}$ degrees, describe the circle GBIC; 2d, and then the circle YXHVZ with a radius of 45 degrees; 3d, and with the same centre and semi-diameter of 90 degrees, draw the circle NEKDP through the two white mock suns, E, D; 4th, and with a semi-diameter of $22\frac{1}{2}$, the zenith being the centre, draw the arch THS; 5th, and also the arch QGR, with a radius of 90 degrees, upon the same centre; 6th, and lastly, the circle BEFDC, parallel to the horizon, with a radius of 90 degrees. And the draught being finished in this manner will appear very beautiful and harmonious."

On the 2d January 1586, Christopher Rothman observed at Cassel another halo, which he describes in the following manner, in his description of a comet seen in that year. "The sky being very clear in the east just before sunrise, there appeared an upright column, exactly situated in a vertical circle. Its breadth was every where equal to the sun's diameter; and it looked as if some village was on fire beyond the mountains. For it appeared like a column of flame, excepting that its thickness was every where the same.

Soon after, in the same column, there arose an image of the sun, exactly resembling the true sun. There was scarce one digit of this image under the horizon when the true sun began to rise in the same column, which was followed in like manner by another image. The column, with its three suns touching one another, continued always upright, or in a vertical circle, as appeared by the plummet of a quadrant.

These suns had all the same appearance, except that the true sun in the middle was brighter than the rest. This appearance of the column passing through three suns lasted almost a quarter of an hour, till they were covered by a black cloud descending from above.

Scheiner observed, in 1630, the halo represented in Fig. 3, which is thus described by Gassendi: "The diameter of the corona MQNE next to the sun, was about 45 degrees; and that of the remoter corona ORP, was about 95° 20′; they were coloured like the primary rain-bow, but the red was next the sun, and the other colours in the usual order. The breadths of all the arches were equal to one another, and about a third part less than the diameter of the sun, as represented in the scheme. Though I cannot say but the whitish circle OGP parallel to the horizon, was rather broader than the rest. The two parhelia, M N, were lively enough; but the other two at O and P were not so brisk; M and N had a purple redness next the sun, and were white in the opposite parts; O and P were all over white. They all differed in their durations. For P, which shone but seldom and but faintly, vanished first of all, being covered by a collection of pretty thick clouds. The parhelion O continued constant for a great while, though it was but faint. The two lateral parhelia M and N were seen constantly for three hours together: M was in a languishing state, and died first, after several struggles; but N continued an hour after at least. Though I did not see the last end of it, yet I was sure it was the only one that accompanied the true sun for a long time, having escaped those clouds and vapours which extinguished the rest. However it vanished at last upon the fall of some small showers. This phenomenon was observed to last four hours and a half at least; and since it appeared in perfection when I first saw it, I am persuaded its whole duration might be above five hours.

The parhelia Q R, were situated in a vertical plane passing through the eye at F, and the sun at G, in which vertical the arches CRH, ORP either crossed or touched one another. These parhelia were sometimes brighter, sometimes fainter than the rest; but were not so perfect in their shape and whitish colour. They varied their magnitudes and colours, according to the different temperature of the sun's light at G, and the matter that received it at Q and R, and therefore their light and colours were almost always fluctuating, and continued as it were in a perpetual conflict. I took particular notice that they appeared almost the first and the last of all the parhelia, excepting that at N.

The altitude of Q above the horizon in the morning, at the beginning of the observation, was 49° 40′; that of R was 76° 10′; that of the true sun was 28° 30′; hence the height of Q above the sun was 21° 10′, and the height of R above the sun was 47° 40′.

"There was a north wind at the beginning of these observations, but by degrees it changed to the east, and at last to the south; yet it brought no very great nor lasting rains. For near a fortnight after, the sky looked always vapourish; and every day before dinner the sun endeavoured to create new suns, but in vain, either for want of matter, or of a due disposition. For in the vertical circle I saw plainly some sketches of parhelia for a long time. I saw also very manifest reciprocations of the lateral parhelia. The iris ORP seems to have been a portion of a single circle concentric to the sun, but towards $\varkappa$ and $\theta$ it did not quite touch the horizon AB; and the lengths of the arches O $\varkappa$, P $\theta$ were variable. The arches Z Q $\alpha$, $\beta$ Q $\gamma$, $\delta\varepsilon\zeta$, that immediately surrounded the sun, seemed to the eye to compose a single circumference, but it was confused, and had unequal breadths; nor did it constantly continue like itself, but was perpetually fluctuating. But in reality it consisted of the arches expressed in the scheme, as I accurately observed for that very purpose. The horns HRC seemed to be a portion of a smaller circle, touching the greater ORP in a contrary position in a common knot at R. The arches cut each other in a knot at Q, and there they formed a parhelion. The parhelia N, M, sprung out from the common intersections M, N of the iris $\delta\varepsilon\zeta$, and of the whitish circle ONMP. The north part of the sky was clearer than the south, which being overcast with slender vapours, afforded more matter for this appearance." See Gassendi's *Opera*, tom. vi. p. 401.

Hevelius observed the following paraselenæ at Dantzic on the 30th March 1660. "In the beginning, at one o'clock in the morning, the moon A was surrounded by an entire whitish circle BCDE, in which there were two mock moons at B and D, one at each side of the moon, consisting of various colours, and shooting out very long and whitish beams by fits. That on the left hand extended its tail towards the thigh of Serpentarius, the other on the right extended its tail towards Jupiter, as represented in Fig. 4. Afterwards, at two o'clock, a larger circle surrounded the lesser, and reached down to the horizon. The tops of both these circles were touched by coloured arches like inverted rainbows. The inferior arch at C was a portion of a larger circle, and the superior a portion of a lesser. This extraordinary sight lasted near three hours; the outward great circle vanished first of all, then the larger inverted arch at C, and presently the lesser, and, last of all, the inner circle BCDE disappeared. The diameter of this inner circle, and also of the superior arch, was 45 degrees; that of the exterior circle, and inferior arch, was 90 degrees."

On the 6th April 1660 Hevelius observed the parhelia shewn in Fig. 5. " At half an hour past five in the evening, while the sun was descending towards the horizon, he was crowned with arches of circles of various colours like the rain-bow. In the corona, on opposite sides of the sun, there were two parhelia, variously coloured with pretty long and whitish tails pointing from the sun. Near the zenith, where the corona was a little faint and imperfect, there shone out another inverted arch, having a third parhelion in the middle of it, which appeared somewhat obscure. This phenomenon lasted half an hour till sun-set, the sun being very clear. The inverted arch, and the upper parhelion, disappeared first; and then the parhelion on the left hand; but the third parhelion set with the true sun. The diameter of the corona round about the sun was about 45 degrees, as I guessed by my eye."

On the 17th December 1660, Hevelius observed at Dantzic, the following paraselenæ, which are shewn in Fig. 6. " On the first day after the full moon," says he, " at thirty minutes past six in the morning, the moon being 12° high, I saw the moon in the west, with three mock moons about her in this manner. The air being very clear at first, I observed the moon surrounded with a double corona (near her body, as the figure seems to represent) tinged with very bright and beautiful colours. On each side of the moon there were two arches of a large circle, about 45 degrees in diameter, which were also coloured like the rainbow, and extended down to the horizon, in which were two mock moons with very long white tails. That on the left hand was near Procyon with a short tail; the other on the right hand had a longer tail. In the upper part, where these collateral arches concurred, there was another arch inverted and variously coloured, with a third mock moon in the middle of it, and somewhat duller than the other two. Moreover, what was very extraordinary, there passed a large white rectangular cross through the middle of the moon, whose lower part reached down to the horizon; but on each side it did not quite touch the corona, as appears by the figure. It was so very bright and strong, that it shone distinctly and clearly till sun-rise; but the mock moons disappeared a little before."

In Mathew Paris's History, the phenomenon seen in Fig. 7. is thus described: " A wonderful sight was seen in England, A. D. 1233, April 8, in the 17th year of the reign of Henry III. and lasted from sun-rise till noon. At the same time, on the 8th of April, about one o'clock, on the borders of *Herefordshire* and *Worcestershire*, besides the true sun, there appeared in the sky four mock suns of a red colour; also a certain large circle of the colour of crystal, about two feet broad, which encompassed all England as it were. There next went semicircles from the side of it, in whose intersections the four mock suns were situated; the true sun being in the east, and the air very clear. And because this monstrous prodigy cannot be described by words, I have represented it by a scheme that shews immediately how the heavens were circled. The appearance was painted in this manner by many people, for the wonderful novelty of it."

Figure 8. represents a parhelion observed at Leyden, A. D. 1653, Jan. 14, between one and two o'clock in the afternoon, in the academical observatory, by Samuel Char. Kechelius a Hollenstein. " The circle BDC was white, and almost 35′ broad; the altitude of its highest point D was 38° 23′. Its centre was in the sun, whose height was 15° 48′; that is, at 36′ past one, his azimuth being 23° 40′ towards the west, and the angle made by his vertical circle and the ecliptic 60° 54′. The mock suns B, C were oblong and unequal, at the distance of 22° 35′ on each side of the sun, and had the same altitudes as the sun. The western parhelion at C was the fainter of the two, and changed from yellow to white, and disappeared first; the eastern one at B was brighter, with a lucid arch shooting from the sun, and was coloured with purple, red, and yellow; the shape of its tail BF was conical, 27° long, the parhelion being the base of the cone; the part BE, 13° 10′ long, consisted of bright yellow, and red light; the other part EF being whitish, which vanished before the parhelion did. It appeared for half an hour, and lasted one quarter longer than C; and the corona disappeared a little after."

On the 13th May, 1652, Huygens observed a halo, which he thus describes:—" I observed a circle about the sun in its centre; its diameter was about 46°, and its breadth the same as that of a common rain-bow. It had also the same colours, though very weak, and scarce discernible but in a contrary order, the red being next the sun, and the blue being very dilute and whitish. All the space within the circle was possessed by a duller vapour than the rest of the air, of such a texture as to obscure the sky with a sort of a continued cloud; but so thin, that the blue sky colour appeared through it. The wind blew very gently from the north."

On the 8th of April, 1702, Dr Halley observed a halo with parhelia, and tangent arches, as shewn in Fig. 9. where S is the sun, Z the zenith, STPP a large white circle passing through the sun, and nearly parallel to the horizon. It was about 2° broad in the northern part about T, and continued of the same breadth in the east and west; but grew narrower towards the sun. Its edges were not very well defined, and the whole circle, seen on the pure azure sky, was considered by Dr Halley as a very extraordinary sight. The halo VXNY was 22° in diameter, the red rays being nearest to the sun. The arch PVP had its centre nearly at N; and at its intersections P, P with the large white circle, there were two bright parhelia tinged with colours. The distance PS was $31\frac{1}{2}$°. Another arch appeared at N, having its centre about V. The height of the sun during the observation was from 40° to 45°. The weather was cooler than ordinary, and the vapour which produced the phenomena was higher than the clouds; for they were seen to drive under the circles. See *Phil. Trans.* 1702, vol. xxiii. No. 278, p. 1127.

A very curious halo, with its accompanying phenomena, was seen by Mr Barker on the 22d of January 1771, a little before two o'clock, at Fort Gloucester, on the river of Lake Superior. The weather was extremely cold. " There was a very large circle, or halo, round the sun, within which the sky was thick and dusky, the rest of the hemisphere being clear, and a little more than half way from the horizon to the zenith was a beautifully enlightened circle, parallel to the horizon, which went quite round, till the two ends of it terminated in the circle that surrounded the sun, where, at the points of intersection, they each formed a luminous appearance, about the size of the sun, and so like him when seen through a thick hazy sky, that they might very easily have been taken for him. Directly opposite to the sun was a luminous cross, in the shape of a St Andrew's cross, cutting at the point of intersection the horizontal circle, where was formed another mock sun like the other two. The two lower limbs of the cross appeared but faintly a little way below the circle. The two higher reached a good way above the circle towards the zenith, very clear and bright. In this horizontal circle, directly half way between the sun and the cross, and those at the ends of the same circle, were other two mock suns of the same kind and size, one on each side; so that in this horizontal circle were five mock suns, at equal distances from each other, and in the same line the real sun, all at equal heights from the horizon. Besides these meteors, there was, very near the zenith, but a little more towards the circle of the real sun, a rainbow of very bright and beautiful colours, not an entire semicircle, with the middle of the convex side turned towards the sun, which lowered as the sun descended. This phenomena continued in all its beauty and lustre till about half after two. The cross went gradually off first, then the horizontal circle began to disappear in parts, while in others it was visible; then the three mock suns farthest from the sun, the two in the sun's circle continuing longest; the rainbow began to decrease after these, and last of all the sun's circle; but it was observable at three o'clock or after it. See *Phil. Trans.* 1787, vol. lxxvii. p. 44.

On the 18th June 1790, a complicated system of halos and parhelia was observed at St Petersburg by M. Lowitz. They are represented in Fig. 10. The arches A, B, and C were coloured, and, like all the other coloured parts, had the red towards the sun. Two anthelia appeared at D and E.

A curious halo, observed by Mr Hall in Berwickshire, on the 18th of February 1796, about 10 o'clock, is shewn in Fig. 11. The moon was about south-west, and the altitude of her limb nearly 54°. The diameter of the great halo was about 112°; and that of the small halo, having the moon in its centre, was between 8° and 12°. The weather was remarkably mild, and there was little or no wind.

On the 20th of November 1802, at 2 o'clock, Sir Henry Englefield observed at Richmond in Surry, two uncommon halos and parhelia. The altitude of the sun was 14°. The circle nearest the sun (Fig. 12.) was about 24° distant from him, and about a degree broad. Its light was a pale yellow, without any of the prismatic colours. The exterior circle was 48° from the sun, and about 1½° broad. It was tinged with the prismatic colours, the red being nearest the sun. In the left branch of the inner circle, in a line parallel to the horizon, and passing through the sun, was a very faint parhelion; but in the upper point of the same circle was a very remarkable one. Its light was so vivid that it could scarcely be viewed, and it was rather brighter than the real sun. "It was of a whiter light than the rest of the circle in which it was, and had a pearly appearance, as partaking a little of prismatic tints. It was large, perhaps in its brightest part near 2° broad, very ill defined every where, but most diffused in the part farthest from the sun. From each side of the bright light proceeded a bright ray, which had a double curvature very distinct, being first convex towards the sun, and then concave. The lower edge of these rays (or that nearest the sun) was tolerably well defined; the upper edge melted away into the sky with a sort of streakiness. They grew both narrower and fainter towards their termination, and they reached pretty near to the other circle. The whole form of this parhelion and its rays bore so striking a similitude to the body and extended wings of a long winged bird, such as an eagle, hovering directly over the sun, that superstition would really have had little to add to the image. See the *Journals of the Royal Institution*, vol. ii. or Nicholson's *Journal*, vol. vi. p. 54. "A coloured drawing of this phenomenon, will be found in Dr Thomas Young's *Natural Philosophy*, vol. i. plate xxix. Fig. 431.

Having thus given a description of some of the most interesting halos and parhelia that have been accurately observed, we shall now proceed to give some account of the theories by which these phenomena have been explained.

Descartes supposes that halos are generated by the rays of the sun refracted through flat stars of pellucid ice; but it follows from this supposition, that the space within the halo should appear brighter than that without, which is contrary to observation. See Descartes, *Meteorolog.* cap. x.

The subject of halos was next investigated by Huygens, who published a large dissertation concerning their cause, which has been translated and reprinted by Dr Smith, in his *Treatise on Optics*. Huygens assumes the existence of particles of hail, some of which are globular, and others cylindrical, with an opaque portion in the middle of each, bearing a certain proportion to the whole; and he supposes these cylinders to be kept in a vertical position by a current of ascending air of vapours, and sometimes to have a position inclined to the horizon in all directions when they are dispersed by the wind or otherise. The cylinders are supposed to have been at first globules, formed of the softest and finest particles of snow. As soon as a globule is formed by a collection of these particles, many more particles will adhere to the bottom of it, but not to its sides, on account of the current of ascending vapours. The globules will thus have an oblong cylindrical figure; and when the warmth of the sun or of the air shall have melted the outsides of these cylinders, a smaller cylinder of snow will remain in the middle of each of them, surrounded with water; and after a certain part is melted, the cylinders within will become round and perfect, and will remain in this state for some time. If this coat of water should be frozen, Huygens supposes that it may possibly remain sufficiently transparent and polished to transmit, refract, and reflect the rays of the sun in a regular manner. By the aid of these assumptions, Huygens has ingeniously explained, in a very minute manner, almost all the principal phenomena of halos which had been seen at the time when he wrote. It is extremely improbable, however, that such hailstones do exist, and still more improbable that they should have such properties as to produce constantly the diameter of 47°.

Sir Isaac Newton ascribes the halo of 22½ degrees by refraction from floating hail or snow, and he accounts for the small coloured coronæ by his doctrine of fits of easy reflection and transmission. "As light reflected by a lens," says he, "quicksilvered on the backside, makes the rings of colours above described, so it ought to make the like rings of colours in passing through a drop of water. At the first reflection of the rays within the drop, some colours ought to be transmitted, as in the case of a lens, and others to be reflected back to the eye. For instance, if the diameter of a small drop or globule of water be about the 500th part of an inch, so that a red-making ray, in passing through the middle of this globule, has 250 fits of easy transmission within the globule, and that all the red-making rays which are at a certain distance from this middle ray round about it have 249 fits within the globule, and all the like rays at a certain further distance round about it have 248 fits, and all those at a certain farther distance 247 fits, and so on; these concentric circles of rays, after their transmission, falling on a white paper, will make concentric rings of red upon the paper, supposing the light which passes through one single globule, strong enough to be sensible; and in like manner the rays of other colours. Suppose now that, in a fair day, the sun shines through a thin cloud of such globules of water or hail, and that the globules are all of the same bigness, and the sun seen through this cloud shall appear encompassed with the like concentric rings of colours, and the diameter of the first ring of red shall be $7\frac{1}{4}°$, that of the second $10\frac{1}{4}°$, that of the third 12° 33′. And, according as the globules of water are bigger or less, the rings shall be less or bigger. This is the theory, and experience answers it. For, in June 1692, I saw, by reflection, in a vessel of stagnating water, three halos, crowns, or rings of colours, about the sun, like three little rainbows concentric to his body; the colours of the first or innermost crown were blue next the sun, red without, and white in the middle between the blue and red. Those at the second crown were purple and blue within, and pale red without, and green in the middle; and those of the third were pale blue within, and pale red without. These crowns inclosed one another immediately, so that their colours proceeded in this continual order from the sun outward; blue, white, red; purple, blue, green; pale yellow, and red; pale blue, pale red. The diameter of the second crown, measured from the middle of the yellow and red on one side of the sun, to the middle of the same colour on the other side, was $9\frac{1}{3}°$, or thereabouts. The diameters of the first and third I had not time to measure; but that of the first seemed to be about five or six degrees, and that of the third about 12°. The like crowns appear sometimes about the moon; for, in the beginning of the year 1664, February 19th, at night, I saw two such crowns about her. The diameter of the first or innermost was about 3°, and that of the second about $5\frac{1}{2}°$. Next about the moon was a circle of white, and next about that the inner crown, which was of a bluish green within next the white, and of a yellow and red without, and next about these colours were blue and green on the inside of the outward crown, and red on the outside of it. At the same time there appeared a halo, about 22° 35′ distant from the centre of the moon. It was elliptical, and its long diameter was perpendicular to the horizon verging below farthest from the moon. I am told, that the moon has sometimes three or more concentric crowns of colours encompassing one another next about her body. The more equal the globules of water or ice are to one another, the more crowns of colours will appear, and the colours will be the more lively. The halo at the distance of $22\frac{1}{2}°$ from the moon is of another sort. By its being oval, and remoter from the moon below than above, I conclude, that it was made by refraction in some sort of hail or snow floating in the air in an horizontal posture, the refracting angle being about 58° or 60°." See Newton's *Optics*, Book ii. Part iv. *Obs.* 13.

M. Mariotte supposes halos to be produced by small filaments of snow moderately transparent, and having the form of an equilateral triangular prism. He conjectures, that the hard flakes of snow which fall during a hard frost, and which have the figure of stars, are composed of little filaments like equilateral prisms, particularly those which are like fern leaves, as may be easily seen by the microscope. Upon examining the filaments which compose the hoar frost, he found them cut into three equal facets, and they exhibited rainbows when placed in the sun. Mariotte then supposes, that, before the hoar frost is formed, some of these separate prisms float among the thin vapours in the air, before they unite into the compound figures. "These little stars," says he, "are very thin and very light, and the little filaments which compose them are still more so, and may often be supported a long time in the air by the winds. Hence, when the air is moderately filled with them, so as not to be much darkened, many of them, whether separated or united, will turn in every direction as the air impels them, and will be disposed to transmit to the eye for some time a coloured light, nearly like to that which would be produced by equilateral prisms of glass." M. Mariotte then calculates the angles; and by deducting 16′ for the sun's semidiameter, and 30′ for the deviation of the red rays, he finds 22° 50′ to be the semidiameter of the halo produced by equiangular prisms.

In attempting to account for parhelia, Mariotte observes, "that they are usually at the same altitude as the sun. Among the prisms of snow, there are often many heavier at one end than at the other, and consequently situated in a vertical direction. These cause a bright parhelion with a tail, which cannot be above 70° long. I have read an account of a halo seen in May, soon after sun-rise, with parhelia in its circumference, which, after two or three hours, were more than a degree distant from it. This appearance arises from the coincidence of the sun's rays with the transverse section of the prism, when they are nearly horizontal, and from their obliquity, when the sun is elevated, causing a greater deviation, and throwing the parhelia outwards, as may be shewn by an experiment on two prisms." See Mariotte *Traité des Couleurs*, Paris 1686, or *Oeuvres de Mariotte*, vol. i. p. 272.

A theory of halos has recently been given by Mr Wood in the Manchester Transactions. He assumes, with Dr Halley, that vapour consists of hollow sphericles of water, filled with an elastic fluid, and having a thickness equal to $\frac{1}{122}$ of their diameter; and he supposes the halos to be produced by refraction, and reflection from these, in the same manner as the rainbow is produced by solid drops. See *Manchester Memoirs*, vol. iii. p. 336. A similar opinion seems to be entertained by M. Brande. See Gilbert's *Journal*, vol. xi. p. 414.

The subject of halos has recently been examined with much attention by our learned countryman Dr Thomas Young, who, before he was acquainted with the explanation of Mariotte, had adopted the very same theory. Our readers will no doubt be gratified with an account of Dr Young's theory and calculations in his own words.

"It is well known, that the crystals of ice and snow tend always to form angles of 60°; now a prism of water or ice of 60° produces a deviation of about $23\frac{1}{2}°$, for rays forming equal angles with its surfaces, and the angle of deviation varies at first very slowly as the inclination changes, the variation amounting to less than 3°, while the inclination changes 30°.

Now if such prisms were placed at all possible angles of inclination, differing equally from each other, one half of them would be so situated, as to be incapable of transmitting any light regularly by two successive refractions directed the same way; and of the remaining two-fourths, the one would refract all the light within these 3°, and the other would disperse the light in a space of between 20° and 30° beyond them.

In the same manner, we may imagine an immense number of prismatic particles of snow to be disposed in all possible directions, and a considerable proportion of them to be so situated, that the plane of their transverse section may pass within certain limits of the sun and the spectator. Then half of these only will appear illuminated, and the greater part of the light will be transmitted by such as are situated at an angular distance of $23\frac{1}{2}°$, or within 3° of it, the limit being strongly marked internally, but the light being externally more gradually lost. And this is precisely the appearance of the most common halo. When there is a sufficient quantity of the prismatic particles, a considerable part of the light must fall, after one refraction, on a second particle; so that the effect will be doubled; and in this case the angle of refraction will become sufficient to present a faint appearance of colour, the red being internal, as the least refrangible light, and the external part having a tinge of blue.

These concentric halos of 23½° and 47°, are therefore sufficiently explicable, by particles of snow, situated promiscuously in all possible directions. If the prisms be so short as to form triangular plates, these plates, in falling through the air, will tend to assume a vertical direction, and a much greater number of them will be in this situation than in any other. The reflection from their flat surfaces will consequently produce a horizontal circle of equal height with the sun; and their refraction will exhibit a bright parhelion immediately over the sun, with an appearance of wings or horns, diverging upwards from the parhelion.

For all such particles as are directed nearly towards the spectator will conspire in transmitting the light much more copiously than it can arrive from any other part of the circle; but such as are turned more obliquely will produce a greater deviation in the light, and at the same time a deflection from the original vertical plane. This may be easily understood, by looking at a long line through a prism held parallel to it: the line appears, instead of a right line, to become a curve, the deviation being greater in those rays that pass obliquely with respect to the axis of the prism; which are also deflected from the plane in which they were passing.

The line viewed through the prism has no point of contrary flexure, but if its ordinates were referred to a centre, it would usually assume a form similar to that which has often been observed in halos.

The form of the flakes of snow, as they usually fall, is indeed more complicated than we have been supposing; but their elements in the upper regions of the air are probably more simple. It happens however not uncommonly, that the forms of the luminous arches are so complicated as almost to defy all calculation. The coincidence in the magnitude of the observed and computed angles is so striking, as to be nearly decisive with respect to the cause of halos, and it is not difficult to imagine that many circumstances may exist, which may cause the axes of the greater number of the prisms to assume a position nearly horizontal, which is all that is required for the explanation of the parhelia with their curved appendages. Perhaps, also, the effect may sometimes be facilitated by the partial melting of the snow into conoidal drops; for it may be shown, by the light of a candle transmitted through a wine glass full of water, that such a form is accommodated to the production of an inverted arch of light, like that which is frequently observed to accompany a parhelion.

The situation of the lateral parhelia without the halo is very satisfactorily explained by Mariotte; and the diversified forms of the tangent arches may, probably, all be deduced from the suppositions laid down in the Journals of the Royal Institution. As an instance, we may take the case there described by Sir Henry Englefield, (see p. 615, *supra*,) where the sun's altitude was about 15°. The horizontal prisms will then cause an appearance of an arch with a contrary curvature, exactly as Sir Henry has described it.

The calculation is somewhat intricate. Its principal steps are these, taking the refractive power $\frac{4}{3}$.

Deviation of transverse rays 23° 37′.

For rays inclined 20°, the inclination of the planes of the rays is 29° 32′, the deviation 26° 12′; the altitude being 15°, the angle with the horizon is 25° 8′ more than the altitude.

For rays inclined 25°, the inclination of the planes is 34°, the deviation 27° 47′, the angle with the horizon 25° 47′ more than the altitude 15°.

For rays inclined 30°, the inclination of the planes is 120°; that is, the rays are in the planes of the surfaces, the deviation 38° 56′, the angle with the horizon 6° 4′ less than the altitude 15°.

When the altitude increases, the tangent arch descends so as to approach considerably to the halo, as in the halos observed by Halley and by Barker. For, calculating upon the true refractive power of ice, the angles become these.

For rays inclined 25°, the inclination of the planes 30° 55′, the deviation 25° 40′=21° 50′ + 3° 50′, the angle with the horizon 56° 24′=45° + 11° 24′. For altitude 15°, 38° 57′=15°+23° 57′.

It may also become double, the inferior arch being visible. Thus the angle with the horizon becomes 21° 18′ or 45°—23° 42′, as well as 56° 24′.

The mode of calculation is this: A being the inclination within the prism, and $r$ the index. Sec. B $= \frac{\text{Sec. A}}{\sqrt{\frac{3}{4}}}$ for the incidence; S. C$=r$. S. B, D $=$ C — B. As S. C : Sec. A :: S : D : $x$, $\sqrt{\frac{3}{4}}x = y$, $1 - y : \frac{1}{2}x$ :: Rad : T.E, 2 E is the mutual inclination of the planes passing through the rays and the axis of the prism, $\frac{\text{T.A}}{r} : \frac{1}{2}x$ :: Rad : S.F; 2 F is the whole deviation; $1 - \overline{y^2 + \frac{1}{4}xx} = zz$; $z : \frac{\text{T.A}}{r}$ :: S. Altitude : S. G, the elevation of the plane of the incident ray: G $\pm$ 2 E $=$ H, the elevation of the plane of the emergent ray; $\frac{\text{T.A}}{r}.z$ :: S.H : S I, the depression of the emergent ray.

Mr Cavendish has suggested, with great apparent probability, that the external halo may be produced by the refraction of the rectangular termination of the crystals, rather than by two successive refractions through the angles of different crystals, which, with the index 1.31, would produce a deviation of 45° 44′. If this supposition is true, the index cannot be greater than 1.31;* for 1.32 would give 47° 56′, which is more than appears to have ever been assigned.

The mean of four accurate observations is about 45° 50′, that of four of the best estimations 46°.

The lateral anthelia may be produced by the rays refracted after two internal reflections, which will have a constant deviation 60° greater than those which form the halo. These anthelia ought therefore to be about 82° from the sun. They are, however, usually represented as much more distant."

In addition to the works referred to in the course of the preceding article, see Zahn *Mundi Economia*. Lycosthenis *Chronicon Prodigiorum*. Fritsch *On Meteors*. *Philosophical Transactions*, 1665—6, i. 219. *Id.* 1669, iv. 953. *Id.* 1670, v. 1065. *Id.* 1699, xxi 107 and 126. *Id.* 1700, xxii. 535. *Id.* 1721, xxxi. 201, 212. *Id.* 1722, xxxii. 89. *Id.* 1727, xxxv. 257. *Id.* 1732, xxxvii. 357. *Id.* 1737, xl. 50, 54, 59. *Id.* 1740, xli. 459. *Id.* 1742, xlii. 47, 60, 157. *Id.* 1748, xlv. 524. *Id* 1749, xlvi. 203. *Id.* 1761, 3, 94. *Id.* 1763, 351. *Id.* 1770, 129. *Id* 1784, 59. *Id.* 1787. 44. *Mem. Acad. Par.* ii. 208. *Id.* x. 47, 152, 168, 275, 411, 454. *Id.* 1699, Hist. 82. *Id.* 1713, Hist. 67. *Id.* 1721, 231. *Id.* 1729, Hist. 2. *Id.* 1735, 87, 585. *Id.* 1743, Hist. 33. *Id* 1745,

* The index of refraction for ice, according to Dr Brewster's experiments, is 1.307. See *Treatise on New Philosophical Instruments*, p. 238. This measure renders Mr Cavendish's suggestion more probable.

Hist. 19. *Id.* 1753, Hist. 75. *Id.* 1754, Hist. 32. *Id.* 1755, Hist. 37. *Id.* 1758, Hist. 23. *Id.* 1786, 44. *Memoires de Berlin*, 1734, iv. 64. *Nov. Comment. Petrop.* vi. 425. *Id.* viii. 392. *Id.* x. 375. Weidler, *De Parheliis Anni* 1736. *Irish Transactions*, 1787, i. 23. *Id.* 1789, iv. 143. *Edinburgh Transactions*, iv. 174. *Edinburgh Essays*, i. 297. Rozier's *Journal*, xi. 377; xxxvii. 308. Dr Thomas Young's *Natural Philosophy*, i. 443; ii. 303—309; and our article GREENLAND.

HALSTEAD, a town of England in the county of Essex, is agreeably situated on the acclivity of a gravelly eminence, at the foot of which passes the river Colne. The streets of the town are broad and airy, but many of the houses are old and inelegant. The church dedicated to St Andrew is an old building. It consists of a nave, chancel, and side aisles, and has a tower and spire at the west end. The spire is of wood, and is the third that has been erected, the other two having been destroyed by lightning. The grammar school was founded in the year 1594, by Dame Mary Ramsay, for 40 poor children of Halstead and Colne-Engaine. The direction of it is vested in the governors, &c. of Christ's Hospital, London. The Bridewell is an ancient building. There is a Greek inscription on a house in the parish, which was brought from a village near Smyrna, where it had been erected in honour of Crato a musician, about 150 years before Christ. Halstead formerly carried on a considerable trade in baize and serges, but it has of late much declined. In 1802, 1654 were returned as employed in manufactures, whereas in 1811 only 1170 were returned. In 1811, there were in the town and parish of Halstead,

| | |
|---|---|
| Inhabited houses - - - | 722 |
| Number of families - - - | 803 |
| Do. employed in agriculture - | 288 |
| Total population - - - | 3279 |

See Morant's *History of Essex*, and the *Beauties of England and Wales*, vol. v. p. 254.

HAM, or HAMM, in Latin *Hammona*, a town of Westphalia, and capital of the county of the same name, is situated near the place where the Asse throws itself into the Lippe. Its principal public buildings are its parish church and Calvinistic academy with three professors, and it has excellent establishments for the support of the poor. Ham was formerly one of the Hanseatic towns. It has long been celebrated for its excellent hams, which are called *hammen* in Holland, and for its fishery. Great quantities of linen are bleached here; and it is famous for a kind of beer called *reut*, which is sold to a considerable extent in the neighbourhood. Distance from Munster 6 leagues S. E. and from Cologne 18 leagues N. E.

HAMAH, *Epiphania*, and the *Apamea* of Strabo, is a town of Syria, situated in a narrow valley on the banks of the Orontes. It lies between Aleppo and Tripoli, and is about 30 leagues east of Tripoli, and 40 north of Damascus. It was founded by Seleucus Nicanor, who supported no fewer than 500 elephants in its fertile territory; and is famous for having been the place where the Romans, under Aurelius, defeated Zenobia, Queen of Palmyra. Hamah was destroyed in 1157 by a dreadful earthquake, but was afterwards rebuilt. This town is now celebrated for its water works, in which the water is raised from the river by wheels 32 feet in diameter. The water, falling into the buckets, is elevated to the height of 30 feet, and discharged into a reservoir, from which it is conveyed to the public and private baths. The gardens around are very agreeable and fertile, and the surrounding country is well adapted for wheat and cotton. The Maronites built a chapel and a tomb here, from which arose a convent which is celebrated in that part of Syria. There is here a strong castle. Hamah is the seat of a Jacobite bishop, and a pacha has the government of all the canton. Population, 4000. See M. De La Roque's *Voyage de Syrie*.

HAMBURGH is a free imperial city of the duchy of Holstein in Lower Saxony, and one of the largest, richest, and most populous cities in Germany. It is situated on the right or northern bank of the river Elbe, at the distance of about seventy miles from its discharge into the German Ocean. East Long. 9° 56′, North Lat. 53° 46′. The number of inhabitants fluctuates from 110,000 to 120,000.

The city is divided by a canal into the old and new town. It is built partly on islands, and partly on the continent of the north side of the Elbe. Towards the east it is washed by the small river Bil, and towards the north by another small river called the Alster, which forms a very large basin just without the town, and another about 1000 feet square within the walls, after which it passes through different parts of the city, and then discharges itself into the Elbe. The several islands formed by the rivers Elbe and Alster, on which the town is built, have a communication with each other by eighty-four bridges. The whole city is surrounded by a lofty rampart and a broad ditch. The town, although large and flourishing, is by no means elegant. The principal streets have long and broad canals, which are filled by the tide; the others, especially in the old town, are mean, narrow, and ill paved. The houses are mostly built after the Dutch fashion, and very lofty, several of them being six or seven stories high. The warehouses of the merchants are generally in the upper part of the building, to prevent damage from the frequent inundations occasioned by high floods in the river, the back part of the houses being commonly so near the water, that their vessels come to unload at the very doors. The most beautiful parts of town are the *Jungfernstoig*, which is the fashionable promenade, especially on Sundays, and the streets and alleys along the Alster. The principal public buildings in this city are, the churches of St Peter, St Nicholas, St Catharine, St James, St Michael, St John, and the cathedral. These are mostly Gothic structures, having lofty spires, beautiful altars, and large organs. From the spire of the church of St Michael, there is an extensive and charming view of the town and its environs. The exchange, the orphan-house, the several hospitals, the room-house, the house of Eimbeck, and the obelisk in honour of Professor Busch, are also worthy of notice.

Hamburgh was founded in the beginning of the 9th century, by Charles, the eldest son of the Emperor Charlemagne, who was commanded by his father to erect two forts on the Elbe, with the view of repelling the incursions of the Venedi, a Sclavonic nation inhabiting the southern coasts of the Baltic. The fort on the north side of the river was called Hammenburg, (whence, by abbreviation, Hamburgh,) or the castle near the wood, according to the etymology of the name given by Christopher Silvius, an ancient poet of Hamburgh:

> Hamburgum silva cui notum nomen ab Hama,
> Inter Billa tuos, et olorifer Alstria ductus.

This city has undergone a variety of revolutions. It was made an archbishop's see by Lewis the Debonnaire in 833; but the see was afterwards transferred to Bremen. Upon the extinction of the Carlovingian line, it became subject to the dukes of Saxony, of whom it was afterwards held by the counts of Holstein. Adolphus III. in conderation of a sum of money, with which the Hamburghers furnished him upon his expedition to the Holy Land, favoured them with a great many privileges, which were subsequently confirmed by the Emperor Barbarossa. The citizens afterwards purchased their entire liberty from Albert of Orlamund, Count of Holstein, for the sum of fifteen hundred marks of silver; and it was confirmed to them by succeeding counts, as well as by Christian I. king of Denmark, after the county of Holstein had devolved to that crown. The Danish kings, however, have, on several occasions, revived their claims to the sovereignty of this city, which has frequently obliged the inhabitants to pay very large sums for the confirmation of their liberties. But Hamburgh was declared a free imperial city in the year 1618, and was summoned to the diet of the empire in 1641.

The government of this city is vested in the senate and the three colleges of burghers. The former exercises the executive power, and has the right of assembling and dissolving the body of the burghers; the latter grant taxes, and administer the revenue. The senate consists of thirty-six persons, viz. four burgomasters, four syndycs, twenty-four counsellors, and four secretaries or clerks, the chief of whom is called a prothonotary. The burgomasters and counsellors only have votes. When a vacancy occurs, a new member is chosen by lot. The members of the legislative body are chosen from the five parishes or wards of the city. The first college consists of the aldermen, three of whom are chosen by the inhabitants of each parish. Every parish also sends nine persons to the second, and twenty-four to the third college. The ordinary business is regularly brought by the senate before this assembly; but when there is a new law to be made, or a new tax to be raised, after having passed this court, the measure must farther be laid before a general assembly of the burghers, in which every inhabitant householder may appear and give his vote.

Hamburgh is most advantageously situated for trade and commerce, both foreign and domestic. The Elbe forms a good harbour, being navigable for ships of large burthen until within four miles of the town, when they must unload into smaller vessels, which, by means of the canals which traverse the city, can be brought to the very doors of the warehouses. At the period when the Hanseatic league was formed, Hamburgh became a principal member of that celebrated confederacy, which brought the trade of the world to the ports of the Baltic and the north of Germany. In subsequent times, when the other nations of Europe, particularly the Dutch and the English, cultivated a more extensive commerce, the trade of Hamburgh, along with that of the other Hanseatic towns, declined. But its situation is so favourable, that it has always been able to command a considerable commerce, especially when the great maritime powers are at war, as Hamburgh then becomes the great mart for colonial produce destined for the supply of the continent of Europe. During the war of the French revolution, the trade of this city rapidly increased; and it still continued to enjoy the advantages of its situation, capital, and credit, under the continental system adopted by Bonaparte, in consequence of which, most of the ports of Europe were shut against the commerce with England. While the blockade of the Elbe continued, the merchants of Hamburgh still carried on a profitable, though circuitous, trade, by the Danish ports of Tonningen and Husum. But the prosperity of this commercial city received a severe blow by its forcible seizure and unnatural incorporation with the French empire, and the subsequent plunder of the bank. Since the overthrow of Bonaparte's system, and the consequent return of Hamburgh under its old laws and government, that city may be expected to recover, in some measure, its former prosperity and importance.

The commerce of Hamburgh consists 1*st*, In the export of its manufactured produce; 2*dly*, In the importation of foreign merchandise; and 3*dly*, In the re-exportation of these last articles to different parts of the continent. The principal manufactures of this city are, the refining of sugar, the printing of cotton cloths, the manufacture of velvets and silk stuffs, of laces, metal buttons, knit stockings, sail cloth, &c. The establishments for the refining of sugar, which are very numerous, have been long flourishing, and are esteemed among the best in Europe. It has been calculated that they produced daily 700 small loaves of sugar, of about 3½ pounds weight, and 400 large loaves, from 6 to 7 pounds. The raw sugar is procured chiefly from England, the earth used in purifying it from Rouen, and a great part of the manufactured article is exported to Russia. The printing of cotton formerly employed twelve establishments, which gave occupation to 600 workmen each; but their number has been since greatly reduced, in consequence of similar manufactories having been established in other countries. There are about twenty establishments for the manufacture of velvets and laces, which are exported to Russia and different parts of Germany. The manufacture of silk stuffs and woollens is inconsiderable, and only for home consumption. That of knit stockings is of more importance. They are sent into the interior of Germany, and some occasionally to Italy. Dyeing forms another branch of the manufactures of Hamburgh, whose dyers are esteemed the best in Germany. Besides its own manufactures, Hamburgh imports from England, France, Holland, Italy, &c. all sorts of rich silk stuffs, and the finest velvet brocades, besides fine cloths of all kinds, for the purpose of re-exportation. This city also exports timber to a considerable amount annually, particularly to France and Spain.

The number of vessels which entered the port of Hamburgh in 1791 was 1484; and the value of the imports, for the same year, amounted to 112,554,026 livres, or about 4,689,751*l.* sterling. After the raising of the blockade of the Elbe, the number of shipping which annually entered the port was calculated at from 1900 to 2000. The number of vessels belonging to the merchants of Hamburgh, and employed by them, amounted to about 400.

The bank of Hamburgh was established in the year 1619 upon the same principles with that of Amsterdam. It was intended as a general fund for the convenience of the merchants, who, by means of this institution, make and receive payment, without the intervention of specie, by a mere transfer in the books of the bank. The specie deposited consists of bank dollars and ingots of silver. This specie has no ordinary circulation; consequently the fund always remains entire; and the money of the bank thus serves as a standard for measuring the value of all other specie. The bank closes every year, from the last day of December to the 14th of January, for the purpose of balancing the books. It is under the direction of four of the principal persons of the city; and no person is entitled to have an account with it, who is not either a citizen or an inhabitant. There are two kinds of money at Hamburgh; real money, and money of account; the latter being partly real and partly imaginary. The mark *lub.* which is equal to about 1*s.* 6*d.* of our money, is divided into sixteen shillings, and each shilling into twelve fennings, or pence. The rix-dollar contains three marks *lub.* It is called the rix-dollar current, which must not be confounded with the rix-dollar of the bank, the latter being more valuable, and equal to about 4*s.* 10*d.* of our money. In general, the money of the bank is worth from 15 to 20 per cent. more than the current money, and the difference in exchange is called *agio*. Besides these, they have gold ducats, current at seven marks, more or less, and double ducats at fourteen marks. Foreign gold is also received at its intrinsic value, according to the rate of exchange, which is regularly advertised twice a week. The bank receives payment in its own money only. In the year 1725, the magistrates of Hamburgh resolved to coin some new specie, which is called the new current money of Hamburgh, and consists of pieces of 1 and 2 marks, of eight shillings, or half a mark, four shillings, or a quarter mark, and several of smaller denomination, conformable to the standard of the old dollar. The *agio* for this specie, in exchange with the bank, was fixed at 16 per cent. A new bank was also established, at the same time, for the convenience of the town, which could not receive any money but that coined in the city, the *agio* being regulated by a combination between the two banks. By these means, business is conducted with more ease and regularity, and the merchants are not liable to loss from the difference of value in the several denominations. The usance, or course of exchange, is at fifteen days sight, for bills drawn on any part of Germany; a month's date, for those drawn on France or on London; and two months for those drawn on Venice, or on Spain or Portugal. There are twelve days of grace allowed, including the day of the bill's falling due, the Sundays, and holidays.

The chamber of marine insurance was instituted in 1705. Six of the most wealthy merchants provided a fund, which was divided into 500 actions, or shares, of 100*l.* each; and the business has been conducted with the greatest success. There are also establishments for the other species of insurance. In the Lombard, or town pledge house, money is advanced, at an interest of six per cent. on every kind of goods and merchandise, without the intervention of a broker. When the time during which the sum was lent has expired, the goods must be redeemed; otherwise they are sold for their value, and the excess is faithfully transmitted to the person to whom they belonged. By this institution the town is said to gain about 150,000 crowns annually.

The police of this city is admirable. There are few or no beggars in the streets, as the magistrates take care to employ the indigent, who are able and willing to work, in the manufacture of knit-stockings, and to send all vagabonds and sturdy beggars, who refuse to work, to the house of correction. The few who are incapable of labour are maintained by their respective parishes. The establishments for the poor, indeed, are no where more liberal or better administered than at Hamburgh. They have a very large hospital for orphans, which possesses a revenue amounting to between six and seven thousand pounds. There is also a large hospital for the reception of poor infirm labourers, and another for aged and disabled seamen; besides many smaller institutions for poor widowers and widows, &c.; with two houses of correction, the *Zucht-Haus*, and the *Spinn-Haus*, in which malefactors are kept close at work, with a spare diet.

Citizenship, at Hamburgh, is personal. The son of a citizen, therefore, is not a citizen of right, but must purchase his franchise. A Hamburgher, or a stranger, who does not chuse to purchase the citizenship, must pay a stipulated sum annually to the town, to entitle him to engage in trade as a merchant, besides all the other duties and imposts to which the other citizens are liable. The income of the state is very large. It is composed partly of standing sources of revenue, and partly of occasional taxes granted by the community. The aggregate revenue is estimated at 3,800,000 marks, or about 285,000*l.* sterling. The established religion of the city is the Lutheran, and no other public exercise of religion is tolerated. But persons of a different persuasion may have an opportunity of attending worship at the chapels of the foreign envoys who reside in the city. The number of the clergy, including those of the dependent territories, amounts to fifty-three. The chief dependencies of this city are, the river Alster, the bailiage of Ham, some islands and low lands on the Elbe; and besides some districts acquired from Holstein, the bailiage of Ritzebuttel, to the north of the duchy of Bremen, including the port of Cuxhaven, and the isle called Neuwerk, situated opposite to that port.

The *Raths-Keller*, or town cellar, may be reckoned one of the curiosities of Hamburgh. It is an immense subterraneous cavern, which is filled principally with Rhenish wine. Several halls and chambers have been formed, for the entertainments frequently given there by the inhabitants and strangers. It is under the direction of a burgomaster, three senators, and three burghers; but the immediate management is committed to a steward, who makes a profitable business of it. There is also an apothecaries' hall belonging to the town, which contains a great quantity of every possible species of drugs. These being superior to those sold by the other apothecaries, have a considerable sale, and produce much profit to the city.

In Hamburgh there are numerous schools, libraries, and literary institutions, which reflect honour on the enlightened taste of its inhabitants; besides several valuable collections of paintings and prints, and cabinets of natural history, &c. which sufficiently prove that the arts and sciences have not been neglected amidst the pursuits of commerce. This city has been, at different periods, the residence of many literary characters of the first eminence, among whom the names of Lessing and Klopstock are conspicuous. The principal amusements of the inhabitants are music and dancing, card-playing and billiards; in winter riding upon sledges; and, in summer, walking or riding to public gardens in the environs of the town. There is a French and a German theatre; and the musical drama, or opera, has long been cultivated with activity and success at Hamburgh. The compositions of Keiser, Matheson, Handel, and Telemann, who all commenced their carrier in this city, are the most celebrated. C. P. E. Bach, the greatest musician of his time, succeeded Telemann as music director in 1767, and retained the situation until his death in 1788.

The merchants of Hamburgh are very luxurious in their style of living; the tone of society is easy and animated; and there is no place where strangers are entertained with more hospitality. See Nugent's *Travels through Germany;* Riesbeck's *Travels;* Peuchet *Dict. de la Geog. Com.* vol. iv.; Reichard, *Guide des Voyageurs; Account of the management of the Poor in Hamburgh; Hamburgische Künstler-Nachrichten.* Hamburgh, 1794. (*z*)

HAMEL, DU, du Monceau, Henry Lewis, an eminent vegetable physiologist, was born at Paris in the year 1700. In the Memoirs of the Academy for 1728, he published an Essay on a Parasitical Fungus, (*Sclerotium Crocorum* of Persoon), which infests the roots of the cultivated saffron; and, in the same year, appeared his Treatise on the Propagation of Trees by Grafting. His principal works on Botany and Vegetable Physiology were the following:

1. *Traité de la Culture des Terres.* Published in 6 vols. from 1750 to 1761.

2. *Elemens d'Agriculture.* 2 vols. 12 mo. 1764. This work was translated into English, German, and Spanish.

3. *Traité des Arbres et Arbustes qui se cultivent en France en pleine terre.* 2 vols. 4to 1755.

4. *Physique des Arbres.* 2 vols. 4to. 1758. This is the principal work of Du Hamel.

5. *Des Semis et Plantations des Arbres et de leur Culture.* 4to. 1760.

6. *De L'Exploitation des Bois, ou moyen de tirer parti des taillis demi futayes et haut futayes.* 2 vols. 4to. 1769.

7. *Du Transport, de la conservation, et de la force du Bois.* 4to 1767. See our article Carpentry. See also the *Mem. Acad. Par.* 1742, 1744, 1764, 1767, 1768.

8. *Traité des Arbres Fruitiers.* 2 vols. 4to. 1768.

Du Hamel was also the author of a treatise on the cultivation and preparation of madder. His works on the mechanical arts are numerous. The following, which were published separately, are the most important:

1. *Art de faire les cartes à jouer.*

2. *Art du Couvreur.* See *Mem. Acad. Par.* 1766. Hist. 156.

3. *Traite de la Corderie perfectionnée.*

4. *Art du Drapier.* See *Mem. Acad.* 1765. Hist. 132.

5. *Art de faire des Tapis.* See *Mem. Acad.* 1766, Hist. 157.

6. *Art de friser et de ratiner les etoffes de Laine.* See *Mem. Acad.* 1766, Hist. 156.

7. *Art de l'Epinglier.* See *Mem. Acad.* 1761, Hist. 152.

8. *Art de forger les enclumes.* See *Mem. Acad.* 1762, Hist. 188.

9. *Art de Peche.*

10. *Architecture Navale.* 4to. Par. 1758. See *Mem. Acad.* 1752, Hist 141.

11. *Art de la Fabrique des Ancres.* See *Mem. Acad.* 1761, Hist 152.

12. *Art de Fabriquer les Pipes.*

13. *Art du Potier de terre.*

14. *Art du Serrurier.*

15. *Art de reduire le fer en fil d'orchal.* See *Mem. Adac.* 1768, Hist. 128, 1778, Hist. 110.

M. Du Hamel died at Paris in 1782. See Botany, p. 30.

HAMELN, formerly called *Quern* or *Muchlen-Hameln*, is a town of Germany, in the kingdom of Hanover. It is situated in a pleasant territory, at the confluence of the Hamel and the Weser. It is very strongly fortified, and contains some good buildings, particularly the Hotel de Ville. Its barracks can accommodate a whole battalion. A fine sluice was erected here in 1734, by George II. for the purpose of facilitating the navigation of the Weser, by which the town carries on a considerable trade. Hameln has been celebrated for its tanneries, its breweries of beer, and for the manufactures which were established by the French refugees. There is here a refinery of sugar. At the mouth of a cave not far from the town is a monument, erected to commemorate the loss of 130 children, who were swallowed up in 1284. From the fort there is a very fine view of the surrounding country. Population 4000. Distance 30 miles south-west from Hanover.

HAMILCAR. See Carthage.

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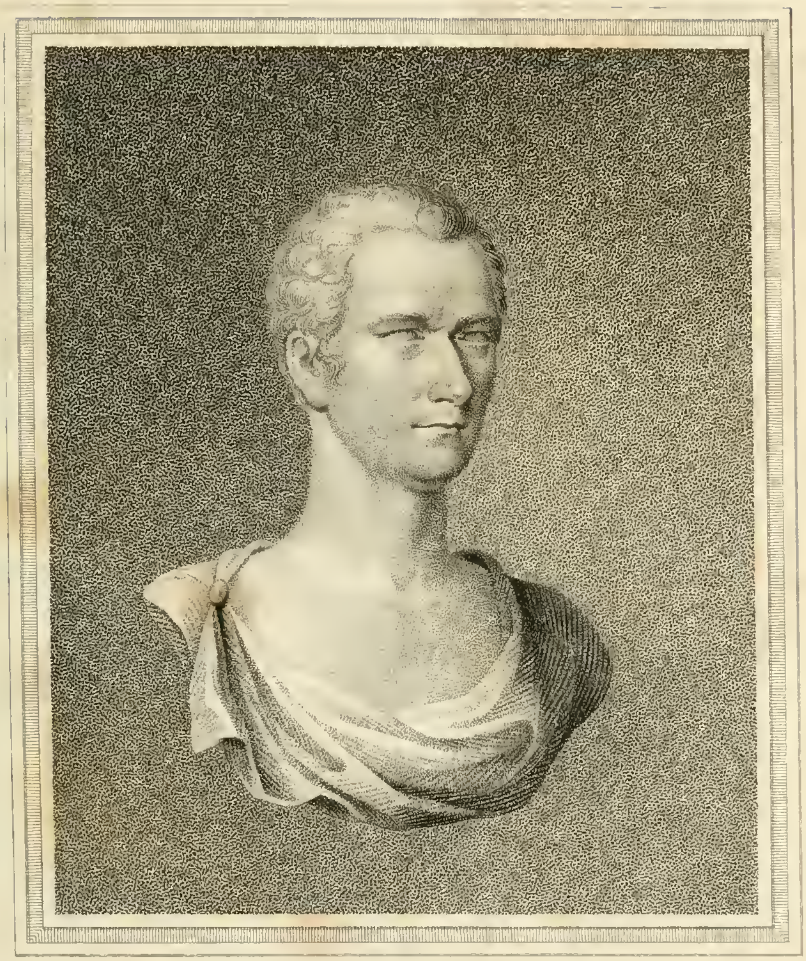
HAMILTON, Alexander, first secretary of the treasury of the United States, a native of the island of St Croix, was born in the year 1757. His father was an English gentleman; and his mother an American lady. At the age of sixteen, he was placed at Columbia College, in the city of New-York; where he continued about three years. He was discovered, while engaged in his collegiate studies, to be a youth of most promising abilities. The contest between Great Britain and her then colonies of America engaged the attention, and employed the talents of many distinguished gentlemen on both sides. The pen of Mr Hamilton was early exercised in the support of the colonies. He asserted their claims against very respectable writers. His anonymous papers exhibited such evidences of wisdom, that they were ascribed to Mr John Jay, then in the possession of extensive fame as a statesman. When the real author was discovered, the Americans beheld with astonishment a youth of nineteen in the society of their ablest advocates. The first sound of war awakened his martial spirit. He entered the revolutionary army as captain of artillery; and soon conciliated the good opinion of his brethren in arms. He early attracted the notice of the commander in chief, Washington, who, in 1777, appointed him his aid, with the brevet-rank of lieutenant-colonel. His sound understanding, comprehensive views, application, and promptitude in duty, soon gained him the entire confidence of the general. In such company, it was natural that his genius should expand. By an alliance with Washington, by a close and discriminate survey of his military plans, by observing his consummate prudence, and by an attentive inspection of the resources he employed, in the preservation and maintenance of the army, in the most critical and embarrassing circumstances, he himself became eminently qualified for command. Throughout the war, he was active and ardent in the cause of independence; often rendered the most valuable services in the field; and was ever an able counsellor and expert amanuensis in the general's cabinet. In the campaign of 1781, which terminated with the capture of Lord Cornwallis, colonel Hamilton commanded a battalion of light infantry. At the siege of York, when the second parallel was opened, two redoubts of the enemy, in advance of his works several hundred yards, flanked it, and very much annoyed the Americans in the trenches. The commander in chief determined to have them carried by storm. The assault upon one was committed to American, and on the other to French troops. In the detachment of Americans, colonel Hamilton, at his own earnest request, led the advance, consisting of two battalions. Late in the afternoon, on the 14th of October, 1781, the several detachments rushed to the charge, without firing a single musket. The redoubts were assailed with irresistible impetuosity, and carried, unexpectedly, with little sacrifice of life. The enemy, in his feeble attempt to repel the storm, lost eight men. Notwithstanding the irritation lately occasioned in the American army, by an unwarrantable and savage slaughter of a surrendering garrison in Fort Griswold, not one man was killed who had ceased to make resistance. The forbearance of the irritated and victorious assailants, who commenced the charge with a determination to be revenged upon the murderers of their countrymen, was ascribed, in both armies, to the merciful interposition of colonel Hamilton.

With the conclusion of the war, which resulted in the independence of the United States, like his great friend, colonel Hamilton laid off the sword; and, having married destitute of fortune, began the study of the law, with a view to the support of his family. He was admitted to the bar, after a short course of preparatory reading; and soon rose to eminence in the profession. But his private pursuits could not wholly detach him from a regard to the public welfare.

In 1782 he was elected a representative in congress, from New-York, and occupied a very high rank in that body. Some of the most important business, ever transacted in the congress of the confederation, came under consideration while he was a member. It has been generally reputed, and the journals of the house abundantly prove, that he was the author of some, and an auxiliary in many, of the very



*Leney del.t et sc.t from the Bust by Ceracchi*

ALEX.R HAMILTON.

important measures then adopted. He was perhaps uniformly a member, and several times chairman, of the committees, to whom was confided the laborious duties of prior investigation, and reporting on such subjects as were deemed most vitally interesting to the nation. Those reports, notoriously prepared by himself, are full of eloquence, energy, and wisdom.

The violence, meditated against the property and persons of those who remained in the city of New-York during the late war, called forth his generous exertions in their behalf. By his influence, and the aid of governor George Clinton, the faithless and resentful schemes against them were defeated. On this occasion he published two celebrated pamphlets, under the signature of Phocion, addressed to the considerate citizens of New-York. Those excellent productions had the happy effect of calming the vindictive passions of the people, informing their minds as to the obligations arising out of the conclusion of the treaty of peace, and finally convincing them, that moderation and justice were not only most honourable, but most consistent with sound policy.

In the year 1786, colonel Hamilton was a member of the legislature of New-York. During the session, a collision, on the subject of territorial rights, which had subsisted between the people of that state, and the inhabitants of the territory, now state of Vermont, was quieted. It had become extremely violent, and menacing to the peace of that section of the United States. The happy result has been universally attributed to the wisdom of his measures, the influence of his character, the moderation of his temper, and the effect of his eloquence. Out of the pacification arose the independence of the state of Vermont, which was admitted into the union in 1791.

Before the expiration of the session of the legislature, in which his great talents had been so happily exerted, he was elected one of the representatives of the state of New-York, in the convention at Philadelphia, whose deliberations resulted in the formation of the federal constitution, which was afterwards adopted by the several states. No more weighty and highly responsible duties were ever conferred upon any assemblage of men, than those committed to the wisdom and prudence of the convention. They were none other than the preservation of the independence of the United States, after it had been asserted by the sword, and at the price of much valuable blood; and an equal distribution, among the people, of the rights, burthens, and benefits, which spring from government. The articles of confederation, formed in the season of war, and under the pressure of common danger, were found inadequate to the efficient government of the same country and people, in the time of peace and commercial enterprize. A radical reform became necessary.

The several confederations, at various periods, among the American colonies, for the purposes of defence, had left an impression on the public mind, of the practicability of permanent union. From the want of power, in that which carried the country safely and successfully through the war, to do any thing having the authority of law, the affairs of the United States became exceedingly perplexed. Commercial jealousies were fast increasing among the several states, and countervailing measures were resorted to, not calculated to maintain the good understanding, which it was hoped would continue to exist among states that harmonized in the resistance of a common enemy. The sufferings of the inhabitants were increased by obstructions in their trade, from which they had been free while colonists. That intercourse with the West Indies, from which they had usually derived great supplies of gold and silver, was forbidden them, in their novel capacity of independent states. Their fisheries received a severe check, in their exclusion from several ports in which they had been accustomed to find ready sale of the fruits of their industry. These evils were still further aggravated by the stoppage of the bounty on whale oil, to which, when British subjects, they were entitled. To add to their misfortunes, they could no longer navigate the Mediterranean in safety; a privilege which they had enjoyed while members of the British empire. Unable to defend themselves against the barbarian corsairs, they were obliged either to quit the sea, or insure their trade at a ruinous premium. In short, the channels of commerce, which had been familiar to them, in their new character of citizens of the United States were completely changed. For the sums needed in the public service, the congress of the confederation continued to send forth annual requisitions; but, as they rested merely upon the recommendation of that body, it was optional with the state legislatures to grant them. They were consequently disregarded by some of the states, and but partially complied with by others. From this failure of public justice, a deluge of evils was likely to flow. It was moreover swelled by an unfavourable balance of trade. The ravages of armies, and the interruption of a free communication between America and Europe, during the war, had multiplied the wants of the former. An inundation of European manufactures was, therefore, one of the early incidents which followed the establishment of peace. They were purchased by the Americans far beyond their means of payment. Adventurers, grasping at the profits of trade with the new formed states, exported to America goods to a great amount; exceeding what either prudence or policy could justify. The Americans found themselves involved in debt, to the discharge of which their resources were unequal. In many instances these debts were contracted on credit, by persons to whom the United States were indebted. Presuming on the justice and ability of their country, they had involved themselves in private engagements, trusting, for the means of discharging their obligations, on payment from the public. To relieve their constituents from the pressure of multiplied and accumulating evils, congress felt its inadequacy; and called on the states to enlarge their powers, and particularly to entrust them with the regulation of commerce; at least for a limited number of years. Some states complied with the call; but others fettered their grants with such conditions as prevented the formation of an uniform system. From the combined operation of these causes and effects, trade languished; credit expired; gold and silver vanished; and real property depreciated to an alarming extent. Instead of creating an artificial medium of circulation by funding their debts, several of the states, to alleviate the distresses arising from the want of money, adopted the fallacious expedient of emitting paper, to supply the place of gold and silver; but the remedy increased the disease. Owing to the imbecility of the existing government, the public debt could not be funded upon any basis that would command confidence; and the advantage of substituting it for metal, as the basis of a national monied institution, was lost. The people began to feel disappointment in their expectations of prosperity and happiness as the fruits of independence. The calamities of war were followed by another class of evils, different in their origin, but not less oppressive in their consequences. The citizens were now peculiarly liable to be led into fatal error They were sensible of pressure, and, not knowing precisely from what sources it originated, or how to remedy it, became restless, and ready to adopt any desperate measures recommended by ambitious and turbulent leaders. In this irritable state, an insurrection actually commenced with a number of the citizens of Massachusetts, who, sore with their enlarged portion of public calamity, were induced, by seditious demagogues, to make open resistance to the operations of their own free government. The votaries of liberty and independence began to be less sanguine in their hopes from the revolution; and to fear that they had reared a visionary fabric of government on fallacious ideas of public virtue. At length, however, recurrence was had to the good sense of the people for the rectification of fundamental disorders. The congress adopted a resolution to the following effect: "That in their opinion it was expedient, that, o nthe second Monday of May, 1787, a convention of delegates, who shall have been appointed by the several states, be held at Philadelphia, for the sole and express purpose of revising the articles of confederation, and reporting to congress, and the several legislatures, such alterations and provisions therein, as shall, when agreed to in congress, and confirmed by the states, render the federal constitution adequate to the exigencies of government, and the preservation of the union." The states accordingly appointed delegates, who assembled in convention, at Philadelphia, at the time appointed. General Washington was nominated president, on the organization of that illustrious and patriotic body. After deliberating nearly four months with closed doors, the convention agreed upon a plan of government, which was reported to congress, "as the result of a spirit of amity, and of that mutual deference and concession, which the peculiarity of their political situation rendered indispensable;" and that, in their opinion, "it should be submitted to a convention of delegates chosen in each state, by the people thereof, under the recommendation of their legislature, for their assent and ratification." The plan of government, reported by the convention, was the present constitution of the United States; which was adopted by the people of the several states in conventions assembled. A glance at the political condition of the country, and an accurate estimation of the dispositions of its inhabitants, at the very solemn and interesting juncture when the convention met at Philadelphia, will sufficiently attest the fortitude of its members, in undertaking, at such a period, the formation of a government to be spontaneously adopted, and yet to be sufficiently energetic to enforce obedience to its authority. Great was their responsibility; and heavy was the load of anxiety which must have hung on their minds, lest their efforts should at last be lost in failure.

The particular services of colonel Hamilton, in the convention, are not accurately known to the public, as that body sat in conclave, and their journals have never been published. It has been remarked, however, by a very respectable member of the convention from a neighbouring state, "that, if the constitution should not succeed on trial, Mr Hamilton was less responsible for such a result than any other member; for he fully and frankly pointed out to the convention, what, he apprehended, were the infirmities to which it was liable: And that, if it answered the fond expectations of the public, the community would be more indebted to him than to any other member; for, after its essential outlines were agreed to, he laboured most indefatigably to heal those infirmities, and to guard against the evils to which they might expose it." It is believed that, in this declaration, his colleague did not do him more than justice.

After the publication of the constitution, colonel Hamilton, in concert with Mr Jay, of New-York, and Mr Madison, of Virginia, commenced the publication of the *Federalist;* a series of essays under the signature of ***Publius***, addressed to the people of New-York, in support of the constitution, and in favour of its adoption. These papers made their first appearance, in the public prints, early in November, 1787. The series was not concluded until a short time previous to the meeting of the state convention, in June 1788. It is well understood that Mr Jay took upon himself a slender share of the work; that Mr Madison composed not a few numbers; but that colonel Hamilton was not only principal author, and wrote at least three-fourths of the volumes, but superintended its publication. The Federalist is not to be classed among those ephemeral productions calculated only for party purposes, and, when those purposes are served, to sink into oblivion. It is a profound and learned disquisition on the principles of federal representative government; and combines an ardent attachment to public liberty, with an accurate discernment of the dangers resulting from an excessive jealousy of power. It will endure as long as the republican institutions of the United States; on which it is a luminous and eloquent commentary. The Federalist was translated and published in France, by Buisson, just as its inhabitants were setting out in the mad career of their revolution. By the sedate and learned politicians of that country, it was esteemed a most excellent work. The wild, furious, and unstable partizans, who conducted the people to the perpetration of the most shocking cruelties, deemed it aristocratical in its tendency. If the leaders of the French revolution had thoroughly studied the Federalist, and received light from this western star, they might possibly have rescued the people from the fury of their tempestuous passions; from a continued vibration between scenes of folly and scenes of horror; and conducted them in safety to peace, independence and liberty. In the United States the Federalist had great popularity; circulated through every part of the country; enlightened the understandings of the people on the nature of government; and warmly disposed them to a preference of the federal representative system. It was eminently successful in the end intended by its authors.

Colonel Hamilton was a member of the state convention of New-York, which assembled in the summer of 1788, to deliberate on the adoption of the Federal constitution. It had to encounter very serious opposition. For a time, the issue of the contest between its advocates and opponents was doubtful; but his argument and eloquence at length overcame hostility, carried conviction to the minds of its adversaries, and finally, and most happily for the union, procured its adoption by the populous and powerful state of New-York.

On the organization of the federal government, in 1789, the president, Washington, selected colonel Hamilton as the secretary of the treasury. The duties of that department, intrinsically difficult, and connected with high responsibilities, were confessedly, at the time, encumbered by much embarrassment and entanglement, produced by the operation of temporary but influential causes; and when recurrence is had to the measures that were originated, matured, and vindicated by him, the candid mind is overwhelmed with astonishment, in the contemplation of the various powers of his vigorous and exalted mind. His reports are so many didactic dissertations, laboriously wrought, and highly finished, on some of the most intricate and abstract subjects in political economy. Among his reports it is proper particularly to designate, as the most interesting, those of January, 1790, on a provision for the support of the public credit; of December, 1790, on the establishment of a national bank; of December, 1791, on the subject of manufactures; and of January, 1795, on a plan for the further support of public credit.

Colonel Hamilton was justly regarded by the intelligent and candid public men in his day, and is now almost universally reputed, the founder of the public credit of this country. He raised it from the dust, and placed it on sound foundations. If it have ever been shaken, the casualty did not arise from any defect in his system, but in the departure from it, by some of his more recent successors. So terribly was the country menaced, by the effects of the temporary abandonment of his financial axioms, in the course of the more recent war between the United States and Great Britain, that it may well be asserted they will never again be suspended. They have now become the fundamental principles of the treasury department. The main spring of public credit, according to the now established fiscal principles of the United States, is good faith ; and a punctual performance of contracts. That the national credit might be placed beyond the reach of doubt, suspicion, or distrust, those enemies to the equal and steady operation of all monied institutions, whether under the direction of individual associations or of government, he urged on congress the express renunciation, by law, of all right to tax the public stocks, or to sequester at any time, or on any pretence, the property of foreigners therein. He qualified the United States to know, develope, and realize their immense resources. Under his administration, the finances advanced to a point of prosperity beyond all expectations. Nor was the credit of the government confined to its own constituents. The stocks of the United States engaged the notice and commanded the attention of capitalists in every part of Europe. At the present moment, in England, six per cent. per annum is above par. It will be observed, in reading his reports on the means of supporting public credit, that he was unfriendly to the accumulation of public debt. He considered a heavy load of debt a disease of the most baneful character; and often fatal to free governments. He maintained that it ought to be guarded against with provident foresight, and inflexible perseverance. It was a fundamental maxim in his system of public credit, and which he uniformly exhibited in his practice, *that the creation of debt should always be accompanied with securities pledged for its extinguishment.* The observance of this wholesome and well-tried specific is the true recipe to render public credit immortal. In his last report in relation to the national debt, he recommended a provision to augment the sinking fund, so as to render it commensurate with the whole debt of the United States ; and proposed to secure that fund by a stipulation the most inviolable, no less than to make the application of the fund to the object a part of the contract with the creditor. By such means, and with such efforts, did he support the initiation of the new government, in its most tender and delicate department ; and build up and establish on solid principles the important interests of the nation confided to his care. He has left little else to be done by his successors, than to follow his precepts ; and earn to themselves fame, by imitating his administration.

His report on manufactures is perhaps the most elaborate performance he left on the files of his office. It is distinguished for extensive research, judicious application of the knowledge attained, and an accurate estimate of the policy of encouraging the manufacturing interest. It is an essential feature in the independence of the nation. This report adopts the principles of the mercantile system, in opposition to the celebrated Adam Smith and the French economists. They attacked the combined manufacturing and mercantile interests of Great Britain, as founded upon oppressive monopoly ; and contended for entire freedom of commerce and industry, undiverted and unimpeded by government, as the best means of advancing nations to prosperity and greatness. The secretary combated with the greatest ability some of the dogmas of these philosophers; and maintained his favourite system as much by the power of his logic, as by illustrative and pertinent reference to the experience of those nations, at once successful in commerce and great in the productions of art. It is now twenty-six years since his report on manufactures was made to congress. Just now his opinions on that great branch of natural economy are becoming popular in the United States. Societies are now forming in every part of the country, composed of gentlemen in all the various pursuits of life, expressly to procure and disseminate information tending to encourage the manufacturing interests of the nation. Memorials, of most interesting and impressive character for eloquence, correct principles, and patriotic devotion, have been published to the people; and committees appointed, to stimulate the federal government to a particular patronage of that branch of industry and political strength. These memorials and committees espouse the sentiments which were assumed by secretary Hamilton. In this particular, as on the subjects of the funded debt and national bank, the experience of the last quarter of a century has clearly proved, that he was, in his time, more correctly impressed as to the true interests and policy of the United States, and better understood their political and domestic economy, than any other statesman who has been at all prominent in their public affairs. All his official reports are remarkable for wide research, profound thought, close logic, and precision of expression. His labours in the treasury department, united with the integrity with which he conducted it, and which the most penetrating inquisition into all the avenues of his office could never bring into question, will form with posterity the fairest monument of his fame.

In his capacity of secretary of the treasury, he was also one of the executive counsellors ; and it is believed few, if any, matters of moment were transacted without the sanction of his opinions. The period of his confidential and official connection with the government was unusually critical. The French revolution raged with great violence ; and threatened to involve the whole civilized world in its inflammatory course. A war of great inveteracy existed between Great Britain and France. At this crisis, M. Genet was sent minister to the United States, charged with secret instructions, afterwards published, to excite the American people to make common cause with France. To meet this important epoch, in consonance with the advice of secretary Hamilton, a proclamation of neutrality was issued by the president. To defend that prudent measure against the prejudices and passions which the French minister was enabled to excite, the essays under the signature of *Pacificus* were published. These essays were written by the secretary in the summer of 1793; and of all his publications, none appeared at a more seasonable juncture, or produced a more salutary effect. Their end was to prove, that the president had competent authority to issue the proclamation of neutrality ; that it only went to declare the existing lawful relations of the American government ; and that, as the constitutional executor of the laws, it was his bounden duty to see them faithfully observed ; that the United States were under no obligations from existing treaties to become a party in the war between England and France ; that, considering the peculiar origin and nature of their contention, the United States had sufficient reasons against any interference ; that the obligations of gratitude imposed upon nations the mutual returns of good will and benevolence, but were no sufficient grounds for taking part in their wars; and that those obligations more naturally pointed to the hand from which antecedent favours had been received, and which, in the present case, was the amiable and unfortunate monarch, whom the revolution in France had recently swept from his throne. The proclamation afterwards received the sanction of congress, and of the community at large.

In January 1795, secretary Hamilton resigned the direction of the treasury department, and once more returned to private life. He still felt himself charged to vindicate another important measure of the government, of which he had been a strenuous advocate; but which had been distorted not a little by party-misrepresentation—Jay's treaty with Great Britain. This treaty had to encounter inveterate prejudices, which had their root in the animosities of the revolutionary war, and which had been rekindled, and armed with increased violence, by the effects of the French revolution on the minds of the American people. Even at this day, it is delicate to comment on some of the events produced by the spirit of party at that period. The ex-secretary devoted all his leisure from professional avocations, in the summer of 1795, to a defence of the treaty, in a series of essays, under the signature of *Camillus*. Error and prejudice were dissipated by their point and truth. The treaty was ratified; and the nation consequently derived great and immediate advantages from the provisions relating to the western posts, and the liquidation of unsettled claims; and subsequently enjoyed a long course of commercial prosperity.

The last great occasion which called secretary Hamilton upon the theatre of public action, arose in 1798. France for some years had been making depredations upon the commerce of the United States. A pacific adjustment by negociation had been repeatedly attempted on their part without success. Their minister had been refused audience. Three ministers extraordinary had been treated with unwarrantable contumely; and money was demanded of them on the most degrading terms, and in the most indignant manner. The door of reconciliation being thus closed, they had left no honourable alternative but open and determined resistance of injury and insult. France was a power the most terrible in strength; the most daring in project; the least scrupulous in the choice of means; the most fatal to its victims, of any that a righteous Providence had hitherto permitted to rise up for the chastisement of the human race. All the republican states of Europe within her wide-spreading grasp, the United Netherlands, Geneva, the Swiss Cantons, Genoa, and Venice, had already been prostrated by her arms, or her still more formidable caresses. She was at the moment rioting in schemes of universal domination; and was actually fitting out a vast armament, in the ports of the Mediterranean, for some expedition of conquest or plunder. At this portentous period, the ex-secretary published *The Stand*, a series of essays, under the signature of *Titus Manlius*, with the view to arouse his fellow-citizens to a sense of impending danger, and to prevail on the government without delay to adopt measures of defence, at once vigorous and manly.

The *Stand* glowingly pourtrays the conduct of revolutionary France towards her own people, and towards other nations; and shows that she had undermined the main pillars of civilized society; that she betrayed a plan to disorganize the human understanding itself, by destroying all religious sentiment, and perverting a whole nation to atheism; that her ruling passions were ambition and libertinism; and that she aimed equally to proselyte, subjugate, and debase every government without distinction, to effect the elevation and aggrandizement of the "Great Nation." It details the accumulated injuries and insults the United States had received from France; and demonstrated, that her object was to degrade and humble their government, excite the American people to revolution, and prepare the way to conquest for herself. In the conclusion, it recommends a suspension of the good understanding which had subsisted between the United States and France; fortification of their harbours; to defend their commerce on the ocean; attack her predatory cruisers on our coast; create a respectable navy; raise, organize, and discipline a provisional army; as indispensible precautions against attempts of invasion, which might distress the inhabitants of the Atlantic border, and seriously prejudice the domestic peace of the nation. Finally, it entreats the people and government of the United States, having taken the attitude recommended, to meet the aggressor in the spirit and fortitude of calm defiance. So undeniable were the facts; so irresistible the conclusions; and so palpable the policy recommended, that, in 1798, the measures suggested by the writer were all literally carried into execution by congress, and approved by a majority of the nation. An honourable, proud, and manly sentiment pervaded the people. The *Stand* reflected honour on the national character. That character was respected in Europe; and afforded additional security to the rights of the United States.

A provisional army was voted by congress; and the late secretary, upon the express solicitation of Washington, the commander in chief, with the rank of lieutenant-general, was appointed inspector-general. The following extract of a letter from general Washington, insisting upon the appointment of Hamilton second in command, and inspector-general, exhibits the sentiments entertained of his merits, by one of the best judges of men: "It is, at all times, an invidious task to draw comparisons; and I shall avoid it as much as possible: but I have no hesitation in declaring, that, if the public is to be deprived of the services of colonel Hamilton, in the military line, the post he was destined to fill will not be easily supplied; and, that this is the sentiment of the public, I may venture to pronounce.

"Although colonel Hamilton has never acted in the character of a general officer, yet his appointment, as the principal and most confidential aid of the commander in chief, afforded him the means of viewing every thing on a larger scale than those who had only divisions and brigades to attend to. By some, colonel Hamilton is considered an ambitious man, and therefore a dangerous one. That he is ambitious I shall readily grant: but his ambition is of that laudable kind which prompts a man to excel in whatever he takes in hand. He is enterprizing; quick in his perceptions; and his judgment intuitively great; qualities essential to a great military character: and therefore I repeat his loss will be irreparable." A loftier eulogium on the merits of general Hamilton could not be written. Its excellence consists in the opportunities the writer had enjoyed of knowing him intimately; for every one acquainted with general Washington will readily admit, that his opinions and candour were always entitled to the highest consideration.

Invested with the rank of inspector-general, Hamilton repaired to his post; and immediately entered upon the duties of his office. The organization and discipline of the army were the appropriate duties of his department. The condition and police of the army, in a short time, supported the expectations of the commander in chief. The arts of war became his constant study; and the knowledge he acquired by research, he happily disseminated among the subordinate officers, who in turn diffused it through the ranks by assiduous drilling.

On the death of the commander in chief, in 1799, general Hamilton succeeded to the command of the army. Hostilities between the United States and France having terminated, and the provisional army having been disbanded, he here turned to the bar, and never afterwards filled any public station; but devoted himself exclusively to the duties of his profession. Notwithstanding the great majority of his days had been spent in the public service, his abilities, industry, integrity, and eloquence, advanced him to the highest estimation as a lawyer and advocate. He was decidedly foremost in New-York; and it is believed he had no superior in the United States. He had the intuitive strength of Marshall, the learning of Parsons, and the eloquence of Henry. In the full possession of great influence over the public mind, and enjoying the entire confidence of every one, he had the prospect of running a long, brilliant, and lucrative professional career: but a sad catastrophe arrested him in the midst of his years; spoiled the hopes of his family; and deprived his country of one, whom she had always accounted second only to Washington.

Aaron Burr, late vice president of the United States, by his endeavours in the year 1801 to supplant Mr Jefferson as the president, lost the confidence of his political friends. So early as he ascertained, that he could no longer look to them for the indulgence of his ambition, he began to cast about for a plan to recover his influence in the country. One was presented to his view, which he eagerly pursued, with no little promise of success. He became a candidate for the office of chief magistrate of New York, at the election in April, 1804; and calculated on success, from a combination of his yet powerful personal friends with the federal party of the state. It was supposed that the coalition would ensure an ascendancy. The scheme was generally favoured by the federalists; and would probably have succeeded, but for the decided opposition of general Hamilton; whose influence enabled him to defeat the coalition, and prostrate the hopes of colonel Burr in the dust. The election having terminated in his disappointment, colonel Burr determined to be revenged on the author of his political overthrow. For this purpose, he addressed a note to general Hamilton, demanding a prompt and unqualified acknowledgment or denial of the use of certain expressions imputed to him, and deemed derogatory to the honour of colonel Burr. The demand was adjudged inadmissible; and a duel was the consequence. The parties met at Hoboken on Wednesday morning, 11th of July, 1804; and, at the first fire, general Hamilton fell, on the same spot where his son a few years before had fallen, in obedience to the same principle of honour, and in the same violation of the laws of God and of man. He was carried into the city; and, being desirous of receiving the sacrament of the Lord's supper, he immediately sent for the reverend Dr Mason. As the principles of his church prohibited him from administering the ordinance in private, this minister of the gospel informed general Hamilton, that the sacrament was an exhibition and pledge of the mercies which the Son of God has purchased, and that the absence of the sign did not exclude from the mercies signified, which were accessible to him by faith in their gracious author. He replied, "I am aware of that. It is only as a sign that I wanted it." In the conversation which ensued, he disavowed all intention of taking the life of colonel Burr; and declared his abhorrence of the whole transaction. When the sin, of which he had been guilty, was intimated to him, he assented with strong emotion; and when the infinite merit of the Redeemer, as the propitiation for sin, the sole ground of our acceptance with God, was suggested, he said with emphasis, "I *have* a tender reliance on the mercy of the Almighty, through the merits of the Lord Jesus Christ." The reverend bishop Moore was afterwards sent for, who, after making suitable inquiries of the penitence and faith of general Hamilton, and receiving his assurance, that he would never again, if restored to health, be engaged in a similar transaction, but would employ all his influence in society to discountenance the barbarous custom, administered to him the communion. After this his mind was composed. He expired about two o'clock on Thursday, July 12, 1804, aged about forty-seven years.

The dying act of general Hamilton affords much consolation and comfort to the humble christian believer. How clearly did it show, that the religion of Jesus is that alone which can impart courage and cheering hope to a departing soul! Hamilton had the intellect of a Solon, and the philosophy of a Plato; but these were not his stay in the hour of death. Hamilton had influence and honour among men; but they could not relieve one dying pang. The critical moment at length arrived. On what did he cast the safety of his soul? Hear himself! "*I have a tender reliance on the mercy of the Almighty, through the merits of the Lord Jesus Christ.*" Yes, the great Hamilton, who filled the world with his fame, when dying, bore his testimony to the insufficiency of every other hope, save that which accompanies the christian over the threshold of life.

The last solemn moment came. Hamilton laid down his great human labours, and all his honours, as worthless and unavailing. To the exclusion of every other concern, *religion* claimed all his thoughts. Jesus! Jesus, is now his only hope. The *friends* of Jesus are his *friends*—not armed with the weapons of blood and death—but armed with the word of life and of truth. The ministers of God, with the words of pardon and reconciliation on their lips, are his companions. While these intercede, he listens in awful silence, or in profound submission whispers his assent.

Sensible, deeply sensible of his sins, he pleaded no merit of his own. He repaired to the mercy-seat, and there poured out his penitential sorrows: there he solicited pardon.

Heaven, it should seem, heard and pitied the suppliant's cries. Disburdened of his sorrows, and looking up to God, he exclaimed, "Grace—rich grace!" "*I have*," said he, clasping his dying hands, and with a faltering tongue, "*I have a tender reliance on the mercy of God in Christ.*" In token of this reliance, and as an expression of his faith, he received the holy sacrament; and having done so, his mind became tranquil and serene. Thus he remained, thoughtful indeed, but unruffled to the last, and met death with an air of dignified composure, and with an eye directed to the heavens.

This last act, more than any other, shed glory on his character. Every thing else death effaced. Religion alone abode with him on his death-bed. He died a christian. This is all which can be enrolled of him among the archives of eternity. This is all that can make his name great in heaven.

Let not the sneering infidel persuade us, that this last act of homage to the Saviour resulted from an enfeebled state of mental faculties, or from perturbation occasioned by the near approach of death. No; his opinions concerning the divine mission of *Jesus Christ*, and the validity of the holy scriptures, had long been settled, and settled after laborious investigation and extensive and deep research. These opinions were not concealed; and had his life been spared, it was his determination to have published them to the world, together with the facts and reasons on which they were founded.

When scepticism, shallow and superficial indeed, but depraved and malignant, breathes forth its pestilential vapour, and pollutes, by its unhallowed touch, every thing divine and sacred; it is consoling to a devout mind to reflect, that the great, and the wise, and the good of all ages; those superior geniuses, whose splendid talents have elevated them almost above mortality, and placed them next in order to angelic natures—yes, it is consoling to a devout mind to reflect, that, while *dwarfish infidelity* lifts up its deformed head, and mocks, these *illustrious personages*, though living in different ages—inhabiting different countries—nurtured in different schools—destined to different pursuits—and differing on various subjects—should all, as if touched with an impulse from heaven, agree to vindicate the sacredness of Revelation, and present, with one accord, their learning, their talents, and their virtue, on the gospel altar, as an offering to Emanuel.

This is not exaggeration. Who was it, that, overleaping the narrow bounds which had hitherto been set to the human mind, ranged abroad through the immensity of space, discovered and illustrated those laws by which the *Deity* unites, binds, and governs all things? Who was it, soaring into the sublime of astronomic science, numbered the stars of heaven, measured their spheres, and called them by their names? It was Newton: but Newton was a christian. Newton, great as he was, received instruction from the lips, and laid his honours at the feet of *Jesus*.

Who was it, that developed the hidden combination, the component parts of bodies? Who was it that dissected the animal, examined the flower, penetrated the earth, and ranged the extent of organic nature? It was Boyle: but Boyle was a christian.

Who was it, that lifted the veil which had for ages covered the intellectual world, analyzed the human mind, defined its powers, and reduced its operations to certain and fixed laws? It was Locke: but Locke too was a christian.

To these may be added, *Hale*, learned in the law; *Addison*, admired in the schools; *Milton*, celebrated among the poets; and *Washington*, immortal in the field and the cabinet. To this catalogue of professing christians, may now be superadded the name of Alexander Hamilton—a name which raises in the mind the idea of whatever is splendid, whatever is illustrious in human nature; and which is now joined to a catalogue which might be lengthened—and lengthened—and lengthened, with the names of illustrious characters, whose lives have blessed society, and whose works form a column high as heaven—a column of learning, of wisdom, and of greatness, which will stand to future ages, an *eternal monument* of the transcendent talents of the advocates of christianity, when every fugitive leaf, from the pen of the canting infidel writings of the day, shall be swept by the tide of time from the annals of the world, and buried with the names of their authors in oblivion.

To such as have only a superficial knowledge of the character and services of the late general Hamilton, the extraordinary grief manifested by the public, on his death, would appear excessive. They may say, the United States have produced many great men. Some preceded him to the tomb; and others yet live. Why then should his departure be mourned, as if it were not a lot to be expected? Why did, and why do still, the American people mourn his fall, as if all were lost? Although general Hamilton had, for some years, withdrawn from public office to the bar, and had been, in some measure, out of the view and contemplation of his countrymen, there was nevertheless a splendour in his character, that could not be contracted within the ordinary sphere of his employments. With really great men it is as with great literary works: the excellence of both is tested by the extent and durableness of their impression. The public has not suddenly, but after an experience of five and twenty years, taken that impression of the just celebrity of general Hamilton, which nothing but his extraordinary intrinsic merit could have made, and still less could have made so deep, and maintained so long. It was not a party; for party distinctions were confounded by the event; it was the nation that wept for its bereavement. It wept as the Romans did over the ashes of Germanicus. Its sorrow was thoughtful, foreboding, took possession of the heart, and sunk with no counterfeited heaviness.

It is here proper, and not invidious, to remark, that as emulation, excited by conducting great affairs, commonly trains and exhibits great talents, it is seldom the case, that the fairest and soundest judgment of a great man's merit, is to be gained, exclusively, from his associates in council or action. Persons of conspicuous merit themselves are, not unfrequently, bad judges, and still worse witnesses on this point. Often rivals, sometimes enemies, almost always unjust, and still oftener envious or cold, the opinions they give to the public, as well as those they privately form for themselves, are, of course, discoloured with the hue of their prejudices and resentments: but the body of the people, who cannot feel a spirit of rivalship towards those whom they see elevated by nature and education so far above their heads, are more equitable, and, supposing a competent time and opportunity for information on the subject, more intelligent judges. Even party rancour, eager to maim the living, scorns to strip the slain. The most hostile passions are soothed or baffled by the fall of their antagonist. Then, if not sooner, the very multitude will decide on character, according to their experience of its impression; and as long as virtue, not unfrequently for a time obscured, is ever respectable when distinctly seen, they cannot withhold, and they will not stint their admiration. If then the popular estimation may be taken for the true one, the uncommonly profound public sorrow for the death of Alexander Hamilton, sufficiently explains and vindicates itself. He had not made himself dear to the passions of the multitude, by condescending, in defiance of his honour and conscience, to become their instrument. He was not lamented, because a skilful flatterer lay mute for ever. It was by the practice of no art, by wearing no disguise; it was not by accident, nor by the levity nor profligacy of party; but, in despite of its malignant misrepresentation, it was by bold and inflexible adherence to truth, by loving his country better than himself, preferring its interest to its favour, and serving it, when it was unwilling and unthankful, in a manner that no other person could, that he rose; and the *true* popularity, the homage that is paid to virtue, followed him. It was not in the power of party or envy to pull him down: but he rose, as if some force of attraction drew him to the skies. He rose, and the very prejudice that could not reach, was at length almost ready to adore him.

It was indeed no imagined wound that inflicted so keen an anguish. For some time after his death, the novel and strange events of Europe succeeded each other unregarded. The nation was enchained to its subject, and brooded over its grief, which was more deep than eloquent; which, though dumb, made itself felt without utterance; and which did not merely pass, but, like an electrical shock, at the same instant smote and astonished, as it passed from Georgia to New Hampshire. There is a kind of force put upon our thoughts by this disaster, that detains and rivets them to a closer contemplation of those resplendent virtues which are now lost except to memory; and there will dwell forever. That writer would deserve the fame of a public benefactor, who could exhibit the character of general Hamilton with the truth and force that all, who intimately knew him, conceived it. His example would then take the same ascendant as his talents. The portrait alone, however exquisitely finished, could not inspire genius where it is not; but if the world should again have possession of so rare a gift, it might awaken it where it sleeps, as by a spark from heaven's own altar: for, surely, if there be any thing like divinity in man, it is in his admiration of virtue: but who alive can exhibit this portrait? If our age, on that supposition more fruitful than any other, had produced two Hamiltons, one of them might then have depicted the other. To delineate genius one must feel its power. Hamilton, and he alone, with all inspiration, could have transferred his whole fervid soul into the picture, and swelled its lineaments into life. The writer's mind, expanding with his own enthusiasm, and glowing with kindred fires, would then have stretched to the dimensions of his subject.

Such is the infirmity of human nature, it is very difficult for a man, who is greatly the superior of his associates, to preserve their friendship without abatement. Yet, though general Hamilton could not possibly conceal his superiority, he was so little inclined to display it, he was so much at case in its possession, that no jealousy or envy chilled his bosom when his friends obtained praise. He was, indeed, so entirely the friend of his friends; so magnanimous; so superior, or, more properly, so insensible to all exclusive selfishness of spirit; so frank; so ardent, yet so little overbearing; so much trusted, admired; beloved, almost adored; that his power over their affections was entire, and lasted through his life. It is not believed, that he left any worthy man his foe, who had ever been his friend. Men of the most elevated minds have not always the readiest discernment of character. Perhaps he was sometimes too sudden and too lavish in bestowing his confidence. His manly spirit, disdaining artifice, suspected none; but while the power of his friends over him seemed to have no limits, and really had none, in respect to those things which were of a nature to be yielded, no man, not the Roman Cato himself, was more inflexible on every point that touched, or only seemed to touch, integrity and honour. With him, it was not enough to be unsuspected. His bosom would have glowed like a furnace at its own whispers of reproach. Mere purity would have seemed to him below praise; and such were his habits, and such his nature, that the pecuniary temptations, which many others can only with great exertion and self-denial resist, had no attractions for him. He was very far from obstinate. Yet, as his friends assailed his opinions with less profound thought than he had devoted to them, they were seldom shaken by discussion. He defended them, however, with as much mildness as force; and evinced that, if he did not yield, it was not for want of gentleness or modesty. His social affections, and his private virtues, are not, however, so properly the object of public attention, as the conspicuous and commanding qualities that gave him fame and influence in the world. It is not as Apollo, enchanting the shepherds with his lyre; it is as Hercules, treacherously slain, in the midst of his unfinished labours, leaving the world overrun with monsters, that he is most deeply deplored.

In all the different stations in which a life of active usefulness placed him, he was not more remarkably distinguished by the extent, than by the variety and versatility of his talents. In every place, he made it apparent, that no other man could have filled it so well; and, in times of critical importance, in which alone he desired employment, his services were justly deemed indispensable. As secretary of the treasury, his was the powerful spirit that presided over the chaos—

> Confusion heard his voice, and wild uproar
> Stood ruled—

Indeed in organizing the federal government in 1789, every man of either sense or candour will allow, the difficulty seemed greater than the first rate abilities could surmount. The event has shown that his abilities were greater than those difficulties. He surmounted them, and Washington's administration was the most wise and beneficent, the most prosperous, and ought to be the most popular, that ever was entrusted with the affairs of a nation. Great as was Washington's merit, much of it in plan, much in execution, was due to the talents, and ought to enhance the memory of his minister. As a lawyer, his comprehensive genius reached the principles of his profession. He compassed its extent; and fathomed its profound, perhaps even more familiarly and easily, than the ordinary rules of its practice. With most men, law is a trade. With him it was a science. As a statesman, he was not more distinguished by the great extent of his views, than by the caution with which he provided against impediments, and the watchfulness of his care, over right, and the liberty of the subject. In none of the many revenue bills which he framed, though committees reported them, is there to be found a single clause that savours of despotic power; not one that the sagest champions of law and liberty would, on that ground, hesitate to approve and adopt.

It is rare that a man who owes so much to nature descends to seek more from industry: but he seemed to depend on industry, as if nature had done nothing for him. His habits of investigation were very remarkable: his mind seemed to cling to his subject, till he had exhausted it. Hence the uncommon superiority of his reasoning powers; a superiority that seemed to be augmented from every source; and to be fortified by every auxiliary; learning, taste, wit, imagination, and eloquence. These were embellished and enforced by his temper and manners; by his fame and his virtues. It is difficult, in the midst of such various excellence, to say in what particular the effect of his greatness was most manifest. No man more promptly discerned truth. No man more clearly displayed it. It was not merely made visible. It seemed to come bright with illumination from his lips. But prompt and clear as he was; fervid as Demosthenes; like Cicero, full of resource; he was not less remarkable for the copiousness and completeness of his argument, that left little for cavil, and nothing for doubt. Some men take their strongest argument as a weapon, and use no other: but he left nothing to be inquired for more; nothing to be answered. He not only disarmed his adversaries of their pretexts and objections; but he stripped them of all excuse for having urged them. He confounded and subdued, as well as convinced. He indemnified them, however, by making his discussion a complete map of his subject; so that his opponents might indeed feel ashamed of their mistakes: but they could not repeat them. In fact, it was no common effort, that could preserve a really able antagonist from becoming his convert. For, the truth, which his researches so distinctly presented to the understanding of others, was rendered almost irresistibly commanding and impressive, by the love and reverence which, it was ever apparent, he profoundly cherished for it in his own. While patriotism glowed in his heart, wisdom blended, in his speech, her authority with her charms. Such also is the character of his writings. Judiciously collected, they will be a public treasure.

No man ever more disdained duplicity, or carried *frankness* further than he. This gave to his political opponents some temporary advantages; and currency to some popular prejudices, which he would have *lived* down, if his death had not prematurely dispelled them. He knew that factions have ever in the end prevailed in free states; and as he saw no security, and who living can see any adequate? against the destruction of that liberty which he loved, and for which he was ever ready to devote his life, he spoke at all times according to his anxious forebodings, and his enemies interpreted all that he had said, according to the supposed interest of their party. But he ever extorted confidence, even when he most provoked opposition. It was impossible to deny that he was a patriot. Virtue so rare, so pure, so bold, by its very purity and excellence, inspired suspicion, as a prodigy. His enemies judged of him by themselves. So splendid and arduous were his services, they could not find it in *their* hearts to believe that they were disinterested. Unparalleled as they were, they were nevertheless no otherwise requited than by the applause of all good men, and by his own enjoyment of the spectacle of that national prosperity and consideration, which was the effect of them. After facing calumny, and triumphantly surmounting an unrelenting persecution, he retired from office with clean, though empty hands, and as rich as reputation and an unblemished integrity could make him. Some have plausibly, though erroneously inferred, from the great extent of his abilities, that his ambition was inordinate. This is a mistake. Such men as have a painful consciousness that their stations happen to be far more exalted than their talents are generally the most ambitious. General Hamilton, on the contrary, though he had many competitors, had no rivals; for he did not thirst for power; nor would he, as it was well known, descend to office. Of course he suffered no pain from envy when bad men rose; though he felt anxiety for the public. He was perfectly content and at ease in private life. Of what was he ambitious? Not of wealth. No man held it cheaper. Was it of popularity? That weed of the dunghill, he knew, when rankest, was nearest to withering. There is no doubt, that, being conscious of his powers, he desired glory, which to most men is too inaccessible to be an object of desire. But feeling his own force, and that he was tall enough to reach the top of Pindus or of Helicon, he longed to deck his brow with the wreath of immortality. A vulgar ambition could as little comprehend as satisfy his views. He thirsted only for that fame that virtue would not blush to confer; nor time to convey to the end of his course. The only ordinary distinction to which we confess he did aspire was military; and for that, in the event of a foreign war, he would have been solicitous. He undoubtedly discovered the predominance of a soldier's feelings; and all that is honour, in the character of a soldier, was at home in his heart. His early education was in the camp. There he became enamoured of glory, and was admitted to its embrace. Those who knew him best, and especially in the army, will believe, that if occasion had called him forth, he was qualified, beyond any man of the age, to display the talents of a great general.

The most substantial glory of a country is in its virtuous great men. Its prosperity will depend on its docility to learn from their example. That nation is fated to ignominy and servitude, for which such men have lived in vain. Power may be seized by a nation that is yet barbarous, and wealth may be enjoyed by one that it finds or renders sordid. The one is the gift and the sport of accident, and the other is the sport of power. Both are mutable, and have passed away, without leaving behind them any other memorial, than ruins that offend taste, and traditions that baffle conjecture. But the glory of Greece is imperishable, or will last as long as learning itself, which is its monument. It strikes an everlasting root, and bears perennial blossoms on its grave. The name of Hamilton would not have dishonoured Greece in the age of Aristides. See *Mason's Oration; Nott's Sermon; Morris's Funeral Oration; Otis's Eulogy; Ames's Sketch; Coleman's Collections, Ramsey's Hist. U. S. &c.*—(E. H. Cummins, A. M.)

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HAMILTON, the chief town of the middle ward of Lanarkshire, is about 12 miles to the south-east of Glasgow, and situated in the parish of the same name. In ancient times, the district in the neighbourhood of Hamilton appears to have borne the designation of *Cadzow*, while the town seems to have been called "the Orchard," probably from the fruit-grounds with which the houses were surrounded. There is little doubt that the town derives its present appellation from the noble family of Hamilton, who appear to have settled in Clydesdale soon after the year 1215.

The first residence of the family was Cadzow Castle, situated on the precipitous banks of the Avon, about a mile from the town. In the statistical account of Hamilton, it is mentioned, that this building was deserted after the injuries it sustained from the army of the regent Murray, but a considerable portion of it is still to be seen, denoting the massy strength of the original structure. The palace of Hamilton, now occupied, (A. D. 1816,) by the most noble the Marquis of Douglas, as representative of his father the Duke of Hamilton, is situated in the higher part of the beautiful and fertile valley through which the Clyde pursues its course, and lies to the west of the confluence of that noble river with the Avon. It was built about the end of the 17th century, and forms three sides of a quadrangle. The apartments are large and lofty, and have lately been very splendidly fitted up. The gallery of paintings is perhaps the finest in Scotland, many additions having been made to it by the present Marquis of Douglas. The portrait of the Earl of Denbeigh by Vandyke, and "Daniel in the Den of Lions," by Rubens, have been noticed by every traveller. To these may be added, a St Sebastian by Guido Reni, a St Francis, and infant St John, by Correggio, and in particular an "Ecce Homo," by the same master. Two landscapes of rocks, and a head of Diogenes by Salvator Rosa, a dying Madona by Ludovico Caracci, and an admirable painting of the Virgin embracing the head of Christ, by Mabeuge. In the great gallery there is likewise a bust of Cleopatra, in which the depth and aggravation of grief are most wonderfully expressed; and in one of the lower apartments there is a statue of "the Venus de Medici." Among the valuable curiosities, we have observed a large table of the most beautiful *malachite*, unequalled, as far as we have been able to learn, in any part of the British empire.

Nearly opposite to Cadzow upon the Avon, and in full view of the palace, stands the castle of Chatelherault, built by the Duke of Hamilton in the year 1730, and meant to represent the castle of the same name in France, of which his ancestors were dukes. It was executed from a design of the elder Adams. In the surrounding park are some of the largest oaks in Scotland, the remains of those extensive forests with which the country was formerly covered. Among these trees grazed the ancient Caledonian cows, mentioned by Hector Boece, as a peculiar breed, and distinguished by their manes resembling those of lions, by their snowy whiteness, and their untameable ferocity. It is believed that the original race are now extinct; for the present breed are not remarkably different in their appearance from the common cow, excepting only that they are all over white, or rather cream-coloured, and have black or brown ears and muzzles. They may be approached without fear or difficulty.

By the exertions of the Marquis of Douglas, the palace is now wholly separated from the town. The latter consists of a main street, running in a south-eastern direction, and forming part of the road from Glasgow to Lanark. There are many cross streets, and individual houses with gardens attached to them. The prison and town-hall are in the centre of the town, and on the former there is a tolerable spire. The parish church was built in 1732, from a design of Adams. It stands upon a rising ground in the upper part of the town, and is a very handsome structure, uniting stability with lightness. Though by no means well seated, it is understood to accommodate about 1300 people. The charge is collegiate, but the stipends of the ministers have lately been equalized. Besides the parish church, there is one belonging to the Relief Seceders, another to the Burghers, and a third to the Antiburghers. The schools are numerous. There is a large hall for a grammar school. It was in this school that the celebrated Dr William Cullen, the father of physic in Scotland, received a part of his education; and the traditionary report of the townsmen bears, that he appeared at one of the annual examinations in girl's clothes, acting the part of a shepherdess, in a Latin pastoral. Nor ought we to omit, that Dr Baillie of London, and the late Mr John Millar, professor of law in the university of Glasgow, are indebted for a portion of their fame, to the instructions they received in the schools of Hamilton.

The town is what is called a burgh of regality; but the appointment of the magistrates rests entirely with the family of Hamilton. It is governed by a first and second magistrate, with the assistance of a town-council, treasurer, and clerk. The population of the town was, in 1753, 3815; in 1792, 5017; and it is now above 7000 souls. Some years ago a subscription library was established in Hamilton, owing principally to the zealous exertions of Dr John Hume. The library is under the direction of a committee of management, who are chosen annually; and the collection of books is multifarious and valuable. (*h*)

HAMMERSMITH. See Middlesex.

HAMPDEN. See Britain.

HAMPSHIRE, Hants, or the *County of Southampton*, is a maritime county, situated on the southern coast of England. It is bounded on the north by Berkshire; on the east by Sussex and Surrey; on the south by the English Channel, and the sound, which separates it from that part of the county called the Isle of Wight; and on the west by Dorsetshire. Its limits on the south side are the numerous creeks and inlets formed by the sea; on the west and east they are mostly artificial; on the north they are chiefly composed by the rivers Enborsa and Blackwater. The figure of Hampshire is nearly that of a square, with a triangular projection at the south-west angle, resembling the bastion of a fortification. Besides the Isle of Wight, the islands of Jersey and Guernsey are included as parts of the county: its length, exclusive of the projection of the south-west and the Isle of Wight, is about 42 miles, and its breadth about 38.

Hampshire is divided into 52 hundreds and liberties; these are subdivided into 356 parishes, precincts, hamlets, and tythings, the parishes alone being 253. In it there is one city, Winchester, which is also the county town, though Southampton is sometimes regarded in that light. Besides Winchester and Southampton, there are 18 other market towns, of which the principal are Portsmouth, Andover, Lymington, Christchurch, Basingstoke, Alton, Fareham, and Romsey. Winchester, Southampton, Portsmouth, Andover, Lymington, Christchurch, Stockbridge, Whitchurch, and Petersfield, send each two members to parliament, so that the county sends in all twenty members to parliament, exclusive of those sent by the Isle of Wight: it pays 14 parts of the land-tax. Hampshire lies in the province of Canterbury, and diocese of Winchester, and, with the county of the town of Southampton, is included in the western circuit.

This county is justly regarded as one of the most agreeable in England, being equally distinguished for the goodness of its soil, the healthiness and mildness of its climate, and the beauty of its prospects. The surface is finely varied with hills of gentle elevation and fruitful vallies, adorned with numerous gentlemen's seats and villages, and interspersed with numerous woodlands. Its southern parts were the first peopled, and there the population is still the greatest; the mildness of the seasons, and the convenience of the ports, operating as strong inducements to continued residence. The ridge of chalk hills may be traced across the county, passing in the parallel of Winchester. The climate in the higher parts is bracing and healthy, from the clearness and pureness of the air; towards the sea, it is mild, and rather moist.

The soil of Hampshire is extremely various, though, for the most part, of a calcareous nature. On the borders of Berkshire, it is deep, of a good quality, and very productive of corn and timber, particularly oak and elm. On the acclivities of the hills towards Basingstoke, it is also very deep and strong, with a calcareous subsoil. Round Whitchurch it is less deep and chalky. From Overton towards Stockbridge, and thence to Redbridge, there is a beautiful vale, which is divided into well-watered meadows. Round Andover the land is high, and approaches to the nature of downs. Towards Romsey it is more fertile. The country here is very beautiful, being interspersed with woods, and fine hedge-row timber. The centre of the county, in general, may be described as consisting of land higher and more chalky than the rest of the county, but by no means of an unfertile soil. On the borders of Dorsetshire, are vast tracts of waste land covered with heath. The vicinity of Redbridge is distinguished for its valuable salt marshes. Down land is met with between Petersfield and Portsmouth. On the banks of the Itchin, are some valuable water meadows. Perhaps the richest and most valuable soil in this county is near Alton.

The principal rivers in Hampshire, are the Itchin, the Avon, the Boldre Water, the Exe, the Anton, and the Tesse, or Test. Several smaller streams rise in the north-west parts of the county, but these soon quit it in their course to the Thames. The Itchin rises near Alresford, near the centre of the county; and after passing Winchester, it unites its streams with the water of Southampton, about half a mile to the east of that town. The Avon enters the county from Wiltshire, near Fordingbridge, and coasts the edge of the New Forest. This part of its course is thus not only well wooded, but enlivened by the numerous villas that ornament its banks. After passing Ringwood, it flows through a less interesting sandy level towards Christchurch. Below this town, it receives the waters of the Stour from Dorsetshire, and with them falls into Christchurch bay. The Boldre Water is formed by various springs rising in the New Forest, which uniting, pass Boldre and Lymington to the sea. The Exe also rises in the same district, and opens in a broad estuary to the sea, below Exbury. The Anton rises in the north-west angle of the county, and flowing through Andover, runs into the Tesse about a mile below Whirwell. The Tesse has its origin below Whitchurch; and after its junction with the Anton assumes a southerly course, and passing Stockbridge and Romsay, receives several small streams from the New Forest, near Redbridge. Below this place it expands considerably, and forms the head of Southampton Water. This, properly speaking, is an arm of the sea, extending from above Southampton to Caldshot Castle, and rendered very picturesque by its woody and irregular banks. Its whole extent is nearly 10 miles. Near Southampton, it is about four miles broad. It is navigable almost to the head for vessels of considerable burden; and the two principal rivers which flow into it, admit small craft some way up into the county. On tracing the sea coast from the east, we come to Portsea island, a low tract of considerable extent, separated from the main by a shallow creek, over which a bridge is built. On this island Portsmouth is situated. Off the point of land terminating this peninsula, is the noted road of Spithead, where the men of war anchor when prepared for actual service. From this, on the east side, commences Trissanton Bay, or Southampton Water.

There are very few mineral substances found in this county. On the southern shores, iron-stone was formerly gathered in some quantity, which seems to have been rolled up by the surf. Between Milton and Christchurch a hard reddish stone is found, apparently calcareous, tinged with the oxide of iron. Several ancient structures in the county are built with it. Chalk of various qualities and colours is worked in different parts. Potter's clay is met with in great abundance in Poolheath, at various depths, from 10 to 20 feet. From the circumstance of this heath bearing all the external marks by which the heath of Purbeck is distinguished, and their being divided only by Pool Water, it is not improbable that the Hampshire clay will be found equally valuable and useful as the Purbeck.

Hampshire is distinguished as an agricultural county for its fine corn, especially wheat; its hops, cattle, sheep, wool, bacon, honey, timber, and the extent and excellent management of its water meadows. The largest estates and farms are in the chalky parts of the county. The largest estate, however, does not exceed 8000*l.* per annum. Tenures are various. Those estates, which formerly composed the demesne lands of the see of Winchester, are granted by the bishop as freeholds for three lives, and generally renewed to the families, who hold them for many generations. These estates consist chiefly of ancient manors and houses, to which certain feudal rights still appertain. Copyhold tenures are granted from manors vested in the church, or by the lay proprietors. There are also lands held on lives by lease, or indenture. Other leases are for 21 and 14 years; but here, as in other parts of England, the practice is extending of letting lands only at will. The average size of farms in the county is small, probably not exceeding 200 acres; and certainly, if the chalk districts are excluded, not reaching that extent. The ploughs are various; but principally with one or two wheels, and by no means constructed on good mechanical priciples. There are a few thrashing machines in the county. The chief part of Hampshire is inclosed, though large tracts of open heath and uncultivated land remain in the vicinity of Christchurch, and on the borders of Dorsetshire. The aggregate extent of the waste lands, exclusive of the forests, is supposed to amount to nearly 100,000 acres.

In Hampshire a considerable quantity of land is annually sown with wheat, which is cultivated with great skill; its quality is excellent. Barley is grown principally on the lighter soils and higher ground. The soil round Andover is very favourable to the growth of this grain. It is generally sown either after turnips, or a winter fallow. In the cultivation of oats, the Hampshire farmers do not display much agricultural skill, since, for the most part, they are sown after one or two white crops. B ans are not much cultivated, even upon soils well adapted to them. The white pea is grown to a considerable extent in various parts of the county; the cultivation is well understood; and the produce abundant and valuable. Turnips are extending; but their culture is not yet nearly so general as it might, or ought to be; nor is it well understood. Potatoes are grown in almost every part, on a good plan, and with abundant produce. The utility and value of the calcareous soils in Hampshire are very much increased by the growth of sainfoin on them. This plant seems to have been long known here, and its culture is well understood. The parishes to the east of Alton, on the borders of Surrey, are chiefly appropriated to the growth of hops, the plantations of which have been greatly increased lately, chiefly in consequence of the high character of the hops grown at Farnham, in the immediate vicinity of Alton; the Hampshire hops, in a great degree, partaking of this character. The hop grounds are supposed to occupy 800 acres. The water meadows, as has already been noticed, are numerous, extensive, and extremely well managed. They are made at first at the expence of 5*l.* or 6*l.* per acre; and the expence of continual repairs is very considerable. But they pay the farmer well. They are usually shut up in November, or the beginning of December; and are watered every alternate week, till the beginning of March, when they are pastured for about five or six weeks with ewes and lambs. An acre is considered equal to the feeding of 400 couples for one day. They are shut up about the beginning of May, and produce at the regular season an abundant crop of hay. Perhaps the largest and finest tract of water meadows in the county lies on the banks of the Itchin, extending from the north side of Winchester, through Twyford and Otterburne, towards Bishops Stoke.

Gardening is carried to a considerable extent in the neighbourhood of all the large towns: Portsea island is supposed to produce the finest broccoli in the kingdom. Orchards are not common or productive in the woodland or chalky districts; but on the marly and clay soils, in the south and south-western parts of the county, they are more common; even here, however, little or no cyder is made for sale, the farmer contenting himself with making two or three hogsheads annually for the use of his family. A considerable portion of Hampshire is occupied by the forest of Alice Holt and Walmer, the forest of Bare, and the New Forest: the first is divided into two portions by intervening private property, one part containing 15,493 acres, and the other 2.744 This forest is situated on the borders of Surrey and Sussex. The forest of Bare extends northward from the Portsdown hills, including about 16,000 acres. The ancient boundaries of the New Forest included the whole of that part of Hampshire which lies between Southampton water on the east, the British Channel on the south, and the river Avon on the West. By a perambulation on the 22d of Charles II. it was ascertained that it extended from Godshill on the north-west to the sea, on the south-east about 20 miles, and from Hardley on the east to Ringwood on the west about 15 miles, containing within those limits 92.365 acres: of these 24.797 belong to individuals; 901 acres are encroachments; 1192 are inclosed land in the possession of the master, keepers, &c.; and the remainder, being about 63,845 acres, constitute the woods and waste lands of the forest. Its officers are, a lord warden, a lieutenant, riding forester, bow bearer, two rangers, woodward, under woodward, four verderers, high steward, under steward, 12 regarders, 9 foresters, or master keepers, and usually under foresters. The quantity of timber supplied by this forest for naval purposes from 1761 to 1786 was 23,000 loads of oak, and 7003 loads of beech; and the number of deer killed annually is about 76 brace of bucks, and 17 brace of does. The timber was so very much neglected, that, in the year 1800, an act of parliament was passed for its increase and preservation. The scenery of the New Forest affords as great a variety of beautiful and picturesque landscape, as can be met with in any part of England, of the same extent. The oaks seldom rise into lofty stems, but their branches are adapted for knee timber, and are commonly twisted into the most picturesque forms. The Cadenham oak is regarded as one of the curiosities of the forest, the buds appearing every year in the depth of winter. The advantages which this forest derives from its situation, in respect to conveniency of water carriage, are superior to those of any other forest in England; in its vicinity are many places for shipping timber, amongst which are Lymington, Beaulieu, and Redbridge, with the additional advantage of the remotest of those places being little more than 30 miles from the dock-yard of Portsmouth. Hampshire is remarkable for the great quantity and excellent quality of its oak bark, supplied chiefly by the timber in the New Forest.

Hampshire does not possess any peculiar or specific breed of cattle; the Sussex, Suffolk, Hereford, Glamorgan, and North and South Devon, are chiefly employed for draught, and the Norman for the dairy. Cows kept for the latter purpose are rented out to dairymen at from 7*l.* to 9*l.* per cow, per annum. In the woodland district of the county, the heath sheep are sometimes met with; but the most common in other parts are the Old Hampshire, something resembling the Dorsetshire in their size, shape, and qualities, and the New Leicester. The Wiltshire and Dorsetshire are also kept for the purpose of house lamb. On the Downs, the South Down sheep are spreading fast. Hampshire has long been justly celebrated for the excellency of its bacon. The native hog of the county is a coarse, ill-fattening animal, from which neither much nor good bacon would be expected; but the mart, and other food which the forests produce, and the excellent mode of curing in practice, have contributed, in a far greater degree, to establish the superiority of Hampshire bacon, than any inherent excellence in its native breed of hogs. These, however, have been greatly improved in form and quality, by crosses with the Berkshire, Suffolk, and Chinese breed.

In this county, there are three distinct series of canals, two of which terminate in the water of Southampton. The north-western part of the county has also been much benefited by the Kennet navigation, leading from Newberry to Reading. The Basingstoke canal commences at that town, and falls into the river Wey near the village of Westley; it is something more than 37 miles in length, with a fall of 195 feet. The Andover and Redbridge canal begins near the former place, and falls into the Southampton water near the latter. Its length is 22½ miles; its fall, 176 feet 9 inches. A collateral branch is navigable to within 2 miles of Salisbury. The Winchester and Southampton canal is one of the most ancient in the kingdom. The act for making it was obtained in the reign of Charles I. There are several fish-ponds in Hampshire, particularly on the wet soils on the borders of Surry. These ponds are usually stocked with carp and tench; and, in favourable circumstances, five acres of water will support 1250 brace of these fish, until the stock are fit for market, and have obtained an average size of 2 lb. per brace, and consequently weigh 2500 lb.; which, at 9d. per lb. the price at which they are usually sold to the London fishmongers, will amount to 93l. 15s. the value of five acres of land so employed for three years.

The manufactures of Hampshire are not very considerable or numerous. At Alton, there are manufactures of serges, and a variety of worsted articles, bombazines, &c. Worsted yarn is spun in this town and neighbourhood. Nearly the same kind of manufactures exist at Alresford. Basingstoke is distinguished for its manufactures of malt and leather. At Overton there is a silk mill of considerable magnitude; and in this part of the county the young female peasantry are much employed in making straw hats. The paper mills near Overton are famous for being employed in making paper for the notes of the Bank of England. There are also paper mills in other parts of Hampshire. Andover is remarkable for the large quantities, as well as for the excellent quality, of the malt made in it and the vicinity. Its former manufacture of shalloons is on the decay. A considerable quantity of yarn and worsted is spun in this part for the manufactures at Salisbury. Stockbridge is noted for wheelwrights and carpenters. In Winchester, many people are employed in the manufacture of light silk goods, and in preparing and winding the silk. The manufactured goods are principally used for umbrellas. Romsey is famous for its beer; the manufacture of shalloons is greatly decayed; considerable quantities of sacking are made. At Fordingbridge, there is an extensive and flourishing manufacture of striped bed ticking; nearly two-thirds of the inhabitants being employed in spinning, bleaching, weaving, &c. for this manufacture. Knit silk stockings, and a watch chain manufactory, particularly distinguish Christchurch. At Lymington there are very extensive and valuable manufactures of culinary and medicinal salts from sea-water. Southampton was formerly famous for its trade in French and port wines; but this is in a great measure gone to decay. At Farnham, there are manufactures of bricks, tiles, chimney pots, and sacking and cordage. There is one fair in Hampshire which deserves particular notice. This is held at Wey-hill, in the hundred of Andover. It commences the day before Michaelmas-day, and is one of the largest in the kingdom for hops, sheep, and cheese. Upwards of 140,000 sheep have been sold in one day. The Farnham hops are almost entirely sold here. The fair generally lasts 6 or 7 days.

The Isle of Wight must be particularly noticed. It is separated from the main land of the county by a channel varying from 2 to 7 miles in breadth. Its form is that of an irregular lozenge. It is nearly divided into two equal parts by the river of Corves. Through the middle of it, in the longest direction, extends a range of downs. The eastern and western parts of the island are almost cut off from the body by arms of the sea. Its length from east to west is about 22 miles; its breadth 13 miles; its circumference about 70. It contains 105,000 acres, of which 75,000 are in a course of tillage, 20,000 in pasturage, and the remainder downs and waste. It is divided into two hundreds, one market town, Newport, and 3 boroughs, returning each two members, Newton, Newport, and Yarmouth. The other towns of consequence are Corves and Ryde. It contains 30 parishes. The face of the country is very diversified. The land round the coast being in some places very high, particularly on the south or back of the island, where there are steep cliffs of chalk and freestone, hollowed out into caverns. On the north side the ground slopes to the water in easy declivities. The western side is fenced with ridges of rocks, of which the most remarkable are those called, from their sharp extremities, the Needles. The height of the cliffs in the north-west is, in some places, 600 feet above the level of the sea. They are frequented by immense numbers of marine birds. Between the island and the main-land are various sand banks, especially off the eastern part, where is the safe road of St Helens.

The land to the north of the ridge already mentioned, is chiefly pasture. To the south of it is a rich arable country, producing great crops of corn. It is said that the grain annually grown here is sometimes greater than the consumption of the island. The farms are small. The crops usually obtained are wheat, barley, oats, beans, turnips, clover, &c.; the prevalent soil, a strong loam on a dry subsoil, being well calculated for all these crops. The butter made here is excellent: the cheese, the worst in England except the Suffolk. The cattle are the Devonshire and Alderney; the sheep mostly Southdown and Dorset. On the downs a great number of fine-fleeced sheep are fed, about 40,000 being annually shorn, and about 5000 lambs sold. Rabbits are very plentiful. The climate is almost proverbially mild; and as the scenery is scarcely equalled in any part of Europe, this isle is a favourite residence. There are not many woods. The most extensive are those of Swainston, Wooten, and Quarr. The chief rivers are, the Medina, the Yar, and the Wooten. The Medina, passing Newport, falls into the sea at Corves: the Yar falls into the channel at Yarmouth: the Wooten falls into Braden's harbour. There are also various creeks and bays. Great variety of fish is found on the coast, particularly lobsters and crabs. The cockles are much celebrated, and the sandeel is very plentiful.

Among the products of this island are to be reckoned a pure white pipe-clay, and a fine white crystalline sand. Great quantities of the latter are exported for the use of the glass-works. Alum formerly was manufactured in some of the western coves of the island.

By the returns respecting the poor-rates in the year 1803, it appears, that in the whole county, including the isle of Wight, 153,427*l.* was annually raised for poor and other rates. The average rate in the pound on the rack-rental was 4*s.* 5¼*d.* 130,983*l.* was actually expended on account of the poor. The number of friendly societies was 62, containing 4733 members. The number of children in schools of industry amounted to 614. In the year ending 25th March 1815, the sum raised in this county for poor and other parochial rates amounted to 211,557*l.*, making an increase since 1803, or in the space of 12 years, of 58,130*l.*, or nearly 30 per cent.

At the invasion of the Romans, great part of Hampshire was possessed by the Regni and Belgæ. The latter kept possession of it for 60 years after the first landing of the Saxons; afterwards it formed part of Wessex. The most remarkable antiquities in the county are, Netley Abbey, near Southampton, founded in the year 1239. The ruins of this abbey, situated as they are on the declivity of a hill, rising gently from the water, and environed by most beautiful wood scenery, form a very interesting object. The cathedral of Winchester, curious as an instructive example of architecture; the chapel of our Lady, the choir, and a magnificently carved screen in stone work, are particularly celebrated. The college of William of Wykeham, at Winchester, is also a remarkable building, independently of their character and utility as a seminary. Hurst and Carisbrooke castles, the latter in the isle of Wight, are remarkable for having been the prisons of Charles I.

The following results, respecting the population of this county, appear from the returns made in the year 1811:

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|---|---|
| Houses inhabited | 43,210 |
| Families occupying them | 50,916 |
| Houses building | 441 |
| ——— uninhabited | 1030 |
| Families employed in agriculture | 21,401 |
| ——— manufactures, &c. | 18,024 |
| ———-not comprised in these classes | 11,481 |
| Males | 118,855 |
| Females | 126,225 |
| Total, | 245,080 |
| Population in 1801 | 226,900 |
| Increase | 38,180 |

See Vancouver's *Agriculture of Hampshire*; *Beauties of England and Wales*, vol. v.: Worsley's *Isle of Wight*: and Gilpin's *Forest Scenery*. (W. S.)

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HAMPSHIRE, New, one of the United States of America, is bounded on the north by Lower Canada; on the east by Maine and the Atlantic; on the south by Massachusetts; and west by the Connecticut river. It lies between lat. 42° 41′, and 45° 11′, N. and between lon. 70° 40′, and 72° 28′, W. Its length is 168 miles: Its breadth, bounding on Massachusetts, is 90, and on Canada 19 miles. On the eastern boundary it has about 18 miles of sea coast. The state is divided into six counties: viz. Coos, Grafton, Cheshire, Hillsborough, Rockingham, and Strafford. These are again divided into two hundred and thirteen towns. The first settlement made in New Hampshire, was at the mouth of Piscataqua, in 1623. In the same year, Dover, eight miles higher up the river, was established. Several germs of settlements were subsequently planted along the coast. The several towns preserved a friendly intercourse with each other, in their respective employments of fishing, trading, and planting; and each governed itself until the year 1641, when they voluntarily came under the government of Massachusetts. This union subsisted nearly forty years: but, in 1679, the report of certain commissioners, appointed by the British government to enquire into, and determine a controversy between the successors of Sir Ferdinando Georges and Captain John Mason, and the colony of Massachusetts, being unfavourable to the latter, a separation took place; and a new and distinct government for New Hampshire was instituted. A governor and council of royal appointment, and an assembly, representing the people, were constituted the ruling power; and the new government went immediately into operation. In the year 1680, Mason, a grandson of Captain John Mason, arrived from England, with a mandamus, requiring the council to admit him to a seat at the board. He soon entered on his real errand; endeavouring to persuade some of the people to take leases of him; threatening others if they did not; forbidding them to cut firewood and timber; asserting his right to the province; and assuming the title of lord proprietor. His agents rendered themselves obnoxious, by demanding rents of the people, and threatening to sell their houses for payment. These proceedings raised a general tumult. Petitions were sent from each town, and from many individuals, to the council for protection; who, taking up the matter judicially, published an order, forbidding Mason or his agents, at their peril, to repeat their proceedings. The controversy between Mason and the council became so serious, that he deemed it expedient to quit the colony, and return to England. On his representations and solicitation, Edward Cranfield was commissioned lieutenant governor and commander in chief of New Hampshire; with power to call, adjourn, prorogue, and dissolve general courts; to have a negative voice in all acts of government; to suspend any of the council, who in consequence thereof would be rendered ineligible as representatives of the people; to appoint a deputy governor, judges, justices, and other officers; and to execute the powers of vice-admiral. The government was administered so flagitiously by Cranfield, that his authority was openly resisted by the people ; and he at length left New Hampshire and proceeded to Barbadoes. Towards the close of the reign of Charles the second, the charter of New Hampshire was merged in a commission issued to Joseph Dudley, appointing him president of his majesty's territory and dominion of New England; William Staughton, deputy president; and twelve others, counsellors. Their jurisdiction extended over Massachusetts, New Hampshire, Maine, and the Naraganset. In 1686, a commission issued to Sir Edmund Andross, appointing him captain general and governor in chief of the same territory, including also the colony of Plymouth. In 1689, in consequence of the tyranny of Andross's government, a revolution took place at Boston ; and the people there revived the government as it existed before the commission of Dudley. The people of New Hampshire supported the revolution, united once more voluntarily with Massachusetts, and continued this relation for three years. The consolidation, however, was not sanctioned by the crown ; but the old governments were restored.

Between the year 1692 and the American revolution there was a succession of fifteen governors in New Hampshire. The colony, in the meanwhile, was involved in war with the French and the contiguous Indian tribes. About the year 1719, it received a very considerable accession of inhabitants, by the emigration of one hundred families from the north of Ireland. They brought with them the necessary implements, and introduced the manufacture of linen. Their spinning wheels, turned by the feet, were a great novelty in the country. They also introduced the culture of the potatoe. The most of the emigrants settled in a town by themselves, which they called Londonderry, from that in Ireland, near which they had mostly resided. During its colonial state, New Hampshire suffered much by Indian hostilities. It was at one time so much harrassed, the population so much reduced, and subsistence so scanty, that the province was near being abandoned. The conquest of Canada, at length, gave peace to the frontiers of New Hampshire ; and the colony continued thenceforward to prosper beyond every calculation. It entered into the general revolution, in 1775, with a population of 82,200. It was well prepared to share in the struggle for national liberty. Its yeomanry were brave, hardy, capable of enduring fatigue, had long been accustomed to the use of arms, and were complete woodsmen. Some of them had acquired a considerable stock of military experience in the previous wars, to the dangers and calamities of which they had been particularly exposed. After the declaration of independence, no part of the territory of New Hampshire was, at any time, the seat of war : but many of its inhabitants fought bravely, and bled freely in the common cause. Dr. Belknap, the founder of the Massachusetts Historical Society, published an excellent history of New Hampshire, which is brought down to the year 1792.

The principal denominations of Christians, in New Hampshire, are congregationalists and presbyterians. There are a few episcopalians, baptists, universalists, quakers, and two small societies of sandemanians and shakers.

According to the constitution adopted in 1792, the civil authority is vested in a governor and council, senate and house of representatives, and a judiciary. The governor is elected annually by the people ; and must be worth five hundred pounds. If there be no choice by the people, the legislature complete the election. The executive council consists of five members. The legislature is called "The General Court." Each branch has a negative on the other. The senate consists of thirteen members, elected from as many districts ; and must be worth each a freehold of two hundred pounds. Every town, having 150 rateable polls, sends one representative to the general court ; and is entitled to another for every additional 300 polls. The representative must be worth one hundred pounds. The judiciary is composed of a superior court, having four judges ; an inferior court in each county, having four judges ; a court of general sessions in each county, in which the justices of the peace preside ; a court of ordinary, holden monthly in each county, by one judge ; and justices courts. All judges hold their offices during good behaviour. The population of New Hampshire, in 1810, according to the federal census, was 214,460. This entitles it to six representatives, besides two senators, in the congress of the United States. The prosperity and growth of the state may be seen by the progress of its population in the period of sixty years, ending with 1810. The number in

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| 1749 was | 30,000 | 1790 was | 141,885 |
| 1767 | 52 700 | 1800 | 183,858 |
| 1775 | 82,200 | 1810 | 214,460 |

All able bodied males, between the ages of sixteen and forty-five, are liable to perform militia duty. These compose a force of about twenty thousand.

Literature, until in latter years, has not been so much cultivated in New Hampshire as in others of the New England states. In 1769, a college, which has recently been erected into an university, was founded, and liberally endowed. It was called Dartmouth, from William, earl of Dartmouth, one of its early and principal benefactors. The edifice stands on a plain, about the half of a mile from Connecticut river, in Hanover County. The rev. Dr. Wheelock, the son of the gentleman who was chiefly instrumental in procuring its charter, at his decease, in 1817, bestowed nearly 40,000 dollars upon the institution. Besides several liberal donations, the funds of the university consist in 80,000 acres of land, which now yield fifteen hundred dollars per annum ; but are daily becoming more productive. When properly tenanted, and judiciously managed, they will afford a handsome revenue. In 1812, there were in the institution a president, who is professor of civil and ecclesiastical history ; a professor of mathematics and natural philosophy ; a professor of languages ; and several tutors. There has also been erected a medical department, in which there are a professor of medicine, and a professor of chemistry. Until some recent feuds of a political and religious nature obstructed the administration, this institution flourished. At one time it had upwards of two hundred students within its walls, in the pursuit of science, who enjoyed the advantages of a valuable chemical and medical apparatus, and a library of 4000 volumes. Connected with the university of Dartmouth is Moore's charity school ; the funds of which, besides an edifice, consist of 12,000 acres of land, mostly in the state of Vermont ; and 11,000 dollars, vested by a society in Scotland for the education and religious instruction of the aborigines. This school has continued in operation nearly 65years ; and has been successful, to a great degree, in improving the manners and religion of several tribes of savages, within and near the boundaries of the United States. There are also several academies in the state. One at Exeter, called Phillips' Academy, was incorporated in 1781, is richly endowed, and has generally from 80 to 100 students. It is one of the best conducted seminaries in the United States. Every town is obliged by law to support one or more common schools. From the premises it will be seen, that science and literature have had liberal friends in New Hampshire.

Portsmouth is the largest town in the state. It is situated on the south bank of the Piscataqua, about two miles from its mouth; and has one of the finest harbours in the Union. A light-house, with a single light, stands at the entrance into the harbour. The population of Portsmouth, in 1810, was 6,934. The public edifices are three congregational churches, one Episcopalian, and one for Universalists; a state-house, a work-house, and two banks. Exeter stands at the head of navigation on the Swamscot; and contains a number of manufacturing establishments. There are in and about it a duck manufactory, six saw-mills, a fulling mill, slitting mill, paper mill, snuff mill, two chocolate and ten grist mills, two printing offices, and iron works. Saddles are manufactured extensively. Its public buildings are two congregational churches, an academy, court-house, and gaol; and its population in 1810 was 1,759. Concord, situated on the west bank of the Merrimac, is a flourishing town; and has between two and three thousand inhabitants. Charlestown on the Connecticut is a pleasant town, with a population of nearly 2000. Dartmouth in Hanover, thirty-six miles above Charlestown, is handsomely built, containing a church, chapel, academy, university, and 2,500 inhabitants. Haverhill has two churches, a court-house, and 1200 inhabitants. Keene, one of the prettiest towns in the state, has a church, court-house, gaol, and 1800 inhabitants.

In addition to the manufactories of Exeter, there are furnaces and iron works in Franconia; ninety looms in Hanover. The people generally make their own wearing apparel; and many articles for exportation. They also manufacture pot and pearl ashes, maple sugar, bricks and pottery.

The chief articles of export are timber of various kinds, dried and pickled fish, whale oil, tar, flaxseed, beef, corn, oxen and cows, horses, sheep, bricks, pot and pearl ashes. The importations are West India rum, gin, molasses, wine, porter, sugars, tea, coffee, cotton, cheese, nails, cordage, salt, sea-coal, steel, lead, and grindstones. The product of the fishery, in 1791, was 25,850 quintals. There have been ten banks incorporated in New Hampshire. Internal intercourse has been much facilitated by canals, locks, bridges, and turnpikes.

The shore of New Hampshire is chiefly a sandy beach interspersed by salt marshes, and intersected by creeks. Only two bluffs appear on the coast, the Great and Little Boor Heads; both in Hampton. Twenty or thirty miles from the sea, the country is either level, or made up of little hills and vallies. Above commences the first range of mountains; north and west of which are several detached ridges of considerable elevation. East of the Merrimac, and between that and Connecticut rivers, is the principal range of mountains in the state. The country on the whole may be denominated mountainous. The soil is generally fertile. The lands on the water courses are rich, and yield good crops of hay and wheat. The high lands produce on an average twenty bushels of wheat to the acre; and also afford good pasture. Pitch pine, white oak, chesnut, white pine, spruce, hemlock, birch, beech, maple, ash, elm, alder, red oak, and white birch, form the forest; and according to their ascendancy denote the soil hard, dry, sandy, thin, loamy, rich, deep, or moist. Winter rye thrives best on new, and maize or barley on old lands. Barley, flax, oats, and peas, will not succeed until the lands have been cultivated some years. Agriculture improves throughout the state. Orchards are multiplying and are productive. The rivers of Hew Hampshire are the Merrimac, Contoocook, Piscataqua, Ammonoosuc, Ameriscoggin, and Connecticut. It has several lakes; of which Winnipiseagee is the largest; being twenty four miles long, and from three to twelve miles wide.

In the township of Chester is an eminence 400 feet high, called Rattle-snake hill. It has a cave on the south side, called the Devil's Den, the entrance into which is near the base. In the town of Durham is a rock of 60 or 70 tons weight, so exactly poised, as to be easily moved by the hand. In the township of Atkinson, in a large meadow, there is an island of six or seven acres extent, which rises and falls with the water, when the meadow is overflowed.

The Isles of Shoals, 8 in number, lie 9 miles S. E. of Portsmouth light-house. They are barren rocks, inhabited by 100 souls, who subsist by fishing. *See Morse's Universal Geography, and The Constitution of the State, &c.*

E. H. Cummins, A. M.

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HANAU is a town of Germany, and formerly capital of the county and principality of Hanau Munzenburg. This beautiful town is divided into the old and new town, the former of which was built in 1303, and the latter in 1597, by the Walloons. The town contains several churches, and the palace in which the reigning Landgrave of Hesse Cassel has apartments; but he generally occupies a small house at Wilhelmsbad when he comes to this part of the country. The garden of the palace, the pleasure house of Philippsruhe, and the baths of Wilhelmsbad in the neighbourhood of the town, are deserving of notice. Hanau contains manufactures of earthen ware, tobacco, woollen stockings, playing cards, arms, and articles in steel. Population 11,000.

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HANCOCK, John, L. L. D. was born at Braintree, Massachusetts, about the year 1737. He was educated in the University of Harvard, and graduated Bachelor of Arts in 1754 On the death of his uncle, Thomas Hancock, esquire, he received a handsome fortune; and soon afterwards became an eminent merchant. He began his political career in 1766; when he was chosen one of the representatives of Boston to the assembly. His colleagues were James Otis, Thomas Cushing, and Samuel Adams, esquires. In the controversy between the colonies and Great Britain, Mr Hancock took the side of liberty and his native country, and rendered many distinguished and patriotic services. He was president of the provincial congress in 1774. On the 12th of June, 1775, general Gage issued a proclamation, offering pardon to all the rebels, excepting Samuel Adams and John Hancock, whose offences were alleged to have been too flagitious to admit of their exemption from condign punishment. At this period Mr Hancock was a member of the continental congress; of which he was chosen president on the 24th of May, in the place of Peyton Randolph, esquire, who was under the necessity of returning home. At the head of the illustrious congress of 1776, he signed the declaration of independence. In consequence of ill health, he took his leave of congress in October 1777; when he received the thanks of that body for his unremitted attention and steady impartiali-

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HANDEL, George Frederic, a celebrated composer, was born at Halle in Saxony, in the year 1684. His father, an eminent physician, designed him for the study of the law; but the decided propensities which he displayed for music at an age when youthful genius rarely begins to expand, speedily demonstrated that his intentions would be disappointed. Handel is said to have privately resorted to a clavichord, an instrument strung with catgut, resembling a piano-forte, in a remote apartment, and continued playing upon it when the rest of the family had retired to sleep. His father, therefore, was induced to place him under the tuition of the organist of the cathedral; and at only nine years of age, he is said to have composed some motets which were adopted in the service of the churches. Distinguished musicians have sometimes exhibited similar precocious talents, but they seldom attain proportional excellence in maturer age: and if we admire the productions of children, it is generally in forgetting how much they would be undervalued were they the compositions of men.

The improvement of Handel, however, was great and rapid, and was strikingly displayed in the composition of an opera at the early period of fourteen, while he filled the ostensible situation of manager of the Hamburgh theatre. He was promoted to this situation in consequence of the flight of Keisser, the regular manager, who had attempted to assassinate him. Having composed the operas of Almeria, Florinda, and Nero, Handel proceeded to Florence, where he prudently resisted the consequences of an attachment, which an actress, who was mistress to the Grand Duke, had conceived for him; and repairing to other parts of Italy, he formed an acquaintance with Corelli and Scarlatti, famous musicians of that era. Then travelling to Hanover, he obtained a considerable pension from the Elector, afterwards Geo. I. of Britain, and arrived in London in 1710.

His fame had already preceded him, and he enjoyed high favour at court. Some of his compositions were intended for the practice of queen Anne; and when he returned to Hanover, after urgent solicitations by the admirers of music to remain in England, she dismissed him with a pension and valuable presents.

After a short interval, Handel revisited Britain, where he was more caressed than ever, and where his musical reputation began to extend. He first resided with the most distinguished persons, composing for performances, and managing some concerts for the nobility; and afterwards a society, called the Royal Academy, was instituted, by a subscription of 50,000*l*, to which the King contributed 1000*l*, for the execution of his works.

Handel now went to Dresden, in quest of performers for this great establishment, where he engaged a native of Siena, Francesco Bernardino Senesino, and Margarita Durastanti, two singers of celebrity, with whom he opened the Academy. But he had to contend with two formidable rivals in composition, Bononcini and Attilio, whose works were performed with applause in the Haymarket theatre. The friends of these three musicians, therefore, in order to decide their respective merits, agreed that

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ty in the discharge of the duties of his office. He was succeeded by Henry Laurens, esquire, of South-Carolina.

On the adoption of the present constitution of Massachusetts, he was chosen the governor of the state, in 1780; and was annually re-elected until 1785, when he resigned. In 1787, he was again elected, and continued in the office of chief magistrate until his death, in October 1793. He died in the fifty-seventh year of his age. His administration of the government of Massachusetts was very popular. His deportment in office was manly and decisive. By his moderation and discretion, a civil convulsion, which broke out while he was at the helm of state, was completely quieted, without bloodshed. In his public speeches to the legislature, he acquitted himself with a popular eloquence seldom equalled. In one of his last official acts, he supported in a firm manner the sovereignty of the states. By a process commenced against the state of Massachusetts, he was summoned to answer the complaint of William Vassal in a court of the United States: but Mr Hancock declined the smallest concession, which might tend to establish a precedent unfavourable to the independence of the state, the interests of which were committed to his care; and in the controversy he supported his opinions with becoming dignity. Litigations of this sort were subsequently precluded, by an amendment of the constitution of the United States.

Mr Hancock was little devoted to science. He was more active than studious. He was of easy address, polished in manners, affable and liberal. As president of congress, he displayed admirable qualifications for the situation. He was sufficiently dignified, always impartial, quick in conception, and constantly attentive to business. He has rarely been rivalled in a similar station by any of his successors in the old congress; or in either house of congress, since the adoption of the constitution. General Washington, as president of the convention in 1787, is reported to have exhibited an almost inimitable pattern as a presiding officer. Aaron Burr, while vice-president of the United States, filled the chair and performed its duties with marked ability and distinguished elegance. Langdon Cheves, esquire, a representative of South-Carolina in the 13th congress, displayed a combination of qualifications to fill the chair in a deliberative body. He was very pointed in observing the rules of the house; most bland and flexible in his disposition and manners; but firm in maintaining his decisions and the dignity of the assembly over which he presided. He presided in the house of representatives at a very stormy time; yet in all the conflicts of party, and they were most violent, his decisions on points of order were uniformly supported; and it is believed that the nation is indebted to his nice discriminating sensibility, his firmness in duty, and peculiarly winning address, that the peace of the house of representatives was preserved, in the fearfully turbulent session of 1814—15, and the character of congress saved from the pollution of sanguinary discord.

From the commencement of the revolutionary war, he took an active stand against the encroachments of the mother country upon the rights of the colonists; and his uniform, energetic, and exemplary patriotism throughout the contest that ensued, is worthy of honourable remembrance. By his good conduct, in public and private life, he became a very popular man. A republican in principle, and a firm supporter of the cause of freedom, he had complete possession of the affections of his fellow citizens; and, whenever he became a candidate for the office of governor, he was uniformly elected by a decided majority. In private life he was charitable and generous. With a large fortune, he had the disposition to employ it usefully and benevolently. The poor shared liberally of his bounty. The university of Harvard experienced the benefits of his devotion to all institutions for the promotion of knowledge and happiness among the people of his beloved country. His donations to that institution were beneficent. Mr Hancock's oration on a memorable occasion, in Boston, has been preserved in most of our school books, as a pretty specimen of eloquence; and is often pronounced at public exhibitions in seminaries, where the students are taught the art of speaking. See *Allen's Biography*. (E. H. Cummins, A. M.)

each should compose the music for an act of an opera, called Muzio Scævola, of which the third fell to Handel's share. Public opinion unanimously declared in favour of the last; and it has been observed, that the performance of one of Handel's operas, after those of the other two, "is going from Arabia Petræa to Arabia Felix; from barren rocks to spontaneous fertility." Handel, therefore, held unrivalled possession of the stage. Some years afterwards, having profited by the talents of Francesca Cuzzoni, a female singer, of whom it was said, "that her intonations were so just and fixed, that it appeared as if she could not sing out of tune," he engaged Faustina, a young, beautiful, and interesting Venetian. But a rivalship commenced between them, and the audience participated in it so keenly, that, amidst the violence of partisans, the merits of the institution were altogether obscured. Each was supported with indiscreet and indecent zeal; and one of them having become refractory, Handel, from a previous example of the same in Senesino, refused to compose for this singer, and obtained his dismissal, probably in order to intimidate the others. By this, and some arrangements of a different kind, he offended the directors of the Academy, which led to its dissolution in nine years from its commencement.

Handel, however, endeavoured to carry on an opera at his own expence, while a rival amusement, patronised by many of the leading persons of the metropolis, was established in Lincoln's Inn Fields. But his success did not correspond with his expectations; and although he continued to compose, with great facility and expedition, his productions were at length performed to empty houses. Neither did his opponents experience better fortune; from which we may infer, that the English taste for operas was beginning to decline. Handel produced no less than thirty operas between 1721 and 1740; but in the latter part of this period, both his health and his fortune were so deeply impaired, that he left Britain to visit the baths of Aix-la-Chapelle.

Having returned to London in a state of convalescence, Handel began to direct his attention more particularly to another species of composition, oratorios, or sacred dramas, in which he expected, by the simplicity of songs, and the grandeur of chorus, to command that public notice which was denied to lighter compositions. The Messiah was performed at Covent Garden in 1741, and it will scarcely be believed, after an interval of 70 or 80 years, that it was but indifferently received. The inhabitants of Dublin, however, to whom the author had it performed for the benefit of the prisoners of that city, viewed it differently; and it was afterwards repeated in England to the most crowded audiences with unbounded applause. Many other oratorios followed in rapid succession, of which the majority were favourably received. The tide of public favour was restored to its original current, and Handel's merits gained their due appreciation. But some of his productions were nevertheless so little adapted to general taste, that the late King George II. attended them almost alone, when abandoned by the rest of his court. Handel annually superintended the performance of the Messiah, with laudable liberality, for the benefit of the Foundling Hospital, which produced above 500*l.* yearly.

In the year 1751, he was attacked by gutta serena; and from the moment that apprehensions for his sight were entertained, his spirits and vigorous imagination deserted him. An operation proving unsuccessful, his melancholy increased; and he was obliged to resort to extraneous assistance for the management of his oratorios. Years were now crowding upon him without bringing any alleviation of his disease; and when he, whose works had so often charmed an admiring audience, was led forward to make his obeisance; or when his own composition—"Total eclipse—no sun, no moon—all dark amid the blaze of noon,"—was performed, it is difficult to determine whether he himself or the spectators were most affected.

Handel was attacked by a general debility in 1758, and from that time he considered his own recovery as hopeless. Nor were his anticipations wrong, for he expired in April 1759, in the 76th year of his age. He was entombed in Westminster Abbey, and a statue was erected to his memory, as one, erected in Vauxhall Gardens in 1738, had already celebrated his genius. In person he was large, and rather corpulent and ungraceful; and in manners he was rough and impetuous. Over his performers he exercised a magisterial sway, exacting implicit obedience in the fulfilment of their respective duties; but it is probable, that posterity has heard his music to even greater advantage than was done by himself. He had no prominent vices, however, and he practised many virtues. Handel died possessed of considerable wealth for the period, and what must be esteemed great for a musician, whose fortune was once ruined; he left about 20,000*l.*, of which 1000*l.* was bequeathed to the Society for supporting decayed musicians, instituted in London in the year 1738. This Society derived 6000*l.* more, from the profits of a grand commemoration in honour of Handel, performed by 525 voices and instruments in Westminster Abbey in 1784.

Handel's merit as a composer ranks very high; and few if any have excelled him, in that particular path which he latterly chalked out for himself. The style of music indeed, has undergone inconceivable alterations since his death; but many of his compositions are even at this day heard with delight, though a century has elapsed since their production. His music is alike sublime in one character, and pathetic in another; and so long as simplicity and grandeur are valued by mankind, they will never lose their impression. The quantity that Handel wrote is surprising. It certainly exceeds what has flowed from the pen of any other composer, however voluminous his works; and it is so great, that we must be content with observing, that he produced between 40 and 50 operas, between 20 and 30 oratorios, besides organ concertos, and other music.

A complete edition of the whole, we believe, was published a few years ago, in 80 folio volumes. Although a large proportion of Handel's compositions are excellent, it is undeniable that many seem dull and heavy to modern taste; and the reiteration of favourite, or what he might conceive appropriate, passages certainly impairs their effect. The Grand Chorusses of the Messiah, the Coronation Anthem, Farewell ye limpid streams, Angels ever bright and fair, and numerous others, can never be listened to without emotion. Yet Handel, with all his excellence, committed that egregrious error to which musicians are so prone,—he wrote too much. It is vain to expect perpetual novelty in thoughts or actions; the inexhaustible renewal of human genius does not exist, or it appears only in arrangement. Nature has bestowed but a trifling portion of originality on any individual, however comprehensive his intellect; and so soon is that of composers bestowed on their works, that extravagance and caprice are offered for what is already exhausted. They enjoy a latitude, it is true, which is denied to literature or painting. These must be guided by certain principles which are special and defined, and of which the violation will ever be rejected by genuine taste. But music is not restricted within definite boundaries; while we acknowledge a few imperfections that should be avoided, we cannot describe that particular course which shall guide us to excellence. Hence public opinion will long be divided on musical merit; that which pleases the ear will gratify the majority; and the rest will seek for some less prominent property, which may be the subject of reflection. Perhaps a piece of music should be compared to a narrative, while it is agreeable in one part, nothing ought to be outdone in another. A general character should be preserved throughout. Were this attended to, fewer useless compositions, particularly instrumental compositions, would be obtruded on the public. Handel's works unquestionably evince the mind of a great master. He who can move an audience, both by pathos and grandeur, must be admitted to have no ordinary genius. Nevertheless he has perhaps fallen into another error, in endeavouring to make the imagination feel what it is necessary to behold, before being alive to the impression, or what it would probably require a kind of complex machinery to represent. For example, the sun standing still, a phenomenon of nature, from which we should at this day expect the annihilation of the terrestrial globe, is feebly imitated by a note of uncommon duration. The hopping of frogs, the buzzing of flies, the falling of hail, are sufficient in words; they are scarcely appropriate in music. Another inimitable master, Haydn, has followed the footsteps of his countryman in these questionable points. But how can any one discover flashes of lightning, the flowing of streams, the roaring of lions, or the crawling of worms, from any association of musical notes? Such allegories are beyond the reach of the most vigorous imagination, which would be perplexed in searching for the analogy. One of Handel's operas opens with an imitation of a storm and a shipwreck; and a symphony is introduced in another, to express the shrieks and cries of tortured souls in the infernal regions.

We must conclude on the whole, that Handel is one of the greatest masters who has ever flourished; and that his style and performance materially contributed to produce that revolution in music, which has taken place in the course of the eighteenth century. (*c*)

HANG-TCHEOU-FOO. See China.

HANNIBAL, the celebrated Carthaginian commander, was born about 220 years B. C.; and, when only nine years of age, accompanied his father Hamilcar to the army in Spain. Before his departure he vowed, at the altar, that he would never be in friendship with the Romans; and in the camp of Hamilcar, the most distinguished general of those times, he acquired that military skill, which afterwards rendered his enmity so formidable. At the death of his father, nine years after, he continued to serve in the field under his brother-in-law, Asdrubal, who had succeeded to the command; and when this general fell by assassination, about eight years afterwards, he was unanimously chosen by the army as their leader, while the senate at Carthage with one voice ratified the election. Soon after his confirmation in the command of the troops, he accomplished the reduction of the Olcades, and, loaded with booty, took up his winter quarters in new Carthage, (the modern Carthagena), where he completely secured the affections of the soldiery by his liberal distribution of the plunder, and the hopes of farther conquests, with which he inspired them. In the following year he reduced all the Spanish nations on the south of the Iberus, except the Saguntines, the allies of Rome; and, upon returning to his former winter quarters, received an admonition from the Romans to beware of molesting a people who had been taken under their protection. Conceiving the armies of his country to have now attained sufficient strength to contend with the legions of Rome, and eager to vent his long cherished hatred against that rival republic, he returned such an answer as clearly intimated his hostile intentions, and immediately transmitted to Carthage direct charges against the Saguntines, of having committed outrages upon the allies of the state. Having received permission to make reprisals, he pushed his measures with a celerity and decision which the Romans were not prepared to anticipate; and, after an obstinate siege of eight months, gained possession of Saguntum before any succours could be received from Rome. While the Romans were supposing the designs of the Carthaginians to have been limited to the reduction of Saguntum, and were preparing to send an army by sea to Spain, as the seat of the approaching contest, Hannibal, having secured the friendship of the Gauls on both sides of the Alps, began his march for Italy with an army of 50,000 infantry, and 9000 horse; evaded the Consul P. Scipio, who attempted, by landing at the mouth of the Rhone, to intercept his progress, carried his army across the Alps in the beginning of winter in the space of 15 days, and appeared in the vicinity of Turin, after a march of 1000 miles from New Carthage, accomplished in five months and a half. His army was now reduced to 20,000 foot, (of which 12,000 were Africans, and the rest Spaniards), and about 6000 cavalry. Having taken in three days the city of the Taurini, and put all who opposed him to the sword, he hastened forward to meet the Consul Publius Scipio, who had returned with the utmost expedition from the banks of the Rhone, and had already passed the river Po with his army. The two armies joined battle on the banks of the Ticinus, a small river in Lombardy; and Hannibal, chiefly by the superiority of his cavalry, gained an easy victory over a general, who was neither deficient in courage or experience, but who seems to have been little aware of the talents of his adversary. The other Consul, Sempronius, having arrived with a fresh army, acted with still greater rashness, and, engaging the Carthagioians near the river Trebia, sustained a much more decisive defeat. In the following campaign Hannibal was again fortunate in having to contend with a self-confident commander, Caius Flaminius; and, having carefully studied his temper, drew him into a defile by pretending a retreat, and cut to pieces, near the Lake Thrasymenus, the greater part of his army. But all his talents and expedients were brought into requisition by the dictator Fabius Maximus, who justly concluded, that to stop the progress of an invader is to gain a victory, and who cautiously directed his operations to preserve a commanding position, and to intercept the foragers of the enemy. The Carthaginian leader, baffled in all his artful movements to surprise his opponent, or to force an engagement, resolved at least to attach the neighbouring nations to his interests, by proving himself master of all the open country, boldly directed his march to the fruitful plains of Campania, which he quietly ravaged within sight of the Roman army. Upon attempting to return with his booty through the same pass by which he entered the country, he found himself, when encamped at the foot of Mount Callicula, hemmed in by the masterly movements of the Dictator; but by dispersing, during the night, 2000 oxen with burning faggots on their horns, he contrived to draw off the detachment which occupied the heights in the line of his march, and to bring off his army in complete safety. By taking care, in the general devastation, to spare the lands of Fabius, he encouraged the accusations and suspicions, which were ungenerously cast upon that general, of holding a secret correspondence with the enemy. In a short time he found means to draw into a snare the one half of the Roman army, commanded by Minucius, who had been raised to equal authority with the Dictator; but, when in full pursuit of the routed legions, he was checked by the advance of Fabius, and obliged to sound a retreat. While reluctantly retiring to his camp, he is reported to have said to his attendants, "Have I not often told you, that that cloud which hovered upon the mountains would one day burst upon us in a storm?" The Roman generals, enjoined by the senate to follow the plans of Fabius, continuing merely to watch the motions of the Carthaginians without risking a decisive engagement, he found his difficulties fearfully accumulating. Without any hope of succours from Carthage and left to the resources of his own genius for the means of subsisting his troops, in perpetual distrust of his allies in Italy, and daily assailed by the murmurs of his exhausted soldiers, he was on the point of sacrificing one part of his army to save the other, when the rashness of his adversaries again afforded him not only a season of respite, but an occasion of triumph. Having understood the fiery temper of Terentius Varro, one of the new consuls, (who held the command of the Roman army, and who bore, with the utmost impatience, the cautious counsels of Paulus Emilius, his colleague), he attacked him in all his detachments, insulted him even in his camp, and succeeded at length in drawing him into the field, near the fatal village of Cannæ. The Roman army consisted of 80,000 foot, and 6000 horse, and that of Hannibal amounted only to 50,000 in all, of which 10,000 were cavalry. Varro, on the day of his turn to command, impatient to punish, as he expressed it, the insolence of the Carthaginian, and confiding in the number of his troops, descended into level ground, as if he had studied to favour the enemy's superiority in cavalry; and in a battle which has already been described in the work, (see CANNÆ), lost nearly the whole of the largest army which had ever been equipped by Rome, while the loss of Hannibal did not exceed 6000 men. "Follow me," said one of the Carthaginian officers, elated with the annihilation of the Roman army; "I will be at Rome with the cavalry before they have notice of my approach. In five days we shall sup in the Capitol." To the refusal of Hannibal to adopt this advice, the preservation of Rome and its empire has been ascribed by Livy, and several other ancient historians; but many later writers have questioned the justice of the censure. Rome had been carefully fortified after the battle of Thrasymenus, and was provided with every thing necessary to sustain a siege. It was full of soldiers well trained to war, and supplied the dictator Junius Pera with four new legions and 100 horse, immediately after the battle of Cannæ. Hannibal's advantages had been principally gained by his superiority in cavalry, which could be of little use in attacking a city; and the rest of his army did not exceed 35,000 men. "His own judgment," says Dr Adam Fergusson, "is of more weight than that of the persons who censure him. He knew the character of the Romans, and his own strength. Though victorious, he was greatly weakened by his victories, and at a distance from the means of a reinforcement or supply. He was unprovided with engines of attack; and so far from being in a condition to venture on the seige of Rome, that he could not attack even Naples, which, after the battle of Cannæ, refused to open its gates."

Hannibal, soon after his victory at Cannæ, withdrew his army to Capua, the principal city of Campania, where he finally took up his winter quarters, sfter several unsuccessful attempts to gain possession of Nola, Casilinum, and particularly Naples, as affording an easy communication with Africa. Nothwithstanding the assertion of the Roman historians, that Capua, by its enervating pleasures, proved as fatal to the Carthaginians as Cannæ had been to the Romans, it does not appear that Hannibal or his troops had lost much of their martial activity and ardour. As soon as the rigour of the season began to relax, he renewed the siege of Casilinum in sight of an army from Rome, amounting, exclusive of allies, to 25,000 men; and the want of supplies from Carthage, which had indeed been promised, but were slow in their arrival, was the principal cause of his power declining in Italy. He had not troops to oppose the Roman armies, which were so rapidly collected against him, and at the same time, to garrison the towns and protect the countries which had submitted to his authothority or accepted his alliance. During the space of four years after the battle of Cannæ, no decisive advantage was gained by either party in the war; and though several victories are stated, by Livy and Plutarch, to have been gained over Hannibal by Marcellus, it is affirmed by Nepos, that the latter was always victorious in Italy, and by Polybius, that he was never vanquished before the battle of Zama. In the eighth year of the war, while Capua was hard pressed by the Romans, Hannibal made an attempt to draw off the besiegers, by marching to the gates of Rome, but found that city too well prepared to resist an attack which he seems after all to have rather feigned than intended. After the fall of Capua, he was frequently obliged to decline the battle which the Roman generals were now ready to offer; and at length, in the thirteenth year of the war, after the death and defeat of his brother Asdrubal, being unable to preserve his conquests in Italy, he retired with all his forces to the barren rocks of Brutium. Even in this weakened condition, in a country incapable of supplying him with subsistence, and at the head of an army composed of Africans, Spaniards, Gauls, Carthaginians, Italians, and Greeks, he continued, by his extraordiary talents as a general, to preserve the discipline of his troops, and to render himself formidable to the Roman commanders, till, in the 16th year of the war, he was recalled to Africa for the immediate protection of Carthage against the victorious legions of Scipio. Leaving Italy with the utmost reluctance, and landing at Little Leptis, a city between Susa and Adrumntum, he received instant orders from the Carthaginian Senate to advance and give battle to the Romans. In obedience to these instructions, he proceeded by forced marches to Zama, about five days journey south west from Carthage; and being struck with the undaunted generosity of Scipio in sending back the spies who had been taken in his camp, requested an interview with the Roman general. The armies had encamped within four miles of each other, and there was a large open plain between them, where no ambush could be laid. Here the two generals, escorted by an equal number of guards, arrived for the conference; and each attended by an interpreter, met in the midway, where they remained for a while in silence, viewing one another with mutual admiration. Hannibal first spoke and proposed a treaty of peace, upon terms which had been recently agreed upon between the two countries; but Scipio insisting upon the perfidy of the Carthaginians in breaking the truce during the negotiations, required them to surrender at discretion. Hannibal, however much disheartened by his misfortunes, and doubtful of victory, could not bring himself to make, at the head of an army, so humiliating a submission. The conference terminated; and both the generals returning to their camps, prepared for battle on the following day. According to the testimony of Polybius, Hannibal drew up his army in the most skilful manner, and performed every thing in the engagement which could have been expected from a great commander. The victory was long and eagerly contested; and the Romans, though superior in numbers, appear to have at one time been on the point of losing the battle. But Masinessa, who commanded the Numidian cavalry, and Lolius who headed that of the Romans, having routed the wings of the Carthaginian army, came in the rear of Hannibal's veteran soldiers, who were almost entirely cut to pieces in their ranks. Of the Carthaginians, 20,000 are said to have fallen in the field, and about the same number were taken prisoners. Hannibal escaped with a few horsemen to Adrumetum, whence he was called to Carthage, to aid the falling republic with his counsels. He instantly declared, that there was no resource except in a peace; and this reply from the constant advocate of the war, and most inveterate foe of the Roman name, decided the senate to submit to the conqueror. See CARTHAGE and ROME.

Hannibal, who had now spent thirty-six years in arms, continued to reside at Carthage; and was afterwards honoured with the chief magistracy in that republic. Having exerted himself to remedy various abuses in the management of public affairs, and having particularly brought to light many instances of the embezzlement of the revenue, he was accused by his enemies to the Romans of secretly holding intelligence with Antiochus the Great, in the designs which that prince was meditating against the power of Rome. In spite of the remonstrances of Scipio, (who generously defended his former opponent in arms, and strongly insisted that it was below the dignity of the Roman people to range themselves among the personal enemies of Hannibal, and take part in the factions of Carthage,) ambassadors were dispatched by the senate to bring the charge against Hannibal, and to require that he should be delivered into their hands. Aware of their design, and doubtful of his countrymen, he made his escape to Tyre, where he was received and entertained in a manner suited to his reputation; and afterwards joined Antiochus at Ephesus, whom he found in a state of hesitation between peace and war. Upon being consulted on the subject, he asserted, as he had always done, that the Romans were invincible every where but in Italy; proposed, if entrusted with 10,000 foot and 1000 horse, to make a descent in that country; and, at the same time, dispatched a messenger to Carthage to persuade them to join in the enterprize. Before the commencement of hostilities, a Roman ambassador, accompanied by Scipio Africanus, arrived at Ephesus; and, during their residence there, many civilities are said to have passed, and frequent conversations to have taken place between them and Hannibal. It is reported that, during this friendly intercourse, Scipio one day asked the Carthaginian, "Whom he thought the greatest general?" Hannibal immediately replied, "Alexander, because that, with a small body of men, he had defeated very numerous armies, and had overrun a great part of the world." "And who do you think deserves the next place?" continued the Roman. "Pyrrhus," replied the other: "he first taught the method of forming a camp to the best advantage. Nobody knew better how to choose, or post guards more properly." "And whom do you place next to those?" said Scipio. Hannibal named himself; at which Scipio asked, with a smile, "Where, then, would you have placed yourself, if you had conquered me?" "Above Alexander," replied the Carthaginian, "above Pyrrhus, and above all other generals;" thus, by a most refined strain of compliment, separating Scipio from the crowd of commanders, as one of inestimable qualities. These familiar conversations are said to have been sought by the Roman deputies, for the purpose of discovering the designs of Hannibal; and they had at least the effect of rendering him suspected by Antiochus. That prince, though afterwards cured of their suspicions of his guest, refused to follow his counsels as to the prosecution of the war; and, upon suing for peace after his defeat at Magnesia, was required, among other conditions, to deliver up Hannibal to the Romans. This illustrious exile, however, anticipating such a demand, had removed from the dominions of the Syrian monarch, and taken refuge with Prusias, king of Bithynia, to whom he rendered eminent services in various wars. At length Flaminius arrived as an ambassador from Rome, for the ostensible purpose of requiring Prusias to desist from hostilities against the king of Pergamus; but principally with a view to induce him to betray his Carthaginian guest. The king, reluctantly, according to Plutarch, but readily, according to Livy, complied with the dishonourable proposal; but Hannibal, who resided in the castle of Libyssa, upon learning that the place was surrounded by soldiers, resolved to die, rather than fall into the power of his persecutors. Taking into his hand a poison which he had kept ready for such an exigence, "let us deliver Rome," he said, "from her perpetual fears and disgust, since she has not patience to wait for the death of an old man." Then, having invoked the gods to take vengeance upon Prusias for his violation of hospitality, he swallowed the poison and expired. He died at the age of 65 years, of which he had passed 36 in camps, and 13 in exile. He had little opportunity, therefore, to cultivate the moral and civil virtues; though, perhaps, if impartially tried even by this test, he will be found, notwithstanding the shocking portrait drawn of him by Livy, to have been by no means inferior to the great body of conquerors in ancient times, or even to his celebrated opponent Scipio Africanus. Neither Plutarch nor Polybius makes any mention of that cruelty, perfidiousness and irreligion, with which he has been charged. In point of military talents, he may be pronounced to stand in the foremost rank; and all the qualities which make a complete general, have not been more constantly and conspicuously manifested in the conduct of any captain of antiquity, than in that of Hannibal. He appears, especially, to have surpassed them all in the talent of forming brave and disciplined soldiers; though he was opposed by troops, consisting chiefly of Roman legions, warriors by choice and education, he was victorious, even over superior numbers, in every battle except his last; and that with an army, which he had in a great measure renewed in conquered countries, which he had collected from various nations, differing in manners and language, and which he preserved attached to his interests in the midst of privations and reverses. See Nepos, Livy, Plutarch, Polybius; Rollin's *Ancient History*, vol. vii.; Ferguson's *History of the Roman Republic*, vol. iii.; Abbé de St Pierre's *Life of Scipio Africanus*; and Hooke's *Rom. Hist.* vol. iv. and v. (*q*)

# HANOVER.

Hanover is a kingdom of Europe, which was formed in 1815 out of the electorate of Hanover and the principality of Osnaburg. It is situated in the circle of Lower Saxony; and is bounded on the north by the territory of Hamburgh, Holstein, and Mecklenburgh, the Elbe forming the line of demarcation as far as Inapesse; on the north-east by Prussia; on the east by the duchies of Brunswick and Prussia; on the south by Hesse and Prussia; on the west by the lands of Lippe, Hesse, Waldeck, and Prussia; on the north-west by the territory of Bremen, and the possessions of the Duke of Olders, and the territories of Aremberg and Looz.

Hanover is of a very irregular form. It comprehends the duchies of Luneburg-Zell, Bremen, Verden, and Saxe Lauenburgh, on the northern side of the Elbe; the countries of Calenburg and Grubenhagen on the south; those of Diepholtz and Hoya on the west; and that of Danneberg on the east. At the treaty of Ratisbon, Hanover lost the bailiwick of Wildehausen; but in 1802, it acquired the principality of Osnaburg.

1. The principality or duchy of Luneburg-Zell, is bounded on the north by the duchies of Lauenburg and Mecklenburgh; on the east by the electorate of Brandenburg and duchy of Brunswick; on the south by those of Brunswick and Calenburg; and on the west by the circle of Westphalia. The Elbe forms the north and north-east boundary. It is from 75 to 80 miles from north to south, and from 60 to 70 from east to west. It contains 200 parishes and 27 towns. It possesses some fruitful marsh lands along the Elbe, the Aller, and the Jetze; but towards the centre and northern parts, it is sandy, heathy, and barren. The principal towns are Luneburg, Harburg, Zell, Helzen, Danneberg, and Lucho.

2. The duchy of Bremen, is bounded by Holstein, Luneburg, Verden, and Westphalia. It is about 65 to 70 miles long from north to south, and 45 to 50 from east to west. The Marschland, or low country, on the rivers Oster, Weser, and Elbe, is fertile, but liable to inundations. The Geestland, or high country, is in some places fruitful, and has its heaths covered with sheep. In this duchy are 2 cities, 12 market towns, 22,276 taxable hearths, 118 Lutheran churches, and 28 noble jurisdictions. The principal towns are Bremen, Stade, Buxtehude, Closter Seven or Zeven.

3. The duchy of Verden, which has a peninsular form, lies on the right bank of the Weser, between Bremen and Luneburg. The extent from north to south and from east to west, is from 25 to 30 miles. It is an elevated, heathy, and dry country, traversed by the rivers Aller and Wummie. Its principal towns are Verden, Rottenburg, and Languedal.

4. The duchy of Saxe-Lauenburg, is bounded by Holstein, Mecklenburgh, and Luneburg, and the territories of Lubeck and Hamburgh. The country is level, and in some places fertile. It yields considerable quantities of wood and flax, and exports rye, butter, cheese, wool, wood, and fish. The small rivers Belle, Steckenitz, &c. which fall into the Elbe, water the southern part of the duchy. The principal lakes are those of Ratzeburg and Schall; and the chief towns Ratzeburg, Lauenburg, and Mollen.

5. The principality of Calenburg is situated in the south-west corner of Lower Saxony, and is cut into two parts by a part of the principality of Wolfenbuttel. The northern part is bounded by Luneburg, Hildesheim, Pyrmont, Lippe, Schauenburg, Hoya, and Minden; and the southern part by Wolfenbuttel, Grubenhagen, Eichfeld, and Lower Hesse. It is about 48 leagues long, and from 6 to 10 broad. The Weser, which forms part of the western boundary, is every where navigable. The country is in some places hilly, and in others marshy and sandy, and no where very fertile. The principal hills, are the Deister, Suntel, and Solingerwald. The principality contains 36 towns, and 221 churches. It is divided into three quarters, viz. 1. The quarter of Hanover, which contains 11 towns, 2 abbies, 6 convents, 81 manors, and 212 villages. The chief towns are Hanover, Munder, Wunstorf, Pattensen, Eldagsen, &c. 2. The quarter of Hameln and Lauenau, which contains 13 towns, and 128 villages. The principal towns are Hameln, and Bodenwarden. 3. The Gottingen quarter, which contains 15 royal bailiwicks, 11 noble jurisdictions, 12 towns, 8 convents, and 180 villages. The chief towns are Gottingen, Nordheim, Munden, Dransfeld, Moringen, Uslar, and Hardegsen.

6. The principality of Grubenhagen, is bounded by Calenberg, Wolfenbuttel, Wernigerode, Blankenburg, Hohenstein, and Eichfeld. The greater part of this principality is mountainous, and covered with woods. It contains, however, some fruitful plains, where considerable quantities of flax are raised. Grubenhagen contains a part of the famous chain of the Hartz. The principal minerals which it contains, are slates, alabaster, marble, rock salt, calamine, sulphur, lead, copper, iron, silver, and gold. For an account of the produce of the mines, see p. 243. Grubenhagen contains 9 small towns, 44 parochial churches, and 7000 taxable hearths. The chief towns are Einbeck and Osterode, which are described in p. 245.

7. The county of Diepholtz is bounded on the north by Delmenhorst and Bremen, on the east by Hoya, on the south by Minden, and on the west by Osnaburg and Munster. It is 25 miles long from north to south, and 10 to 14 from east to west. This county consists of heaths, moors, and pasture lands; and the people are chiefly employed in breeding cattle, and manufacturing coarse linens. It contains ten parishes, and five towns, the principal of which are Diepholtz and Lemforde.

8. The county of Hoya is bounded on the north by Delmenhorst, Bremen, and Verden, on the east by Luneburg and Calenburg, on the south by Minden, and on the west by Minden and Diepholtz. It is 25 to 30 miles from north to south, and 30 to 33 from west to east. The soil is chiefly sandy; but there are some fruitful tracts, which produce wheat, barley, and flax. Some parts are heathy, and others fit for pasture. It contains 54 parishes, and 100 towns and villages, the chief of which are Hoya, Drakenburg, Nienburg, Liebenau, Suhlingen, Harpsteadt, &c.

9. The principality of Osnaburg is bounded on the north and south by Munster, on the east by Hoya, Minden, and Ravensberg, on the west by Techlenburg and Lingen. It is about 43 miles long from north to south, and 32 from west to east. The river Hase traverses it from north to south. Nearly one half of the county consists of heathy and barren land. Rye and flax are its chief produce. It

contains seven towns, the principal of which are Osnaburg, Iburg, Furstenau, Quackenbruck, Vorden, and Wiedenbruck. See OSNABURG.

Hanover comprehends 107 bailiwicks. The country is intersected by a great number of rivers and streamlets, and is in general extremely marshy. The principal rivers are the Elbe towards the north, the Weser and the Leine on the west, and the Aller and the Ilmenau in the centre of the kingdom. The chief lakes are those of Diepholtz and Stinhuder. The Aller rises in the duchy of Magdeburg; and, after traversing the southern parts of Luneburg-Zell, it falls into the Weser below Verden. The Leine rises in Eichfeld, runs northward through the eastern part of Calenburg, and falls into the Aller. The lake of Diepholtz is called the Drummer-see, and though very extensive is extremely shallow.

The climate is by no means good. The temperature is very variable. The winters are rigorous, and frosty days often intervene between the greatest heats of summer. A north-west wind commonly blows during the cold season, an east wind in spring, and a south-west wind in summer. The common diseases are catarrhs, intermittent and nervous fevers, phthisis, apoplexy, and palsy. When July is very warm, dysenteries are peculiarly malignant. The epidemics are of a rheumatic nature, and consumptions are very fatal.

The Hartz mountains are the most considerable in the kingdom. See HARTZ. The mountains which separate the west and south of Hanover from the principality of Hesse are either of a calcareous or basaltic nature, and consist of large pyramidal blocks, which furnish excellent stones for mending the roads, and paving the streets.

Very little progress has been made in improving the heaths and the marshy grounds of Hanover. A few fertile spots are occasionally seen in the midst of barren wastes, although, by a little judicious management, a great part of the soil might be brought under cultivation. Nearly one half of the land is covered with weeds; a fifth part of the arable fields is employed in pasturage; and of the parts from which grain is raised, a third is occupied by peas and beans, a fourth by wheat, rye, and buckwheat, a fifth by barley, and a sixth by oats. On the sandy lands good potatoes are produced. Notwithstanding the general sterility of the country, there are many fertile and populous vallies on the banks of the Elbe and the Weser. The duchy of Saxe Lauenberg is completely cultivated, owing to a wise agreement between the seigneurs and the peasants to relinquish some mutual privileges. The grain raised in Hanover is not sufficient for the consumption of the inhabitants; but though the pasturage is not luxuriant, they export a considerable number of horses to France, Italy and Saxony. If the operation of draining were extensively carried on, Hanover might supply Germany, Holland, and France, with a sufficient number of horses and black cattle. The wool is of a very bad quality. It is used in Belgium in the manufacture of coarse cloth, and the Hanoverians work it into a tolerably good looking stuff. Several rams of the Merino breed have, however, been imported from Upper Saxony; and the wool has thus been greatly ameliorated. The cows are neither large nor beautiful. They are generally of a black and white, or a white and fawn colour. In order to improve the breed, bulls are brought from Holland. The Hanoverian goats are very poor, and few in number. The oxen are of a middle size, and make excellent beef, the pork is good, and the mountain mutton is highly esteemed. Flax is more abundant than hemp throughout the kingdom, and it is the chief occupation of the females to spin it in the winter evenings.

The natural history of this country is in no respects interesting. Boars and deers are much less numerous than formerly; and, during the last century, wolves have been extremely rare. The last bear was killed at Hartz about the beginning of the 18th century. Roebucks and hares are excellent, but rabbits are very scarce. Thrushes, partridges, skylarks, wild-ducks, heathcocks, and a small species of tetran, are very numerous. The rivers do not produce a great variety of fish, but the markets are well supplied with turbot, perch, carp, pike, and large eels. The streams that issue from the Hartz, and other wooded mountains, abound with a small trout of exquisite flavour. The mineral waters of Limmer are much frequented. The hot baths of Limmer are built of grey stone, firmly cemented, and fixed in the ground. The descent is by four steps, with a ballustrade. A bench 5 inches broad serves for a seat, and it has a fir back, in order to prevent a sudden shock from the cold stone before it has acquired the temperature of the water. The charge for each bath is a franc.

The minerals of this country are rich and numerous: They consist of silver, copper, lead, iron, cobalt and zinc, with marble slate, coal, turf, and limestone. Boracite has been found in the Calkberg and Staurolite at Andreasberg in the Hartz. The annual produce of the mines of the Hartz which belong to Hanover, is reckoned at 1,172,733 rixdollars. The annual produce of the lead mine called Caroline is 194,000 rixdollars. See the article HARTZ.

The territory of Hanover is governed by a regency, composed of seven ministers. Four of these reside in Hanover, the capital; and the fourth, who presides over the law department, the police, and the high court of appeal, resides at Zell. The sixth, who is at the head of the College of Nobles, likewise presides over the subordinate regency of Bremen and Verden, which is held at Stade; and the seventh has a permanent establishment in the court of the electoral king. This regency possesses regal power, and decides in all matters on which the provincial states are not entitled to interfere. It communicates with these assemblies in the same manner as the elector himself, and superintends all the departments of the government. There is a subordinate regency for the bailiwicks of Lauenburgh, which sits at Ratzeburg, and another for the principality of Osnaburg, which sits at Osnaburg.

The provincial states of the kingdom consist of the prelates of the equestrian order, and the magistrates of cities. The priests are of the first rank, the nobles are of the second, and the magistrates of the third rank. The duty of the states is, to watch over the liberties of the people and the different orders of the citizens,—to enforce a regular administration of the laws,—and to superintend the distribution of the public money. No tax can be levied without their consent, and every new law must have their sanction.

The Roman and public law, the constitution of the empire, the bulls of the emperors, and the particular constitutions of the different provinces of which Hanover is composed are precedents, by which the magistrates are guided in their political, civil, and criminal judgments. The high court of appeal sits at Zell, and the minister is bound to consult the regency in certain difficult cases. The decisions of this court have always been highly respected. When M. Wrisberg was its president, George II. one day said to him, "How does it happen that I lose every process that I bring before your tribunal?" "Sire," replied the president, "it is because your Majesty is always in the wrong." "M. de Wrisberg," replied the king, "you speak to me like a magistrate." Capital punishments are very rare in Hanover. The principal punishments are fine, reprimand, detention in a house of correction, imprisonment, or compulsion to labour for a limited period. Breaking on the wheel is still practised in this country, but it is always preceded by strangulation. Every sentence, however, which inflicts this punishment, must be submitted to the deliberation of the regency. Public works, where the criminals labour, are established in five of the principal cities: the more hardened are sent to Hameln, and others to the quarries of Luneburg. The use of preparatory torture is said to remain unabolished.

The revenues of the kingdom are derived principally from a tax on land,—from a contribution from the peasantry in money, grain, and labour on the roads,—from a poll tax from the different classes of citizens,—from duties on cattle, on the consumption of luxuries, and on salt, coals, and turf. Taxes are also levied on mills, leases, horses, and public carriages, and considerable sums are obtained from tythes,—from tolls on the transit of goods,—from the custom-house, the forests, fisheries, game-laws, the mines of Hartz, the coinage of money, and the postage of letters. The total amount of the revenues has been estimated at 962,500*l* sterling. The national debt is considerable, and was principally contracted to support the seven years war.

Hanover has 10 garrison towns, viz. Hanover, Munden, Zell, Luneburg, Nienburg, Stade, Harburg, Ratzeburg, and Osnaburg. The works of Hameln and Harburg are the most considerable. The fortifications of Stade were demolished in 1781, but those erected on the Klutberg, above the Weser, in 1760, and called Fort George, have become very strong from the addition of new works, The military commandants of these garrison towns enjoy no rank in the army. The following is the military force:—

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| Infantry | 12.015 |
| Cavalry | 4,600 |
| Artillery | 671 |
| Corps of engineers | 95 |
| Militia | 5,500 |
| | 22 881 |

The soldiers are all Hanoverians. The cavalry is generally composed of the sons of farmers, and the militia consists of pensioners who have served 25 years in the army. They have the same organization, equipment, and clothing as the regular troops. The operations of the commander in chief are subordinate to the regency. Every soldier has a right to demand his discharge after 20 years service, and he is entitled to a pension according to his rank. The number of invalids amounts to 7000. No British subjects are employed in the Hanoverian army. The cannon foundry is at Hanover. It is situated on the glacis of the city, on the side next the road leading to Zell. The only manufactory of small arms is one at Hertzberg, which enjoys much reputation in Germany. The best gunpowder is made at Hersen near Hameln. The manufacture of cannon and of powder are both carried on by private individuals.

Hanover contains about 750 parishes, with seven superintendants. The people are divided into Jews and Christians, and the Christians into Catholics, Calvinists, and Lutherans. Before the union of Osnaburg, the Jews were the most numerous sect next to the Lutherans. The Jews are the principal bankers in the large cities, and they keep butchers' shops in the small villages.

The Lutheran is the established religion. The supreme consistory, composed of some of the most enlightened citizens, has the right of superintending all the other sects. The Lutheran clergy are supported by a portion of the property which once belonged to the Catholic church; but the greatest part of it is appropriated for the university of Gottingen, the lyceum of Hefeld, and other public institutions. The ministers of the other sects receive a small sum from government, and derive the rest of their income from their parishioners. The Calvinists are few in number, and there are only a very few Roman Catholics in the kingdom.

A regular system of instruction was adopted in Hanover after the year 1750, in consequence of the liberality of M. Botticher, who endowed a seminary for schoolmasters in the city of Hanover. The electorial regency did all in its power to promote the objects of this institution; and, in order to combine practical with moral and literary knowledge, the children of both sexes were taught to sew, spin, knit, &c. In the middle or secondary schools are taught geography, history, drawing, the French and English languages, together with the elements of geometry. In the academies, or schools of the third order, are taught antiquities, and the Latin, Greek, and other languages. Academies of this kind are established at Zell, Clausthal, Einbeck, Hameln, Hanover, Harburg, Ultzen, Hefeld, Gottingen, Bremen, Luneburg, Minden, Nordheim, Osterode, Stade, and Verden. Besides these academies, there are establishments at Hanover and Luneburg for the education of the young nobility of both sexes, from the period of eight to fifteen years of age. The Georgianum, an establishment of this kind, was founded in May 1796 for the education of 40 pupils, who must be the sons of Hanoverian nobles. Every pupil pays at his entrance about 95 thalers, or nearly 16*l*. sterling; and 15 of those whose parents can afford it pay the additional sum of 120 thalers. They are all boarded, clothed, and taught, at the expence of the establishment. Their dress is a blue uniform, faced with scarlet. They are admitted at the age of 10, and as soon as they have received a suitable education, they may either enter into the military service, or pursue their studies at the University of Gottingen, in order to fit themselves for any other profession. Those who enter into any regiment receive 260 thalers for their equipment out of the funds of the institution; and the most distinguished of the pupils, who are sent to Gottingen, enjoy an annual income of 300 thalers during their three years residence at the university. Belonging to the institution is an excellent library, a collection of natural and artificial curiosities, and a good philosophical apparatus. Primary schools are established in every village; while schools for the classics and the elements of the sciences are founded in all the principal towns. The university of Gottingen is provided with 42 professors. See Gottingen.

Hanover is very far from being a commercial country. At the four fairs which are held annually at Hanover, and the two at Osnaburg, are exposed to sale the commodities which have been purchased at the fairs of Brunswick, Leipsic, and Frankfort. They consist chiefly of earthenware, agriculture and handicraft implements, pins, needles, coarse linen drapery, baskets, coarse stuffs, lace, thread, ribbons, and toys. Articles of English merchandise are brought from Hamburgh, Emden, Bremen, and Brunswick; and the linens of Friesland and of Prussia, and the cloths, silks, and jewels of France, are also met with in Hanover.

A great deal of plain and table linen is manufactured in Hanover. At Osnaburg the most common employment is spinning flax, which is afterwards wrought up into damask, greatly inferior to that of Prussia and Friesland. The greater part of it is sold at home; but in times of peace, the surplus is exported, through the Hanse towns, to North America and the Spanish colonies. Very little hemp is raised in Hanover. Their domestic linens are principally made of flax, which is never spun sufficiently fine to be made into lawns or cambrics. There are also manufactories for coarse cloth and paper, several tanneries, and some glass-houses; and a manufactory for iron and copper utensils at Hartz. The coarse cloths are principally used by the poor, and for clothing the army. The paper is inferior to the Dutch and French papers. One half of the leather, which is not good, is consumed in the kingdom, and the other half exported to Saxony and Belgium. The best glass is made in the bailiwick of Lauinstein. The manufacture of iron articles at Hartz is said by Mangourit to be superior to any thing of the kind carried on in France. Silver plate, jewellery, gold and silver lace, embroidery, and saddlery, are made at Hanover. Diamonds are set in a very superior manner, and the artists also cut white, yellow, or red amber globes, with facets for ear-rings, necklaces, and bracelets, which are bought by the Jews, and sold at an enormous profit.

The principal articles of export are, horses, black cattle, wax, lead, linens, leather, salt, oats, barley, thread, the iron and copper of Hartz, the turf of Bremen, and planks of timber. The two last articles are bought by the merchants of the Hanse and maritime cities.

The principal towns in the kingdom of Hanover are, Hanover, Gottingen, Bremen, Osnaburg, Stade, Ratzeburg, Munden, Zell, Hameln, Klausthal, Einbeck, Harburg, Ultzen, Lauenburg, Mollen, Hefeld, Nordheim, Osterode, Verden, and Nienburg.

Einbeck, or Einbike, the capital of the principality of Grubenhagen, is a walled and fortified town, situated in a fertile territory at the confluence of the Ilm, Krumewasser, and Leine, near the borders of Calenburg. Besides ramparts, bulwarks, and towers, it has moats and outworks. Considerable quantities of woollen cloth are made here, and it has several breweries. Its population is 4500. Osterode, containing 4000 inhabitants, is situated six leagues east of Einbeck, at the conflux of the Sole and Apenke. It has an ancient castle; and a manufacture of camblets, besides quarries and mills, and lime-kilns. Nordheim, erected into a town in 1252, is situated on the Ruhme, which here divides itself into two branches, a few miles above their influx into the Leine. The organ of the parish church is famous for its immense size. Tobacco is cultivated in the neighbourhood, and it has several flourishing manufactures. Near this town a sulphureous spring was discovered in 1804, and baths have been erected at the house of the woodkeeper. It contains 3000 inhabitants. Ultzen, or Uelzen, is a trading town, consisting of 330 houses, situated on the Ilmenau, at the confluence of several small streams. It had formerly a great trade in flax, linens, wool, wax, and butter; but it is now on the decline. Verden has a fine cathedral, with very interesting monuments, and a population of 4000. Danneberg is a decayed town of 160 houses, with a ruinous castle on an eminence, watered by the Tetze. The chief export is beer. Nienburg is situated on the Saale, in upper Saxony, but near the borders of Lower Saxony, it has a fine stone bridge over the Weser. It contains a palace erected out of a convent of monks, and is celebrated for a kind of beer like English ale. For an account of the other towns, see Bremen, Gottingen. Hameln, Hanover, Harbourg, Klausthal, Luneburg, Munden, Osnaburg, Ratzeburg, Stade, Zell.

The illustrious house of Hanover is descended from Margrave Azo, who possessed the Milanese, Genoa, and part of Lombardy, in the 11th century. He was succeeded by Welpho the Fat, who married the Marchioness of Tuscany. Welpho having died without issue, his Italian estates, and the duchy of Bavaria, came into the possession of his brother Henry the Black, who obtained the county of Luneburgh with his wife Wulphilda, daughter of Magnus Duke of Saxony. His son Henry the Proud having married the daughter of Lotharius II. obtained along with her the duchy of Saxony, and the hereditary lands of Brunswick Nordheim, and Supplingenburg; and the dominions of the family extended from the Rhine to the Vistula, when her son Henry the Lion reduced the Slavi, on the coast of the Baltic. In 1179, he was put under the ban by the Emperor, and deprived of all his possessions in Italy and Swabia, and of the duchies of Saxony and Bavaria. He was allowed, however, to retain Luneburg, some lordships, and his Slavian conquests. His son Otho obtained the imperial dignity in 1209; and, in the course of time, his family was divided into two branches, two of which now exist, viz. those of Wolfenbuttel and Zell. The first was founded by Henry, and the second by William, the sons of the Duke Ernest, who introduced into his dominions the reformed faith. Ernest Augustus, his grand nephew, and Elector of Hanover, married Sophia, the daughter of the Elector palatine, and of Elizabeth, the daughter of James I. of England, and established the right of primogeniture in the Wilhelmine line. In the year 1714, George Louis his son succeeded, in virtue of the act of succession, (see Britain,) to the throne of England, and since that time the kings of England have been the electors of Hanover. In the year 1715, the Duchy of Verden was ceded to the Elector of Hanover by the alliance concluded at Wismar; and in 1719, by the treaty of Stockholm, Bremen was also transferred to the elector, who, in 1732, obtained the emperor's investiture for both Bremen and Verden. In October 1801, the Prussians, under the fatal influence of the government of France, had declared war against Great Britain, and had taken possession of the Electorate of Hanover; but at the peace of Amiens, the electorate was restored to its lawful sovereign. The Bishopric of Osnaburg, or Osnabruck, which, by the peace of Osnaburg, was to be occupied alternately by a Roman Catholic and a Lutheran bishop, the last of whom must be selected out of the house of Brunswick Luneburg, was secularised by the treaty of Luneville, and was ceded by the treaty of Amiens, in 1802, to George III. as elector of Hanover.

When Bonaparte had determined to make war upon Great Britain, he marched his army into Osnaburg and Hanover. On the 9th of June 1803, the French, under the command of General Drouet, took possession of the country and city of Osnaburg; and after a slight engagement, the convention of Suhlingen was entered into on the 3d of June 1803, between General Mortier and Marshal Walmoden, the commander of the Hanoverian army. The first consul immediately sent this convention to England, declaring that he would ratify it as soon as it had been sanctioned by his Britannic Majesty. The English government, however, refused to give any sanction to this convention. They averred, that the character of George III. as elector of Hanover, was distinct from his character as king of Great Britain, and that in the year 1795, the French government had acknowledged his neutrality as elector of Hanover during the existence of a war with Great Britain. The king therefore resolved to abstain from every act which might be considered as contravening the stipulations of the convention concluded on the 3d of June, between the deputies appointed by the regency of Hanover and the French government, until he should make an appeal to the empire and to the powers of Europe, who had guaranteed the Germanic constitution, and consequently his rights and possessions as a prince of the empire. On the 30th of June, General Mortier communicated the resolution of the British government to Marshal Walmoden, and summoned him to surrender his army in 24 hours, to be sent prisoners of war into France. The Hanoverian general declared that his army should perish in the field rather than consent to such humiliating terms. General Mortier was thus induced to offer milder terms, and a capitulation was signed on the 4th of July, by which the Hanoverian army laid down its arms, which, with all the artillery, was to be delivered up to the French, along with the cavalry and artillery horses, to the amount of 4000. The soldiers were to return to their respective homes, and engaged not to serve against the French till regularly exchanged.

Hanover continued in the possession of the French till the year 1806, when it was occupied by the Prussians. It was afterwards annexed to the new kingdom of Westphalia, which was formed for Jerome Bonaparte.

In consequence of the great events in 1813, (see France,) which have led to the liberation of Germany, Hanover was restored to its ancient rights, by the army of the Crown Prince of Sweden. It of course reverted to its legitimate sovereign at the treaty of Paris in 1814, and has since continued in a state of tranquillity and happiness. At the second treaty of Paris, in 1815, the electorate of Hanover was converted into a kingdom.

The population of Hanover is about 800 000 souls, which gives about 1500 to every square German mile. The population of the principality of Osnaburg is about 133,000; so that we have, according to Mangourit,

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| Hanover Proper . . . . . . . . . | 800,000 |
| Principality of Osnaburg . . . . | 133,000 |
| Population of Osnaburg . . | 933,000 |

The following is another estimate of the population:

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| Principality of Calenburg, . . . . | 210,000 |
| Principality of Luneburg-Zell, . . . | 200,000 |
| Duchy of Bremen, . . . . . . . . | 167,149 |
| Principality of Osnaburg, . . . . | 117,896 |
| Principality of Grubenhagen, . . . | 80 000 |
| Duchy of Saxe Lauenburg, . . . . | 40,000 |
| County of Hoya . . . . . . . . . | 40,000 |
| Duchy of Verden, . . . . . . . . | 30,000 |
| County of Diepholtz, . . . . . . . | 12,000 |
| | 897,045 |

See particularly Mangourit's *Travels in Hanover*, during the time of its occupation by the French; Catteau de Calleville's *Voyage en Allemagne;* Peuchet's *Dictionnaire de la Geogr. Commerc.*; and the article Hartz.

HANOVER is a fortified town of Germany, and capital of the kingdom of the same name. It is situated in a sandy plain, on both sides of the river Leine, which divides it into two towns, viz. Old and New Hanover. The old town lies on the left bank of the river, which here forms two branches, and, after inclosing an island, they again reunite and become navigable. The old and new towns are connected by bridges. The town is built in the form of a half moon, and contains several good streets. The houses of the new street called George-strass are all built on the same plan. This street, or rather row, is built along the side of a fine rampart, from which it is separated by iron chains, resting on pillars of free-stone. There is a Gothic appearance in most of the buildings of Hanover. The houses resemble the galleries of a vessel of the sixteenth century, and the time of their erection is always marked upon them. In those dated 1565, each story projects several feet over the one below it, and exhibits medallions, pagan deities, warriors, and verses of the Psalms. Red and green bricks are intermixed in some of the edifices, and in others varnished tiles are arranged in rows. Sometimes bricks are only used for the doors and windows, while the rest of the house consists of wood, painted of various colours. In some houses, the bricks are placed in wooden frames, and secured by plaster. The town, however, contains many handsome buildings. The Elector's palace, which, after being destroyed by fire, was rebuilt in 1791, is a fine building, constructed of hewn stone. This was the seat of the regency. The newly erected part of the electoral church, and the palace of the Princess of Wales, are likewise excellent buildings of stone. Hanover contains also a theatre, three parish churches, a poor-house, and three hospitals. The public library of Hanover is a respectable building. The first story is appropriated to charts, state papers, and judicial records. The upper stories contain works of imagination and belles lettres. When the French threatened to invade Hanover, the Elector ordered the four copies of the beautiful Oxford Bible, the books, and the precious monuments, to be packed up and removed. We believe that they were afterwards sent back to the capital. This library was founded by Leibnitz, who bequeathed to it his own fine collection of books. There are two portraits of this great man in the library, one at the age of 40, and the other at 60; and the arm-chair in which he expired is there carefully preserved. His remains are interred under a stone in the Lutheran church in the new city. A very fine monument is also erected to his memory by private subscription. It is an Arian temple, situated in an umbrageous thicket, at the end of a long avenue of linden trees. Twelve columns of the Tuscan order, of hard grey stone, quarried in the Hartz mountains, support a light cupola, beneath which is placed a white marble bust of Leibnitz, taken from the picture of him at the age of 60. "To the memory of Leibnitz," is the simple inscription which reminds us of the labours of this great philosopher.

The cemetery of the Jews is situated on an oval eminence near the city; and that of the Lutherans is a vast field, surrounded by a parapet, and crowded with funeral monuments. The tomb-stones of the noble families occupy a large space in the middle of the field. The graves of the lower classes are every day covered with fresh flowers. The remains of the celebrated physician Wherloff lie under a triangular pyramid. "Not far distant," says Mangourit, "is a monument, representing a mother stretched upon the body of a beloved daughter; the scissars of fate cut a half blown rose, and the parent tree, stripped of its leaves, is torn up by the root. Just by is the tomb of the lover of the young lady. The sculptor has succeeded in depicting the beauty and elegant figure of this youth. On one side of the monument we behold a superb oak; on the other, the oak is reversed, its branches are broken, its leaves fallen, and its seed scattered." There are here some tombs and sarcophagi of white marble; but the greater number are formed out of stones from the Hartz mountains.

There is at Hanover a society of natural history; the seminary for schoolmasters; the female school of industry, conducted by Madame Klockenbrigg, in which some excellent pieces of embroidery are executed, and sold at a very high price.

Hanover formerly carried on manufactures of various kinds, particularly linen, damask, printed cotton, tapestry, wax-cloths, stockings, caps, gloves, flannels, serges, tobacco, lace, gold and silver lace, and ribbands; but we have not been able to learn in what state these manufactures are at present. There is a cannon foundry at Hanover, situated on the glacis of the city. The retail shops of Hanover, and the ware-houses of cloths and of French silks, are well supplied; English cloths and cottons a so abound.

The environs of Hanover are very beautiful. The city looks well at a distance with its four steeples, its houses intermixed with poplars and lime-trees, and its rural suburbs. The irregular assemblage of religious monuments, plain and handsome palaces, Gothic buildings, small wooden houses, churches painted of various colours, and arbours of different shapes and sizes, have a very singular effect. The windings of the Leine are very agreeable, and the triple row of lime-trees planted along its banks, which are covered with rose bushes and sword-grass. The windings of the Leine are, however, artificial. The springs near the fortifications not being sufficient to fill the ditches, a canal was cut in a serpentine direction, to the distance of about three kilometers above the city. This canal now conveys the provisions to the capital. In order to prevent the river from flowing back to its former bed, and to relieve it when too full, a large barrier, about 2 kilometers long, has been built of gray stone, so as to allow the surplus waters to flow into its former channel by three long dams. This work is admirably and solidly executed.

The principal promenades at Hanover are the garden of Madame La Baronne de Decker, the garden of Count Field Marshal Walmoden, Montbrillant and Herrenhausen, the country seat of the Electors of Hanover. The approach to Herrenhausen is by a long avenue of lime-trees. The castle is by no means a handsome building, and the grounds are laid out with the greatest uniformity. The water works are good, and before the central basin is a neat rural theatre. The orangerie, which formerly served as a ball room to the court, is a very long hall, decorated at every twelve feet with copies of ancient busts. It contains some fine orange plants, placed in boxes surrounded with laurels, and cut into a pyramidal shape. The garden of Herrenhausen is extremely interesting to botanists, and is said to be surpassed only by that of Schoenbrunn. Population, 15,500, or 19,444 according to Tynna *Almanac du Commerce pour* 1811. East Long. 9° 42′ 55″, and North Lat. 52° 22′ 25″. See Mangourit's *Travels in Hanover*, passim; and Reichard's *Guide des Voyageurs en Europe*. tom. ii.

HANSE TOWNS, is the name given to a number of towns in Germany and the north of Europe, who entered into a league for the protection of their commerce. This association is supposed to have commenced in 1169. It was confirmed in 1226 and 1284, and a general assembly of the members was held every ten years.

Almost every trading town in Europe became ambitious of joining the league; but it seems to have been a fixed principle, that every town was excluded that was not situated on the sea, or on some navigable river.

In the year 1226, the Hanse Towns were 72 in number; and among these were Calais, Rouen, St Maloe, Bourdeaux, Bayonne, Marseilles Barcelona, Seville, Cadiz, London, Lisbon, Antwerp, Bruges, Rotterdam, Ostend, Dunkirk, Messina, Leghorn, and Naples.

The towns were distinguished into four classes, at the head of which were Lubeck, the capital of the league, Cologne, Brunswick, and Dantzic.

This powerful association was in its most flourishing condition about the end of the 14th and the beginning of the 15th century, and interfered, to a great extent, in the affairs of Europe. The jealousy, however, of the European princes induced them to withdraw the merchants of their respective countries from the league; and in a short time it was so much reduced, as to comprehend only the four principal towns of Lubeck, Cologne, Brunswick, and Dantzic. In 1803, the only members of the league were Lubeck, Hamburgh, and Bremen. What changes it is to receive from the recent revolutions which have taken place in Europe time only can determine. See COMMERCE, and DENMARK.

HAN-TCHONG-FOO. See CHINA.

HAPAEE ISLANDS. See FRIENDLY ISLANDS.

HAREM. See SERAGLIO.

HARBOROUGH. See LEICESTERSHIRE.

HARBOUR. See INLAND *Navigation.*

HARBOURG, or HAARBURG, is a town of Germany, in the kingdom of Hanover. It is situated opposite to Hamburgh, on the Seeve, near its influx into the Elbe. It is pretty strongly fortified, and is advantageously situated for carrying on a considerable trade. Great quantities of wood are cut in the neighbourhood, and sent to Holland and France. There is here a manufactory for bleeching wax, a refinery of sugar, and manufactories of starch, stockings, ribbonds, and hats. Two packet boats set out every morning and evening for Hamburgh, the distance of which is only seven miles. The harbour of Harbourg, which is called Lotz, is so deep, that the largest vessels from Holland and Friesland can enter it and deliver their cargoes. A ditch or canal, furnished with two sluices, has been cut from the Elbe to the castle, which greatly facilitates the navigation and trade of the town. Population of the town 3500.

HARDICANUTE. See ENGLAND.

HARE. See MAMMALIA.

HARELIP. See SURGERY.

HAREWOOD, is a small town of England, in the west riding of Yorkshire, and one of the most beautiful in the kingdom. It lies between Harrowgate and Leeds, in a fine, rich, and beautifully wooded country. The houses are almost all built uniformly, and covered with slate. Before we enter the town from the north is Harewood castle, on the west side of the road. It stands on the brow of the hill, and is a lovely ruin almost covered with ivy. It is esteemed a fine specimen of castellated architecture, and is described in the *Archæologia*, vol. vi. The gateway to Harewood house, the seat of Lord Harewood, is at the south end of the town. It is recently built, and is one of the finest pieces of architecture we have seen. The view of Harewood house, and the surrounding country from the top of the hill, at the southern gate, is unusually grand.

HARFLEUR, is an ancient town of France, in the department of the Seine. It was formerly called *Hareflotum*, *Harflevium*, and *Heriflorium*. It is situated on the small river Lezarde, at the mouth of the Seine, and was formerly the key of France on the side of England; but it has fallen into decay, in proportion as Havre has risen in importance. Its walls have been razed, its harbour choked with sand, its fortifications demolished, and its trade ruined. There are here small manufactories for lace, cotton, linen, and beer. Peuchet, in 1800, has stated the population at 4388; but Tynna, in the *Almanac du Commerce* for 1811, makes it only 1600. A work was published at Harfleur in 1720, entitled *Antiquités de Harfleur*. See ENGLAND, for an account of the siege of Harfleur.

HARIDI. See ACHMIM.

HARMATTAN. See GUINEA.

HARMONIÆ, in music, an interval so named by M. Henfling, whose ratio is $\frac{125}{128}$, $=21\Sigma+2$ m, and is the greater ENHARMONIC *Diesis*, which see.

HARMONIC ELEMENTS, or *Concordant Elements*, are the three smallest concords, viz. 3d, III, and 4th, each one of which singly is harmonious; so is the sum of every two of them, as 3d+III=V, 3d+4th=6th, and III+4th=VI; and so is the sum of all three, as 3d+III+4th=VIII; and further, this latter concord (VIII) may be added once, or any greater number of times, to itself, or to any one of the six concords above mentioned, and still a concord will result: thus, 2 VIII=XV; 3 VIII=XXII; VIII+3=10th; VIII+III=X; 2 VIII+4=18; 2 VIII+V=

XIX, &c. are all concords; and, except the *Unison* (I), there are in nature no other *concords*, or combinations of two sounds, which are agreeable and pleasant to the ear, and produce *beats* when slightly altered or tempered, but those derived in the manner above described. See Concord. (ϱ)

HARMONIC Sliders, are the contrivance of Dr Thomas Young, for exhibiting to the eye the effects of the undulations or *beats* of tempered concords, which he has described in the *Journals of the Royal Institution*, p. 261, and illustrated the same by a drawing, intended to represent the *beating* of the imperfect *unison*, whose ratio is $\frac{17}{18}$, $=50,46033\Sigma+f+4m$; but which being nearly as large as the elementary *semitone* and a discord, is very improperly called a *unison*, or a beating concord.

The following is Dr Young's own account of this invention: "The combination of undulations is of acknowledged utility in illustrating the phenomena of musical consonances and dissonances, and of undeniable importance in accounting for many of the phenomena of the tides. Each tide is an undulation on a large scale; and supposing the general form of the ocean, in consequence of the attraction of a distant body, to coincide with that of an oblong spheroid, as it is found by calculation to do, the section of the surface of each tide, if conceived to be unbent from the circular form, and extended on a plane, would form the harmonic curve: (Young's *Syllabus*, IV. 151. 155.) It is remarkable that the motions of the particles of the air in sound have been generally supposed in theory to correspond with the ordinates of this same curve, and that there is also experimental reason to believe, that the purest and most homogeneous sounds do in fact agree very nearly with the law of this curve. It is therefore by far the most natural as well as the most convenient to be assumed, as representing the state of an undulation in general; and the name of these harmonic sliders is very properly deduced from the harmonic curve.

By means of this instrument, the process of nature, in the combinations of motion which take place in various cases of the junction of undulations, is rendered visible and intelligible, with great ease, in the most complicated cases. It is unnecessary to explain here, how accurately both the situations and motions of the particles of air, in sound, may be represented by the ordinates of the curve at different points: it is sufficient to consider them as merely indicating the height of the water constituting a tide, or a wave of any kind, which exists at once in its whole extent, and of which each point passes also in succession through any given place of observation. We have then to examine what will be the effect of two tides, produced by different causes, when united. In order to represent this effect, we must add to the elevations or depressions in consequence of the first tide, the elevations or depressions in consequence of the second, and subtract them when they counteract the effect of the first: or we may add the whole height of the second above any given point or line, and then subtract, from all the sums, the distance of the point assumed below the medium.

To do this mechanically is the object of the harmonic sliders. The surface of the first tide is represented by the curvilinear termination of a single board, Plate CCLXXXVIII. Fig. 1. The second tide is also represented by the termination of another surface; but, in order that the height at each point may be added to the height of the first tide, the surface is cut transversely into a number of separate pieces or sliders, which are confined within a groove or frame, and tightened by a screw, Fig. 2. Their lower ends are situated originally in a right line; but by loosening the screw and moving the sliders, they may be made to assume any other form: thus they may be applied to the surface representing the first tide; and if the similar parts of each correspond, Fig. 3, the combination will represent a tide of twice the magnitude of the simple tides.

The more the corresponding parts are separated, the weaker will be the joint effect, Fig. 4.; and, when they are furthest removed, the whole tides, if equal, will be annihilated, Fig. 5. Thus, when the general tide of the ocean arrives by two different channels at the same port, at such intervals of time that the high water of one would happen at the same instant with the low water of the other, the whole effect is destroyed, except so far as the partial tides differ in magnitude. The principle being once understood, it may easily be applied to a multiplicity of cases; for instance, where the undulations differ in their dimensions with regard to extent. Thus, the series of sliders being extended to three or four alternations, the effect of combining undulations in the ratio of 2 to 1, of 3 to 1, of 2 to 3, of 3 to 4, may be ascertained, by making a fixed surface, terminating in a series of curves, that bear to those of the sliding surface the ratio required: and, by making them differ but slightly, the phenomenon of the beating of an imperfect unison in music may be imitated, where the joint undulation becomes alternately redoubled and evanescent. In Fig. 6. the proportion is that of 17 to 18, and the curvilinear outline represents the progress of the joint sound from the greatest degree of intensity to the least, and a little beyond it."

HARMONICAL Mean, is a term used by arithmetical and algebraical writers to express certain relations of numbers and quantities: but with which *musical* calculators will find that they need have little to do, any more than with the harmonical or *musical* proportions and progressions of the same writers. If two quantities $a$ and $b$ are given, then $\frac{2ab}{a+b}$ is said to be the *harmonical mean* between them; for example, between 2 and 6, the harmonical mean is $\frac{24}{8}=3$: between 5 and 9, it is $\frac{90}{14}=6\frac{3}{7}$. Dr Smith in his *Harmonics*, 2d edit. p. 125, shews, how to find the harmonical mean, among any number of quantities: see also p. 141, *Ibid.*

HARMONICAL or Musical Proportion, of arithmetical and algebraical writers, is said to obtain between three quantities, as $a$, $b$ and $c$, when $a:c::a-b:b-c$; and between four quantities, as $d$, $e$, $f$ and $g$, when $d:g::d-e:f-g$; and so 2, 3 and 6; and 1, 3, 2 and 6 are said to be in musical proportion: And several of these writers say, that if to the three terms above mentioned, "proportional terms are continued, there will arise an *harmonical progression*" or series: but in all these cases, the terms *harmonical* and *musical*, seem only *figuratively* applied. (ϱ)

HARMONICS, in music, besides being used to designate the science or philosophy of musical sounds, as Dr Robert Smith uses this term, in making it the title of his justly famous work on this subject, imply also certain derivative or dependent *new sounds*, which, under favourable circumstances, are generated and heard, along with every single musical sound, or accompanying every consonance of two such sounds, but with less intensity or loudness than the original, or *generators* of these new sounds; and in the latter case, of their production by a consonance, when they are called *grave* Harmonics, (see that article,) such new sounds are further distinguished, by not having a *fixed direction*, towards (or from) the sounding body, but, like the sensation called "a singing in the ear," they are alike heard in any direction to which the ear is turned; a property of these derivative sounds, which Mr John Gough first explained, we believe, in

Nicholson's *Journal*, 8vo. vol. iv. p. 2. The other kind of these new sounds, derived from a single sound, are called *acute* HARMONICS, which see. (ϱ)

HARMONICS, ACUTE, are phenomena attending a sounding string or pipe, &c. which were first noticed by Galileo, and subsequently by Peter Marsenne, M. Sauveur, M. Tartini, &c.: but Daniel Bernoulli first discovered the reason, and explained the theory of the acute harmonics, by shewing, that a sounding string, at the same time that its whole length vibrated a given note, might maintain subordinate vibrations of its *half*, its *third* part, its *fourth*, and its *fifth* parts in length; each of such vibrating parts impressing on the surrounding air independent pulses, the times of whose single vibrations are in the ratios 1, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$; and by which the original sound, or *generator*, would be accompanied by its octave or VIII, its major twelfth or XII, is double octave or XV, and by its major seventeenth or XVII; although only the XIIth and XVIIth, or octave of the fifth and double octave of the major third, had yet been described, among the acute harmonics attending a sound. And this great mathematician, although unable to contrive any experiment, by which the vibrations of the $\frac{1}{5}$ and $\frac{1}{4}$th part of the string might be evidently shewn to subsist along with the whole vibrations, yet he shewed, from the nature of the Taylorean or harmonical curve, that these subdivisions of a sounding string were not only alike possible, and even more probable to happen than those of $\frac{1}{3}$d, and $\frac{1}{5}$th; but that theory and probability were not against the happening of even more minute vibrating divisions of the whole string, as $\frac{1}{6}$th, $\frac{1}{7}$th, $\frac{1}{8}$th, $\frac{1}{9}$th, &c.: and that in the use of the trumpet, horn, and other sounding tubes or pipes, all these subdivisions of the whole vibrating column of air might be made, separated by nodes or points in the axis of the tube, in a comparative state of rest with regard to these inferior or harmonical vibrations, although moving to and fro with the velocity peculiar to the sound of the whole tube: and he inferred, with great seeming probability, that the parts of bells, and most other bodies yielding musical sounds, were in the same manner capable of subordinate or acute harmonic vibrations, along with those of their principal or gravest sound.

It was probably not until about the year 1765, after the very ingenious Mr James Watt of Birmingham had contrived his wheel monochord, that the acute harmonics of a vibrating string were produced in experiment, and some of them actually rendered visible to the eye; as is related by the late Dr Robinson, who, several years after, made a more extended and complete set of experiments on the same instrument which Mr Watt had before used; thereby fully confirming all that D. Bernoulli had theoretically advanced.

Some years after this, Mr John Isaac Hawkins of London, the ingenious inventor of the piano-forte with spirally coiled strings, and of the *claviole*, or finger-keyed viol, contrived an experiment, which seems to leave nothing to wish with regard to this very curious and interesting subject. A spirally coiled string, many feet in length, was prepared by winding a brass piano-forte bass wire closely round a steel wire about the size of a crow quill, and when removed therefrom, pulling it out, so that its spirals became considerably more open, comparatively, than those of a common cork screw, or the string was nearly in the state of being "cockled," as tuners call it, at equal distances, throughout its whole length. Along the side of a large wainscoated room, this spirally coiled string was stretched, over two bridges, near its extremities, and brought to such a degree of tension, as not to yield a sound, but leave its vibrations, when strongly twitched, plainly visible to the eye. The space between the bridges had previously been carefully divided, on the wainscoat, into numerous equal parts, and marked $\frac{1}{2}$; $\frac{1}{3}$, $\frac{2}{3}$; $\frac{1}{4}$, $(\frac{2}{4})$, $\frac{3}{4}$; $\frac{1}{5}$, $\frac{2}{5}$, $\frac{3}{5}$, $\frac{4}{5}$; $\frac{1}{6}$, $(\frac{2}{6})$, $(\frac{3}{6})$, $(\frac{4}{6})$, $\frac{5}{6}$, &c.; and if, when the whole string was vibrating, a slight obstacle was opposed to the vibrations of the string, opposite to any one of these divisions, like the edge of the feathers of a quill, held to touch it very lightly, or even if a sudden blast of air from the mouth were made on the string, opposite a division, the string instantly assumed all the subordinate vibrations proper to the aliquot division against which the obstacle or impulse was directed; and the eye and ear too, in many of the instances, could be gratified, by seeing these very compound vibrations simultaneously carried on by the whole string, and by its several aliquot parts, during several minutes, under favourable circumstances, many of the vibrations being slow enough to be counted, and their number in a given time ascertained and compared, by which every point of the theory of D. Bernoulli is in the fullest manner confirmed.

Thus an evident explanation is offered, of all the curious harmonic effects of several unison strings on the ÆOLIAN *Harp*, (see that article) when agitated by irregular gusts of wind: acting momentarily on the whole string, and on its different nodes, with sufficient force to excite *the determinate vibrations*, which the elasticity of the string, and its parts, *dispose them* severally to take; but all of which vibratory motions are so vastly quicker than the mere motion of the wind, that we cannot agree with Dr Matthew Young in thinking, that particular tones are excited, or kept up, by that means.

We have calculated the values of all the aliquot parts of a string or pipe (in Farey's Notation of Intervals) above the note of the whole string, viz. $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, &c. as far as $\frac{1}{32}$, and deducted octaves, so as to bring them all within the compass of one octave; and the same, when arranged under their respective finger-key intervals, stand as follows, viz.

| | | |
|---|---|---|
| VIII | $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, $\frac{1}{32}$, | |
| | $\frac{1}{31}$, | = 5 VIII — 28.11748 Σ — 2 m |
| VII | $\frac{1}{15}$, $\frac{1}{30}$ | |
| 7th | $\frac{1}{29}$ | = 4 VIII + 7th* + 6 12449 Σ + m |
| | $\frac{1}{7}$, $\frac{1}{14}$, $\frac{1}{28}$, | . . . 7th — 24.9472 Σ — 2 m |
| VI | $\frac{1}{27}$ | = VI′, = VI + 11 Σ + m |
| | $\frac{1}{13}$. $\frac{1}{26}$, | . . . VI — 22.58107 Σ — 2 m |
| 6th | $\frac{1}{25}$ | = 6th — 21 Σ — 2 m |
| V | $\frac{1}{3}$, $\frac{1}{6}$, $\frac{1}{12}$, $\frac{1}{24}$ | |
| 5th | $\frac{1}{23}$ | 5th + 9.46026 Σ + m |
| IV | | IV + 19 46026 Σ + 2 m |
| 4th | $\frac{1}{11}$, $\frac{1}{22}$, | . . . 4th + 27.25171 Σ + 2 m |
| | $\frac{1}{21}$ | = 4th — 13.9472 Σ — m |
| III | $\frac{1}{5}$ $\frac{1}{10}$, $\frac{1}{20}$ | |
| 3d | $\frac{1}{19}$ | . . . . = 3d — 9.27098 Σ — m |
| II | $\frac{1}{9}$, $\frac{1}{18}$ | |
| 2d | $\frac{1}{17}$ | . . . . = S — 3.46819 Σ |
| I | $\frac{1}{1}$ | |

Wherein the errors or temperaments of all these acute harmonic notes are set down; and hence we perceive clearly the reason why a sound is accompanied chiefly by its VIIIth, VIII + Vth, and 2 VIII + IIIrd, and rarely by any other of its harmonics, viz. because $\frac{1}{2}$ of the string is strengthened, or reinforced by four other octaves to it: the XIIth (or V) is re-inforced by 3 other octaves to it, and the XVIIth (or III) by two other octaves to it; and these three are the only *concords* to the whole string, that

* The ratio of this minor seventh being $\frac{5}{9}$, = 519 Σ + 10 f + 45 m.

are found among its numerous harmonics. The II and the VII, each with the reinforcement of an octave thereto, should, and accordingly are, next heard in the order of acute harmonics. The harmonic 6th, being a diatonic interval, viz. 6—ℰ, whose ratio is $\frac{16}{27}$, $=394\Sigma+8f+34m$, may perhaps, under very favourable circumstances, be heard as an acute harmonic: but when the very discordant nature of all the remaining sounds in one table, both with the generator and with all of its other harmonics, respectively, are considered, it seems very plain why these sounds, although momentarily produced by a gust of wind, or other impulse, *on the proper part of the string*, almost immediately die away, and cannot be maintained, as the VIIIth, XIIth, and XVIIth may be, and others, in less degrees. (ϱ)

HARMONICS, Grave. These are low sounds, of small intensity or loudness, which, if attentively observed by an experienced ear, will be heard to accompany every accurate or perfect consonance of two sounds, whose ratio is expressible in small numbers, whether the same may be composed of the Diatonic primes 1, 2, 3, and 5, or of somewhat larger prime numbers.

A grave harmonic of a different species from the above is also heard, whenever the Beats of an imperfect or tempered concord (see that article) exceed 12 or 13 in a second of time.

About the beginning of the last century, M. Sauveur considered the reinforcement of sound which must periodically take place, while we hear a consonance of two musical sounds, whose ratios are in small numbers, occasioned by the coincidence at short intervals of the pulses of the two sounds. These reinforcements he called *beats;* and, as Dr Robert Smith has observed, improperly confounded these, which are grave harmonic sounds, (because rarely occurring so seldom as twelve times in a second,) with the *beats* (of imperfect concords) properly so called, which can be separately heard, and distinctly counted, in every instance where the degree of temperament or imperfection is sufficiently small.

About the year 1754, M. Rameau and M. Tartini first made observations on the coincident pulses of consonances with small ratios; but each of the ten grave harmonics which the latter has mentioned, have been found by later observers to be an octave too high; that is, the new sounds really heard to result from the rapid coincidence of the pulses of the single sounds, are an octave lower with regard to these sounds than Tartini supposed; errors which few will wonder at, who have experienced the difficulty of avoiding errors of an octave, or sometimes more than one, in estimating sounds that are either very high or very low.

In 1807, Mr John Holder published a work on music, in which he attempted to build a good deal of the theory of composition and harmonical effect on these grave harmonic sounds, accompanying consonances as their "dependants;" but most of his speculations have failed, and many of them led to very absurd conclusions, owing to his having set up and used a defective or false rule, for assigning the grave harmonic of a given consonance.

It is the more necessary, therefore, to give here a true rule for finding the grave harmonic of any given consonance, viz. Find the vibrations made by each of the sounds of the given consonance in one second, divide these successively by the reversed terms of the given ratio of the consonance, and the quotient (in each case) will give the vibrations for 1″ of the grave harmonic; the ratio of which vibrations, to the vibrations of either of the given sounds respectively, will give the interval of the harmonic below such given sound.

If, for example, the major second CD were given in the middle of the scale, where the ratio is $\frac{8}{9}$, and the sound of the lowest note (on the tenor cliff line) makes 240 vibrations per 1″, then $\frac{9}{8}\times240=270$ is the vibrations of D, and $\frac{270}{9}=30$, or $\frac{240}{8}=30$, the vibrations of the harmonic note; and its interval below the lower note C is $\frac{30}{240}=\frac{1}{8}$, or 3 VIII; and below the upper note D is $\frac{30}{270}=\frac{1}{9}$, $=$ 3VIII+II. The principal intervals of the scale, and some others, calculated as above, have their grave harmonics shewn in the following Table, viz.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $\frac{1}{2}$ | VIII | 480 | 240 | $\frac{1}{1}$ | 1 | $\frac{1}{2}$ | VIII |
| $\frac{8}{15}$ | VII | 450 | 30 | $\frac{1}{8}$ | XXII | $\frac{1}{15}$ | XXVIII |
| $\frac{5}{9}$ | 7′ | 432 | 48 | $\frac{1}{5}$ | XVII | $\frac{1}{9}$ | XXIII |
| $\frac{9}{16}$ | 7 | $426\frac{2}{3}$ | $26\frac{2}{5}$ | $\frac{1}{9}$ | XXIII | $\frac{1}{16}$ | XXIX |
| $\frac{3}{5}$ | VI | 400 | 80 | $\frac{1}{3}$ | XII | $\frac{1}{5}$ | XVII |
| $\frac{5}{8}$ | 6 | 384 | 48 | $\frac{1}{5}$ | XVII | $\frac{1}{8}$ | XXII |
| $\frac{2}{3}$ | V | 360 | 120 | $\frac{1}{2}$ | VIII | $\frac{1}{3}$ | XII |
| $\frac{3}{4}$ | 4 | 320 | 80 | $\frac{1}{3}$ | XII | $\frac{1}{4}$ | XV |
| $\frac{4}{5}$ | III | 300 | 60 | $\frac{1}{4}$ | XV | $\frac{1}{5}$ | XVII |
| $\frac{5}{6}$ | 3 | 288 | 48 | $\frac{1}{5}$ | XVII | $\frac{1}{6}$ | XIX |
| $\frac{27}{32}$ | 3′ | $284\frac{4}{9}$ | $8\frac{8}{9}$ | $\frac{1}{27}$ | XXXIV | $\frac{1}{32}$ | XXXVI |
| $\frac{8}{9}$ | II | 270 | 30 | $\frac{1}{8}$ | XXII | $\frac{1}{9}$ | XXIII |
| $\frac{9}{10}$ | II′ | $266\frac{2}{3}$ | $26\frac{1}{3}$ | $\frac{1}{9}$ | XXIII | $\frac{1}{10}$ | XXIV |
| $\frac{15}{16}$ | 2 | 256 | 16 | $\frac{1}{15}$ | XXVIII | $\frac{1}{16}$ | XXIX |
| $\frac{1}{1}$ | 1 | 240 | 0 | | | | |

The *first* column of the above Table shews the ratios of the given consonances; the *second*, the intervals expressed in numerals; the *third*, the vibrations per second, supposing the lower part to be the note on the tenor-cliff line of the stave; the *fourth* column contains the calculated vibrations of the harmonic note; column *five* shews the ratio, and column *six* the interval of this harmonic, below the lowest of the given notes or C; and columns *seven* and *eight* shew the same things with regard to the highest of the given notes.

For the sake of more ready comparison with Mr Holder's defective rule for calculating grave harmonics, the errors of which it seemed of some importance to place in as clear a view as possible, we have given above a far less simple rule for obtaining the ratios of the new sounds, with relation to either of their generators, than the one which we are now about to add, viz. The ratio of any given consonance above a bass or fundamental note being $\frac{a}{b}$, $a$ being the least term of the ratio; then $\frac{1}{b}$ is the ratio of the grave harmonic below the bass note, and $\frac{1}{b}$ the ratio of the same harmonic below the upper note of the consonance; which is too evident, from an inspection of the above Table, to need a particular example.

With regard to the other kind of grave harmonics, the results of *tempered* concords, which beat too fast to be separately counted or perceived: If, for instance, we were to consider the grave minor third $\frac{27}{32}$ in the above Table to be a tempered concord, we should have, by our fourth method in the article Beats, $240\times6-284\frac{4}{9}\times5=1440-1422\frac{2}{9}=17\frac{7}{9}$, the beats per second, or vibrations of this grave harmonic, being just double, or an octave higher, than those in the Table above, and so of others; but our limits will not admit of our enlarging further on this subject. (ϱ)

HARMONICA. See Musical Glasses.

HARMONY, in Music, is a term which appears to have completely changed its signification since the first use of it. The ancient Greek writers, who seem to have contemplated only the *succession* of sounds which we call Melody, (see that article,) attached to such successions as were pleasing and agreeable to the ear, the name of a woman celebrated among them. But in more modern times, when the *simultaneous* as well as the progressive effects of sounds on the ear came to be practised and considered by writers on this subject, the term *melody* was applied to successions of sounds, particularly to such successions as are on the whole pleasing, and the term harmony was transferred to the newly contemplated and pleasing effects of certain intervals, when their limiting sounds are heard together, viz. 1, 3, III, 4, V, 6, VI; VIII, 10, X, 11, XII, 13, XIII; XV, 17, XVII, &c.* whose ratios are $\frac{1}{1}$, $\frac{5}{6}$, $\frac{4}{5}$, $\frac{3}{4}$, $\frac{2}{3}$, $\frac{5}{8}$, $\frac{3}{5}$; $\frac{1}{2}$, $\frac{5}{12}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{1}{3}$, $\frac{5}{16}$, $\frac{3}{10}$; $\frac{1}{4}$, $\frac{5}{24}$, $\frac{1}{5}$, &c. called CONCORDS. See that article.

The further progress of musical discoveries next shewed, that certain others of the simple intervals, as I, 2, II, IV, 5, 7, VII; 8, 9, IX, XI, 12, 14, XIV; 15, 16, XVI, &c.; or $\frac{128}{135}$, $\frac{15}{16}$, $\frac{8}{9}$, $\frac{32}{45}$, $\frac{45}{64}$, $\frac{9}{16}$, $\frac{6}{15}$; $\frac{64}{135}$, $\frac{15}{32}$, $\frac{4}{9}$, $\frac{16}{45}$, $\frac{45}{128}$, $\frac{9}{32}$, $\frac{4}{15}$; $\frac{32}{135}$, $\frac{15}{64}$, $\frac{2}{9}$, &c. are called DISCORDS, (see that article,) might be occasionally introduced among, or in the place of some of the concords above mentioned, without destroying, but, on the contrary, heightening the pleasure of their effect on an ear accustomed to this mixed harmony of concords and discords.

When this mixed harmony came to be practised on instruments having fixed notes, the pitch of which the performer could not alter, as the singer, violinist, &c. can their notes, it was further discovered, that each of the concords and discords abovementioned, admitted of alteration, in small and unequal degrees, without altogether losing their respective characters or effects, when heard together in chords; but the pleasing effect in composition of many of these chords, were sometimes even improved, by the alteration of a major comma, (c, or $\frac{80}{81}$;) and hereby another class of comma-deficient and of comma-redundant concords were introduced, as 3‵, 3′, III′, 4′, V‵, V′, 6‵, 6′, VI′, VIII‵, &c. and so of the discords, I‵, 2′, II‵, II′, IV‵, IV′ V′, 7′, VII‵, VII′, 8′, &c.

And in adapting music to only twelve fixed sounds, within each octave, the simple or numeral intervals above mentioned were found altered, in some instances, more than the major comma, but in more numerous instances, by less and very different degrees of alteration or attemperament, in order to render music played thereon tolerably agreeable to the ear. And hence it becomes necessary for the musical student to be aware of the distinctions, which we shall now proceed briefly to enumerate, viz.

*Artificial* HARMONY, implies a mixture of simple or untempered concords, and of discords in the chords, or between the notes that are heard together, in any piece of music.

*Equal* HARMONY implies, according to one class of writers, an equality of harmoniousness between the different *keys* of music, but which is more properly called EQUAL *Temperament*: See that article, and ISOTONIC. But ac-according to Dr Robert Smith, and others of our best writers on the subject, this term should be restricted to systems in which each of the six concords, 3, III, 4, V, 6, and VI, are so tempered, as to be equally and the most harmonious or pleasing amongst themselves, while 1 and VIII remain perfect. See EQUAL *Harmony*.

*Natural* HARMONY, according to Dr Busby, admits only of the harmonic triod, or common chord, $\frac{V}{III}$, in the accompaniments of a piece of music.

*Perfect* HARMONY, implies the use of perfect or untempered concords only, such as are produced by good singers, violinists, &c. when they perform full music in concert, and which, as Mr Farey has shewn, in the *Philosophical Magazine*, vol. xxvii. pp. 206 and 314, contains all its temperaments in the leaps or successive intervals of the melodies of the different parts, and none of such in their combined or simultaneous intervals of harmony, all of which are produced perfect, or without temperament. Mr Maxwell, in 1781, fully explained this system, as applicable to the violin, and made some attempts at applying the same to the organ, but without effect, (See MAXWELL'S *Scales*.) Several years afterwards, however, the Rev. Mr Liston completed his EUHARMONIC *Organ*, (see that article,) and, in 1812, published his *Essay on perfect Intonation*, wherein this curious and important system is fully explained. See LISTON'S *Scales*.

*Tempered* HARMONY, is such as must of unavoidable necessity be heard, in several or all of the concords, (and discords too,) in performance on the common or imperfect keyed instruments, having only twelve, or even a greater number of sounds in each octave. See TEMPERED *Systems*. (g)

HAROLD I. See ENGLAND.

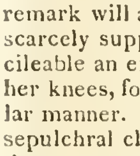
HAROLD II. See ENGLAND.

HARP, is a stringed musical instrument, which has gained much celebrity from the estimation in which it was held among the ancients. Though the harp be of eastern origin, it has been the subject of animated controversies, whether the instrument was actually known to the Greeks and Romans in any shape analogous to its present form. It appears most probable, however, that they were not ignorant of it, and that some of the instruments passing under different names, whose elementary parts and principles are the same, should be considered only as modifications of each other. But the researches of late travellers have brought more interesting objects to view than those exciting dry disputations. Mr Bruce, in visiting the catacombs of the Theban kings, who are supposed to have been cotemporaries with David, king of the Jews, 1000 years before Christ, discovered two paintings of the harp in fresco, each played by an old man standing, clothed in a wide tunic, and having his head shaven. One has thirteen strings, but wants the upright, or that piece of the frame next to the longest; and the sounding board is of a conical form, enlarging below in proportion to the length of the string. The other has eighteen strings, and seems to be a harp formed of similar materials; but the distribution of the parts is different, and the lower strings are united to the bass, not to the sounding board. Both are represented as being played in the same manner, and by men in the same position. After describing the ornamental parts, Mr Bruce affirms, that "it would be even now impossible either to construct or finish a harp of any form with more taste and elegance." However, while preparing to make further researches, he could not prevail on his conductors to wait any longer in the catacombs; "with great clamour and marks of discontent, they dashed their torches against the largest harp, and made the best of their way out of the cave, leaving me and my people in the dark; and all the way they went, they made dreadful denunciations of tragical events that were to follow their departure." It is to be inferred from the figures, that each harp is above six feet high. The purport of Mr Bruce's description, which is much more copious than quoted here, has been strangely misunderstood, though it must be admitted that this was

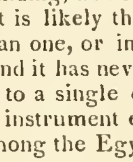
* No limits have yet been assigned to this harmonic or concordant series, found by adding *seven, fourteen, twenty-one*, &c. to each of the first seven numeral terms; or by multiplying the terms of the first seven ratios by $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, &c. to produce the ratios of concords in the successive octaves.

partly owing to his own imperfect communications to Dr Burney. Whence it has been asked by Mr Jones, "Whether the Theban harp originated in a phantasm?" and even Mr Browne, the African traveller, says, while visiting the catacombs of Thebes, "I particularly observed the two harpers described by Bruce, but his engraved figures seem to be from memory." We cannot entirely solve these difficulties; but had those who have spoke most positively on the subject, referred to the first volume of Mr Bruce's Travels, instead of Dr Burney's History of Music, they would have obtained more distinct ideas of it. However, during the late expedition of the French, the sepulchres of the kings of Thebes were again visited; and M. Denon acquaints us, that in a "fourth chamber, there is a figure clothed in white, playing on a harp with eleven strings; the harp sculptured with ornaments of the same tint, and consisting of the same wood as ours are now made." On recurring to Plate CXXXV, of the large edition published by the French government, we observe two figures playing on harps, one represented with 27 strings, the other with 33; and also a third, apparently in miniature, touching a harp with only 9. The first of these is a person standing, clothed in a robe tucked up between the legs; the second is a naked woman on her knees. Both harps are of elegant workmanship, ornamented with sphinxes: and, instead of being triangular, the upright is bent into a curve along with the base. Neither of them bears any resemblance to the first or triangular 13-stringed harp of Mr Bruce, but his second is formed after the same fashion. From all this it is to be inferred, that the harps represented by Denon were seen in a chamber different from that visited by Bruce, and most probably the same remark will apply to what is said by Mr Browne. We can scarcely suppose it possible that there could be so irreconcileable an error as to mistake a naked woman sitting on her knees, for a man standing, and clothed after a particular manner. Farther, it is likely that Denon was in more sepulchral chambers than one, or in different recesses of the same apartments: and it has never been said that these paintings were confined to a single excavation only. The harp, therefore, was an instrument evidently brought to a degree of perfection among the Egyptians, while Greece was yet in its infancy.

In order to facilitate the understanding of illustrations which may be given of the more ancient construction of the harp, we shall briefly describe its present structure and compass. This instrument is now, as it has always been, of a triangular shape; and the gradual elongation of the strings also produces their general arrangement in a corresponding triangular outline. One side of the triangle is formed into a large expanding sounding-board, on the construction of which much of the intonation depends. The whole strings are united to it. A base whereon the harp rests solidly is formed at the lower angle; and here are placed several pedals, which, by an ingenious mechanism, produce flats and sharps. It is commonly, but not always, strung with 35 strings, the lowest equivalent to double A or



of the piano forte, and the highest note equivalent to double G, or



of the same instrument: thus the compass which is arbitrary, is considerable. However, most of the modern harps have seven or eight strings of the bass, to increase it still farther, which, in our opinion, is a very questionable expedient, rendering the total number 43. But this is considerably augmented by the operation of the pedals. These are usually seven in number, and are designed according to the effect they produce: the E pedal changes E flat, in which the harp is now invariably tuned into E natural; the F pedal changes F natural into F sharp, and the G pedal changes G natural into G sharp. In some instruments, the change by simple pressure is to the extent of a semitone; in others of the latest construction, by increasing the pressure on the pedal, the strings affected by it are sharpened another semitone. Three notes are thus obtained from a single string. The action of the pedals, as their name implies, is operated by the feet; four being appropriated for the right foot, and three for the left. All the strings are of catgut, except seven or eight of the lowest, which consist of silk covered with silver wire, as the lowest strings of the violin and violoncello. In the harp the C's are coloured red, and every F is blue, in order that they may be more readily distinguished by the performer; the others are of the ordinary yellowish white of catgut. The whole instrument of the largest size is nearly six feet high, and in Britain costs 100 guineas.

The name of the harp is said to be of Saxon origin; and we can probably trace it to the tenth century; for the author of the life of St Dunstan, who is supposed to have been a cotemporary, observes, "Sumpsit secum ex more citharam suam, quam lingua paterna *hearpam* vocamus." (*Acta Sanctorum*, tom. iv. p. 350.) Venantius Fortunatis, a continental author of the seventh century, uses this expression, "Plaudat tibi, Barbarus *harpa*;" which has been conjectured to apply to Britain. The harp is called *Telyn* in Welsh, and *Clarsach* in Irish.

We can scarcely ascertain, at the present day, under what form this instrument first appeared in these kingdoms; but it was undoubtedly well known in Wales and Ireland. Nor were the English and Scotch strangers to it; though its music was less cultivated among them. An ancient Irish harp which has had 28 strings, and is 32 inches high, is reported to have belonged to a certain king, Brian Boromh, who was killed in battle in the year 1014. His son having retired to Rome, presented his father's harp and crown to the Pope, on purpose to obtain absolution for a murder he had committed; and both remained in the Vatican, until the harp was sent by the reigning Pope to King Henry VIII. and, after passing through the hands of various owners, it was, in 1732, deposited in the library of Trinity College, Dublin. That such an instrument was actually at Rome in the time of Adrian IV. between 1154 to 1159, seems established from record; but the presumption of this particular harp remounting to so very ancient a period of Irish history as 1014, rests only on a very slight foundation. Two harps of considerable antiquity have lately been seen in Scotland; one of which, in size, appearance, and structure, narrowly resembles the Irish harp. Both are preserved in the family of Robertson of Lude; and the history of the oldest can be traced to about the year 1460. It is 38 inches and a half in height, and has had 30 pins, originally of brass, with as many corresponding string holes, all neatly ornamented. The other is ascertained to have belonged to Queen Mary, and is altogether of a more modern fashion and smaller dimensions. It is 31 inches high; the sounding board is only 11 inches and a half broad at the base, whereas that of the former is 16; and there have been 28 strings, the shortest two inches and a half long, while the second and third of the Caledonian harp have not exceeded two inches. The longest string of the latter is only 21 inches and a half in length; that of Queen Mary's 24. It is said that Mary having carried this instrument along with her in an excursion to the Highlands, in the year 1563, presented it to a lady who was married into the family of Lude. It was formerly ornamented with the Queen's portrait, and the Scotish arms executed in gold, of which and other jewels it was despoiled during the rebellion of 1745.

None of the harps we have named exhibit pedals, which are reported to have been invented by M. Simon at Brussels, between 1750 and 1760. The principal object of the pedals is to diminish the number of strings; for although the most grateful music certainly does not consist in the greatest variety of notes, a considerable range becomes necessary to adapt an instrument to all compositions. Probably the strings of the harp were originally very few; indeed in this respect its structure is altogether arbitrary; and the number has been different at different eras and in different countries, as is proved by the examples already given. In France, a harp is spoken of in the 14th century with 25 strings: in England, one of the same century, or perhaps earlier, is represented with only 14, and one of the 16th is described to have had 33. It will be observed, that we have hitherto spoken of the strings of a harp with a single row: and they have even been greatly augmented beyond these numbers; but some ingenious mechanics have adopted a second or third row, for the purpose of multiplying the notes. Galileo, in a work written about the year 1582, speaks of harps with 54, 56, or 60 strings, used in Ireland, from which island the harp of Italy was introduced; and having obtained one from an Irish gentleman with two rows of strings, consisting in all of 58, he found they were disposed in the same manner as a harp of the same construction introduced a few years previously into his native country. Mersenne represents a harp with 75 strings, arranged in three rows. The Welsh are said to have had one similar; and the number has sometimes been increased to 100. The introduction of pedals, however, has superseded the necessity of such a variety of single notes.

The harp was generally strung with brass or steel wire. The western Islanders or Highlanders of Scotland had a particular kind of harp strung with the tendons of animals; and the Welsh sometimes used horse hair. We are quite uncertain regarding the real compass of the most ancient harps, or the manner in which they were tuned.

Diodorus Siculus says, that the instruments used by the Gallic bards resembled lyres; but it is doubtful whether or not this was the harp, and there is very little certainty regarding its origin in these islands. Its most ancient appearance is of very rude and imperfect form, though considerably diversified; but the strings seem invariably to be very few. Performers too are frequently represented as holding it in one hand while they are playing with the other. Mr Ledwich conceives it was introduced into Ireland in the fourth or fifth century, from the close connection of the Irish "with the Saxons and other rovers from the Baltic shores, who conjunctly ravaged the coasts of Gaul and Britain in those ages." In Scotland it appears sculptured on a very ancient monument near the church of Nig in Ross-shire, engraved by Mr Cordiner; and ancient sculptures or drawings of it are to be seen in England, though frequently with a reference to religious matters. Probably the harp was not used in Scotland to any extent, though it was known to individuals; and, subsequent to the date of the instruments before alluded to, there is recorded, in a curious account of an insurrection in 1594, a prophecy regarding the Earl of Argyle's harp being heard in the district of Buchan. In Ireland and Wales, the case was different; for the harp seems to have been carefully and extensively cultivated; at least in as far as the rudeness of the people would admit. Giraldus Cambrensis bears the most unequivocal testimony to their powers, and the quality of their music; affirming, that the Irish were incomparably the most skilful of any nation in music, and not of that dull and languid description to which the inhabitants of Britain were accustomed, but what required much rapidity in execution. Probably their abilities greatly declined; for we afterwards find it observed, that Crusus was to be considered as almost the only harper about 1584. In Wales still greater attention was paid to the instrument, and Giraldus is alike lavish of his praises on the performers. There was even a triennial congress, whither all the most distinguished musicians repaired to compete in skill; and there is still preserved a small silver harp, about six inches and a half high, which was conferred on the victor. The privilege of bestowing this badge seems to have been vested in the family of Mostyn. The congress was held by royal authority at some of the royal residences in Wales; and, besides others, we read of a mandate issued by Henry VIII in 1523, for the purpose of instituting order and government among the professors of poetry and music, and regulating their art and profession according to the old statute of *Gryffyd ab Cynan*, Prince of Aberffraw. Another was assembled by order of Queen Elizabeth, in 1568, at Caerwys, where degrees were to be bestowed according to merit; but those not qualified were enjoined to betake themselves to some honest livelihood and profession, under pain of being apprehended and punished as vagabonds. At that time 55 degrees were conferred, 17 for vocal, and 38 for instrumental performance. At length the institution fell into total disrepute, and the harp seems to have become obsolete; for a traveller in Wales between 1780 and 1790 observes, that the only harp he heard in all the country was at Conway. An attempt was lately made to revive the Eistedfodd, as it was called, after several considerable intervals of repose; and at a meeting, one of the last that was held, 12 minstrels attended, (*Gent. Mag.* vol. lxii. p. 96) And, we believe, a similar congress was unsuccessfully attempted in Ireland during the year 1785, where only indifferent performers appeared. The art of playing upon the harp, however, is at present considered an elegant accomplishment, particularly in youthful females; and it has gained much ground in Britain within these twenty years. At present it is sometimes to be heard at public concerts; and we have understood, that the combination of a number of harps has lately been introduced into an orchestra in Paris. The harp, however, can never be more than a chamber instrument: it labours under many defects, notwithstanding all the modern mechanical improvements which it has received; whence we may reasonably infer, that the excellences of the ancient Welsh and Irish music, as performed upon that instrument, are highly exaggerated. Complicated music does not belong to an uncivilized people. Their tunes are but a kind of whining chant; and the further we ascend with those best known to us, they are found the more inharmonious. Yet enthusiasm can figure any thing, as at this day we see savages dance in extacy to beating on a wooden drum. The minstrels too, who in modern times have been regarded with admiration, and who held a prominent part in the musical performances of old, were nothing but a worthless vagrant race, generally proscribed as vagabonds. See Galileo *Opere*, tom. iii.; Mersennus *Harmonicorum*, p. 68; *Giraldus Cambrensis*, cap. 12; Denon's *Voyages*, tom. i. p. 237, tom. ii planche 135; Bruce's *Travels*, vol. i. p. 133; Carter's *Specimens of Sculpture and Painting*, vol. ii. p. 11, 16, 42. 43; Cordiner's *Antiquities of Scotland*, plate 1; Walker's *Memoir of the Irish Bards*; Jones' *Relics of the Welsh Bards*; Gunn's *Historical Enquiry*; Evan's

*Tour in North Wales*; Pennant's *Tour in Wales*; Strutt's *Manners of the People of England*, vol. i. p. 50, plate 17, 19; Strutt's *Dress and Habits of the English*, vol. i. plate 57; and ÆOLIAN HARP. (*c*)

HARPOON. See WHALE FISHERY.

HARQUEBUSS. See GUNMAKING.

HARRIS, JAMES, one of the most celebrated philologists of modern times, was born at Salisbury on the 20th of July, 1709. His father was a gentleman of independent fortune, of the same name, and his mother sister to the Earl of Shaftesbury, author of the *Characteristics*. He was educated in early life under Mr Hele, at the grammar school of his native city. At the age of 16 he was removed to Oxford, where he passed the usual number of years as a gentleman commoner of Wadham college, and was then entered at Lincoln's Inn, for the purpose of studying law as a part of liberal education. Having, in his 24th year, succeeded, by the death of his father, to his patrimonial property, he followed more completely his own inclinations, by devoting himself to the study of Grecian and Roman literature. He studied profoundly the philosophical writings of the ancients, and acquired a great partiality for the philosophy of Aristotle. His studies were conducted in his house at Salisbury, where his habit was to rise very early, for the purpose of prosecuting them in quiet, and to mingle occasionally through the day with the society of that city. He also officiated with great credit as a magistrate for the county of Wilts.

His first work, which appeared in 1744, was a volume containing three treatises; the first on art, the second on music, painting, and poetry, and the third on happiness, which contained some sound moral observations, and were adorned with elegant literature. In 1745 he married Miss Clarke, daughter of John Clarke, Esq. of Sandford in Somersetshire, by whom he had five children. Two of these died young; but two daughters and his son, now Lord Malmesbury, survived him.

Persevering in his favourite studies, he published, in 1751, his *Hermes, or Inquiry concerning Universal Grammar*—a subject to which his attention had been particularly directed by the *Minerva* of Sanctius. The *Hermes* was received with great applause, and placed the author in the highest rank of philosophical grammarians. But the credit which that work derived from having remained so long unchallenged. was at last shaken by the severe animadversions on it, which were published by Mr Horne Tooke, in his celebrated *Diversions of Purley*. This author has convicted Mr Harris of some incongruities; and has, in his turn, laid the world under deep obligations, by furnishing valuable materials for the correction and improvement of dialectic science: (See our article GRAMMAR, *passim.*) How Mr Harris would have felt had he lived to see himself so contumeliously treated as he is in the work now mentioned, is a question of personal patience, and neither justice nor good nature would delight in seeing any man of worth subjected to such a trial. But now that both of these authors are out of the reach of each other's opposition, as well as the partiality of their respective friends, neither of them appears sufficiently perfect to be adopted as a guide, and both are too respectable to be treated with contempt. Mr Harris had the undoubted merit of delighting such of his cotemporaries as took an interest in the subject. Although, when the import of the words in which his theories are expressed is severely scrutinized, we find them sometimes inconsistent; candour will still endeavour to appreciate the truths which they imperfectly express, and will not fail to find out, in the most unmeaning phrases, some just views which the author aimed to unfold. The difficulty of expressing new opinions on a new subject, in which language is employed in explaining its own nature, may have given rise to some faults in the theoretic dissertations of Mr Harris; but it is no small praise, that his errors required the acuteness of Mr Tooke to discover them, and it must be acknowledged, that the latter has not done justice to his merit. The works of these two authors may be profitably employed for correcting one another, and extending jointly the limits of the science. The views of Mr Harris are on the whole pleasing; and the manner in which they are exhibited, shews an elegant and scientific mind. His writings are not disfigured by wanton satire, expressions of personal antipathy, or querulous moroseness, paradoxical turns of phrase, or an inclination to sport with the feelings of one part of his readers, and carry off by force the admiration of others. Trusting to the interesting nature of his subject, he does not go in quest of spurious sources of animation. After bestowing much labour on the investigation of his subject, he presents his readers in a respectful manner with the best views which he is able to form. He cherishes throughout a spirit of philosophical inquiry, free from any character of extravagance, and possessed of an admirable tendency to generate a placid satisfaction, and a chaste consistency of feeling.

From the time of his marriage till the year 1760, Mr Harris lived entirely in Salisbury during winter, and retired in the summer to his country house at Durford, in the neighbourhood of that city. Besides attending to the pursuits of literature and the duties of a magistrate, he devoted an adequate proportion of his time to the sacred task of superintending the intellectual and moral education of his children; and he zealously promoted a refined taste in music and other elegant pursuits in the circle of society in which he lived.

In 1761, he was elected member of parliament for the burgh of Christchurch, which seat he retained till his death. In the following year, he was made one of the lords of the admiralty; and in two years after a lord of the treasury; In 1765, he went out of office with the ministry with which he was connected. In 1774, however, he was, much to his gratification, appointed secretary and comptroller to the Queen.

During the hours of leisure which the duties of public life allowed him, he prosecuted, with great regularity, his literary labours. In 1774, he published his *Philosophical Arrangements*, a work in which he displayed all his former admiration of the Peripatetic logic, and combatted the doctrines of chance and materialism, animated by a zealous re-

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HARRISBURGH, originally LOUISBURGH, the seat of government in Pennsylvania, is situated on the north-east bank of the Susquehanna river. It is regularly laid out, and contains, perhaps, six hundred houses; of which some are neat and convenient. The houses are generally built of brick or stone. Harrisburgh is likewise the seat of justice for Dauphin county; and has a courthouse and gaol. The former is nearly 100 feet long, and half as many wide, with a cupola and bell. The legislature, for the present, convene in this building; the permanent state house not yet having been erected. There is here a beautiful bridge over the Susquehanna; and the surrounding country is picturesque. The population of Harrisburgh is something upwards of two thousand. They vend merchandise to the country people, and manufacture leather, hats, nails, &c. The lumber used in building is generally brought down the Susquehanna. There is a German church in the town; a presbyterian congregation, respectable for numbers and character, worship in the court-house. Harrisburgh is 107 miles W. N. W. from Philadelphia; 53 W. S. W. from Reading; and 17 E. N. E. from Carlisle. Lat. 40° 16′ N. (E. H. CUMMINS, A. M.)

gard for the happiness of mankind,—an object of which, many who have espoused the opposite side of these questions, have betrayed an unfeeling neglect, by the style and manner in which they have published their opinions.

In 1780, the same year in which he died, he printed for the use of his circle of private friends a work, which was published immediately after his death, entitled *Philological Inquiries*, containing a popular summary of the conclusions to which the philosophical investigations of the ancients conducted them, accompanied with pleasing illustrations and examples. It contains also some affectionate expressions of personal attachment to his friends, and, on the whole, furnishes a good example of talents retaining at a very advanced age their former vigour, as well as of candour and benevolence continuing undiminished. His health, however, was now much impaired, and he died on the 22d of December 1780, in the 72d year of his age, beloved and regretted by all who knew him.

His private character appears to have been thoroughly amiable. With a mind well disciplined to severe thought, he united an unrestrained freedom and cheerfulness of character, which inclined him to take a ready part in all the subordinate interests and common amusements of life. He exhibited on all occasions a temper the most humane, gentle, and forgiving. As a critic, he was candid and indulgent; and, with a sagacity which enabled him to discern deformities, he had a sense of justice and of gratitude which made him chiefly delight in acknowledging literary beauties. Those who dispute the accuracy of some of his conclusions, would do well to copy the tender solicitude which he expressed for the general interests of his species, and the delicacy with which he communicated to the world the fruits of his researches.

His son Lord Malmesbury, published an edition of his works in two quarto volumes, to which he prefixes a brief account of his life. He seems to value his father's memory, chiefly for the steady resistance which he made to those opinions on general subjects which have prevailed in modern France, and which, from their harsh collision with previously existing systems, and, as he thinks, from their intrinsic repugnance to the interests of society, gave rise to that political discord, and those consequent ravages of war, with which Europe has in our age been visited. (*H. D.*)

HARRIS. See Invernesshire.

HARRISON. See Horology and Longitude.

HARRISON'S Temperament of the musical scale. The late Mr John Harrison, who laboured so successfully in improving chronometers, about the year 1748, conceived the idea of a tempered system of intervals, in which the interval of the major third should bear the same proportion to the octave as the diameter of a circle to its circumference. On reference to Mr Farey's corollaries regarding regularly tempered douzeaves, in the *Philosophical Magazine*, vol. xxxvi. page 374, the temperaments and wolves of this system may easily be calculated, and these applied to the respective intervals will stand as follows, viz.

| | | | |
|---|---|---|---|
| 11 of the Vths, viz. on C, G, D, A, E, B, ♯F, ♯C; and on F, ♭B, and ♭E, each of the value . . . . . . . . . . . | 354 69244Σ+7f+31m | = | 3901.61684Σ+77f+341m |
| And the wolf fifth on ♯G, . . . . . . . . . . . . . . . . . . . . | | = | 382.38316Σ+ 7f+ 30m |
| Make 7 octaves, each . . . . . . . . . . . . . | 612Σ+12f+53m | = | 4284 00000Σ+84f+371m |
| 8 of the IIIds, viz. on C, G, D, A, and E; and on F, ♭B, and ♭E each, | 194.77762Σ+4f+17m | = | 1558.22096Σ+32f+136m |
| And 4 wolf IIIds, viz. on B, ♯F, ♯C, and ♯G, each . . . . . . . . . . . | 222.44476Σ+4f+19m | = | 889.77904Σ+16f+ 76m |
| Make 4 octaves, each . . . . , . . . . . . . . | 612Σ+12l+53m | = | 2448.00000Σ+48f+212m |
| 9 of the 3ds, viz. on A, E, B, ♯F, ♯C, and ♯G; and on D, G, and C, each | 159.92268Σ+3f+13m | = | 1439.30412Σ+27f+117m |
| And 3 wolf 3ds, viz. on F, ♭B, and ♭E, each . . . . . . . . . . . . . . . . . . | 132.23196Σ+3f+14m | = | 396.69588Σ+ 9f+ 42m |
| Make 3 octaves, each . . . . . . . . . . . . . . | 612Σ+12f+53m | = | 1836.00000Σ+36f+159m |

The fourths, minor sixths, and major sixths, complements to the above Vths, IIIds, and 3ds, will be each of them as much tempered *sharp* as these are tempered *flat* respectively. It appears, from the preface to the first edition of Dr Smith's *Harmonics*, that Mr Harrison adjusted frets on the finger-board of a base viol according to this system, and that Mr Harrison declared himself much pleased with the "extremely fine harmony" of its consonances. It is, however, to be regretted, that Dr Smith did not himself hear, and give us his opinion, on the harmony thus produced by Mr Harrison. Several years afterwards, Mr Maxwell, as he informs us p. 249 of his "Essay on Tune," did hear and attend to Mr Harrison's performance on his six-stringed viol thus fretted, and Mr Maxwell by no means approved the harmony thereof. In 1775 Mr Harrison gave some account of his musical scale in his work on chronometers. (*ς*)

HARROW. See Agriculture.

HARROW on the Hill, is a village of England in Middlesex. The hill on which it stands is the highest ground in the county, and has an insulated appearance, being visible from great distances almost in every direction. This village is celebrated for its free school, which is now universally allowed to be one of the best seminaries in the kingdom. It was founded in 1592 by John Lyon, a wealthy yeoman of Preston in this parish. He allotted 20*l.* for two exhibitions to Caius College, Cambridge, and two to Oxford. This sum, however, has been doubled. The number of scholars at Harrow school is generally about 150. The rent of Mr Lyon's estates amounted lately to 669*l.* which is disbursed in paying the salaries of the masters, the exhibitions already mentioned, in educating poor children, relieving decayed house-keepers, repairing roads, &c. The church of Harrow, which contains several sepulchral monuments, is partly of ancient architecture. The lower part of the tower, and the columns between the nave and aisles, are supposed to have been built by Lafranc in the time of King William I.

The view from Harrow is very fine. Towards the east it is terminated by the metropolis; to the south by the Surrey hills; to the north is a view of Harrow Weald, with the village of Stanmore and Bentley Priory, the seat of the Marquis of Abercorn: and to the south-west is seen Windsor Castle, with a considerable part of Berkshire and Buckinghamshire. On the top of the hill is a well of excellent spring water, which is never dry even in the hottest summers. In 1811 the number of houses in the town, including the hamlets of Roxeth and Sudbury, was 283, and the population 1689. See Lyson's *Environs of London*, 4to. vol. ii.

HARROWGATE is the name of a celebrated watering place in England, in the West Riding of Yorkshire. It is situated in the forest of Knaresborough, about three miles south-west of the town of Knaresborough. The village is divided into High and Low Harrowgate, and consists principally of the inns and lodging houses for the accommodation of the numerous invalids who flock hither from every part of the united kingdom. Before the mineral springs were discovered, Harrowgate was a miserable hamlet; and it was not till 1687 that the first inn, called the Queen's Head, was erected. Before the year 1700, there were three good inns in the village, and it now contains eight spacious inns, viz. the Granby, the Dragon, the Queen's Head, and the Hope Tavern, at High Harrowgate; and the Crown, the White Hart, the Crescent, and the Bell, at Low Harrowgate; beside numerous lodging houses for those who wish for a more retired life. The Crown Inn at Lower Harrowgate, is a long row of plain buildings. The public hall or promenade is a large and elegant apartment, with an organ at one end. The Crescent is situated behind the Crown Inn in a less public situation.

The chalybeate springs, which are two in number, are both at High Harrowgate. The oldest of these, called the Old Spa, was discovered by Captain Slingsby in 1571, and is situated opposite the Granby Inn. It was covered in 1786 with an elegant dome, erected at the expense of Lord Loughborough, who also laid out an extensive plantation on his property here, which affords an agreeable shade to a walk eight feet broad, and two miles long. The other chalybeate spring is about half a mile west of the Old Spa, and is called the Tewit well, from the birds called tewits which frequent it.

The sulphureous springs, which are two in number, are situated at Lower Harrowgate, and are inclosed with stone buildings, one of which, near the Crown Inn, is a temple of the Tuscan order, 24 feet in diameter, consisting of a cupola, supported by 12 columns. The water of this spring is extremely offensive to the smell and the taste. When taken in small quantities, it is an excellent alterative; but when copiously drunk, it is strongly purgative, and has been found very efficacious in cutaneous diseases and scrophula, in destroying worms, in removing chronic obstructions, and in all disorders of the stomach. The second sulphureous spring was discovered in the gardens of the Crescent in 1783. It is of an intermediate quality between the chalybeate and sulphureous waters.

The buildings at Harrowgate are rapidly increasing every year. It now contains more than 1500 inhabitants. See *Beauties of England and Wales*, vol. xvi. p. 652.

HARTLEPOOL, a town of England, in the county of Durham, is situated on a promontory nearly encircled with the German Ocean, which forms a capacious bay on the south side of the town. It is built on the western slope of a hill, and consists of a principal street, a back street, and several cross streets. The chief buildings are, a chapel of irregular structure, a town hall, a free school, and a custom house. The town is surrounded with ancient fortifications, which are described at great length by Hutchinson in his *History of Durham*. Hartlepool is much frequented in the summer months for bathing, but at other seasons it is inhabited principally by the fishermen. Within a few yards of the Watergate, a chalybeate spring has lately been discovered. It is covered by the sea at low water. About five miles north of the town are the singular rocks called the Blackhalls: (See DURHAM.) A life boat has lately been established here by subscription. On the moor near the town are two batteries mounted with cannon, beside an intrenchment. In 1811 the township contained 242 houses, and 1047 inhabitants. See Hutchinson's *History of Durham*, and the *Beauties of England and Wales*, vol. v. p. 119.

HARTLEY, DAVID, was born on the 30th of August 1705. He was the son of a respectable clergyman, vicar of Armley, in the county of York, where he died, leaving behind him eight children. The subject of this article was brought up by a Mrs Brooksbank, who lived near Halifax. He received the first rudiments of his education at a private school, and his academical education at Cambridge. He was admitted at Jesus College at the age of fifteen years, and was afterwards elected a fellow of that society, and took the degree of M. A. He was originally designed for the church, and proceeded for some time in his thoughts and studies towards that object; but he was restrained by some scruples, which made him reluctant to subscribe the thirty-nine articles. He continued, nevertheless, a member of the church of England, conforming to its public worship. This he did upon the principle, that the church of England maintains, in substance, the practical doctrines of Christianity, and that it was not incumbent to separate himself from its communion on account of some articles, which he regarded as speculative and abstruse. Having, it would appear, from conscientious scruples, relinquished the profession of his first choice, he applied his talents to the medical profession, in which he arrived at considerable eminence for skill and industry, but still more for philanthropy. He exercised the healing art with equal attention and fidelity to the poor and the rich. He visited the humblest recesses of poverty and sickness. He was not unmindful that bodily sickness renders the mind more impressible with moral and religious truths, and embraced opportunities, in the course of his medical practice, of exercising mental charities to afflicted minds, as well as of employing

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HARTFORD, the second town, as to size, in the state of Connecticut, lies on the bank of Connecticut river, fifty miles above its mouth. It is in the centre of a pleasant and fertile section of the country. The houses are built chiefly on one street, parallel with the river. The intersecting streets cross it at right angles. The public edifices are, a state house, two Congregational churches, one Episcopalian, and others for the administration of justice. The houses are generally of brick, three stories, and well built. Their whole number may be about seven hundred. The population of Hartford in 1810 was 3.995. It is understood to have considerably increased. Besides its local advantages, the town has benefited by the meeting of the legislature of the state in it. It has been rendered more memorable, by the convention of delegates from the legislatures of Massachusetts, Connecticut, and Rhode-Island, in the year 1814; whose principal views were to concert opposition to the administration of the federal government, in the prosecution of the late war, &c. Hartford has many advantages. It has an extensive and fertile country lying about it. It cherishes a number of manufacturing establishments, supports several distilleries, and has a good communication with the sea. (E. H. CUMMINS, A. M.)

his knowledge of the healing art to the restoration of bodily health.

He was industrious in acquiring all collateral branches of knowledge, and lived in personal intimacy with the learned men of his age. Dr Law, Dr Butler, Dr Warburton, afterwards Bishops of Carlisle, Durham, and Gloucester, and Dr Jortin, were his intimate friends. He was much attached to Dr Hoadley, Bishop of Winchester, whose opinions on religion and politics seem to have been very similar to his own. Dr Hales, and Dr Smith, master of Trinity College in Cambridge, with other members of the Royal Society, were his companions in the sciences of optics, and other branches of natural philosophy. Mr Hawkins Browne, the author of an elegant Latin poem, *De Animi Immortalitate*, and Dr Young, the moral poet, stood high in his esteem. Dr Byrom, the inventor of a scientific short-hand writing, was much respected by him for useful and accurate judgment in philology. Mr Hooke, the Roman historian and disciple of the Newtonian chronology, was amongst his literary intimates. The celebrated poet Pope was likewise admired by him as a man of genius, and a true poet; yet he regarded the celebrated Essay on Man as tending to insinuate, that the divine revelation of the Christian religion was superfluous, in a case where human philosophy was adequate. He suspected the secret influence of Lord Bolingbroke, as guiding the poetical pen of his unsuspecting friend, to deck out in borrowed plumes the plagiarisms of modern ethics from Christian doctrines. From his earliest youth he was devoted to the sciences, particularly to logic and mathematics, which last he studied under the celebrated Professor Saunderson. He published, 1. *A View of the present Evidence for and against Stevens's Medicines as a solvent for the Stone*, London 1739, 204 pages 8vo. dedicated to the President and Fellows of the Royal College, London. His own case is the 123d in the book; yet he is said, after all, to have died of the stone, after having taken above two hundred pounds weight of soap; and it must be acknowledged, though with regret, that that celebrated medicine has no power of dissolving stones in the kidneys or bladder. 2. Dr Hartley is said to have written in defence of inoculation against Dr Warren of St Edmund's Bury; and some letters of his are to be met with in the *Phil Trans.* 3. But his most celebrated work is entitled, *Observations on Man, his Frame, his Duty, and his Expectations*, in two parts; part the first, containing observations on the frame of the human body and mind, and on their mutual connections and influences; part the second, containing observations on the duty and expectations of mankind; London, 1749. The author gives the following account of the origin and progress of the work. "About eighteen years ago, I was informed that the Rev. Mr Gay, then living, asserted the possibility of deducing all our intellectual pleasures and pains from association. This put me upon considering the power of association. Mr Gay published his sentiments on this matter, about the same time, in a dissertation on the fundamental Principle of Virtue, prefixed to Mr Archdeacon Law's translation of Archbishop King's *Origin of Evil.* From inquiring into the power of association, I was led to examine both its consequences, in respect of morality and religion, and its physical cause. By degrees, many disquisitions, foreign to the doctrine of association, or at least not immediately connected with it, intermixed themselves. I have here put together all my separate papers on these subjects, digesting them in such order as they seemed naturally to suggest, and adding such things as were necessary to make the whole appear more complete and systematical." The author, aware that he had thus laid himself open to the charge of having first adopted a theory, and afterwards accommodated his observations in subserviency to it, adds, that "he did not first form a system, and then suit the facts to it; but was carried on by a train of thoughts from one thing to another, frequently without any express design, or even any previous suspicion of the consequences that might arise; and that this was most remarkably the case in respect of the doctrine of *Necessity;* for I was not at all aware, that it followed from that of association, for several years after I had begun my inquiries; nor did I admit it at last without the greatest reluctance."

In regard to the doctrine of necessity, justice to the author requires that his note of explanation should be here given, viz. "that he no where denies practical free will, or that voluntary power over our affections and actions, by which we deliberate, suspend, and choose, and which makes an essential part of our ideas of virtue and vice, reward and punishment." To the doctrine of associations he has added *vibrations*, and endeavoured to establish a connection between these, and to shew the general use of these in explaining the nature of sensations. In the introductory remarks to the second part of the work, "*On the Duty and Expectations of Man*," he says, that "the contemplation of our frame and constitution appeared to him to have a peculiar tendency to lessen the difficulties attending natural and revealed religion, and to improve their evidences, as well as to concur with them in their determination of man's duty and expectations; with which view he drew up the foregoing observations on the frame and connexion of the body and mind: And in prosecution of the same design, he goes on in this part, from this foundation, and upon the other phenomena of nature, to deduce the truths of natural religion; laying down all these as a new foundation whereon to build the evidences for revealed religion, to inquire into the rule of life resulting from the frame of our natures, the dictates of natural religion, and the precepts of Scripture. And, lastly, to inquire into the genuine doctrines of natural and revealed religion, thus illustrated, concerning the expectations of mankind here and hereafter."

The intentions of the author seem to have been upright and pious; and considerable ingenuity, as well as acquaintance with the human frame, are displayed throughout the work. Yet few, it is believed, will be found to assert that his system throws any light on the mysterious union of matter and mind, or that his *reduction* of all the operations of the human mind to association of ideas, has tended in any degree to simplify the subject. "The philosophy of mind (observes Professor Stuart) has its alchemists; men, whose studies are directed to the pursuit of one single principle, into which the whole science may be resolved; and they flatter themselves with the hope of discovering the grand secret by which the pure gold of truth may be produced at pleasure. Of such metaphysical alchemists, Hartley is clearly entitled to the first place. But all the generalizations of his system are verbal only, and it succeeds in bringing all our mental operations under the head of associations, only by using the term in such an unprecedented latitude, as to make it comprehend all sorts of mental operations, and every kind of connection of ideas. Every thing, according to Hartley, of which we are conscious, excepting only our sensations, may be called *ideas;* and every kind of relation between them he terms an association, so that the connection betwixt twice two and four, is merely an association of ideas, and that all mathematical relations are of the same denomination. This, it is evident, is not a discovery in philosophy, but an innovation in language." (*Philosoph. Essays.*) It is said that he did not expect that his work would meet with any general or immediate reception in the philosophical world, or even that it would be much read or understood; but that at some distant period it would become the adopted system of future philosophers. There seems no probability of this expectation being realized. The prevailing systems of Reid, Stewart, &c. the inductive philosophy of mind, seems to bid much fairer for general adoption. Although Hartley cannot be recommended as a guide, either in philosophy or in religion, his private and personal character seems to have been amiable and exemplary. His thoughts were not immersed in worldly pursuits or contentions, and therefore his life was not eventful or turbulent, but placid and undisturbed by passion or violent ambition. From his earliest youth, his mental ambition was pre-occupied by the pursuits of science. His hours of amusement were likewise bestowed upon objects of taste and sentiment. Music, poetry, and history, were his favourite recreations. His natural temper was cheerful and social. He was addicted to no vice in any part of his life. The virtuous principles which are instilled in his works, were exemplified in his conduct. His person was of the middle size, and well proportioned; his complexion fair, his features regular and handsome. His countenance open, ingenuous, and animated. He was peculiarly neat in his person and attire. He was an early riser, and punctual in the employments of the day; methodical in the disposition of his library, papers, and writings, as the companions of his thoughts, but without any pedantry, either in these habits, or in any other part of his character. His behaviour was polite, easy, and graceful, flowing from benevolence of heart. His whole character was eminently marked by simplicity of manners, and uprightness of conduct. The dispositions of his heart shine very evidently through his works, and the conclusion of the work on Man, in which he addresses various classes of the community, and exposes prevailing vices, does much honour to his moral and religious character, and evince an affectionate concern for the best interests of his country, and of mankind. He died at Bath on the 28th of August, 1757, at the age of fifty-two years. He was twice married, and left issue by both marriages, two sons, and a daughter. His eldest son got a travelling fellowship, and his younger son was entered at Oxford in Michaelmas term, 1757. *See a Sketch of the Life and Character of Dr Hartley, prefixed to Notes and Additions to the work on Man.* By Herman A. Pistorius, rector of Poseritz in the island of Rugen, London, 1791; and Dodsley's *Ann. Register*, vol. xviii.

HARTZ, or Harz, a tract of mountainous country, situated in the kingdom of Hanover. It is about 70 miles long, and 20 broad. The forests of the Hartz have about one-third of hard wood, and two-thirds of soft wood. An insect belonging to the order Coleoptera, nearly allied to the *Dermestes typographus*, has lately committed great ravages in these forests. It infests fir trees, and in one tree 80,000 larvæ have been found. The principal minerals are lead, copper, silver, zinc, iron, green vitriol, blue vitriol, white vitriol, and sulphur. The silver mines, which are said to have been discovered in the year 968, were the first that were opened in Europe. The annual product of the lead, silver, and copper mines, is stated at 157.994 dollars.

The Editor is indebted to Professor Jameson for the following account of the mineralogy of the Hartz mountains.

This interesting tract of country is composed of primitive transition, flœtz, and alluvial rocks; but hitherto no volcanic substances have been met with in it.

A. *Primitive Rocks.*

These are granite, primitive greenstone, horn-rock, quartz-rock, primitive flinty slate, primitive clay slate, and primitive limestone.

1. *Granite.* This rock is supposed to form the central part of the Hartz, and consequently to support all the other mineral strata of this part of Germany. It is occasionally traversed by veins of quartz, schorl, and hornstone. At its line of junction with the superincumbent strata, intermixtures of the rocks are to be observed, and even veins of the granite shoot from the massive rock into the superincumbent ones. These facts are differently explained by the Neptunian and Plutonian speculators. The Neptunists consider them as illustrative of the *cotemporaneous formation* of the two rocks; while the Plutonists view them as irrefragible proofs of the granite having been projected in a fluid form from the interior of the earth amongst *previously existing strata.*
2. *Primitive greenstone.* This rock rests immediately on the granite, and sometimes beds of it occur in the clay-slate. Like the granite, it is magnetical, although it contains no disseminated magnetic iron-stone or magnetical pyrites.
3. *Horn-rock*, (Horn-fels.) Hitherto mineralogists have not attended to this rock. It is an intimate mixture of splintery quartz and compact felspar, in which sometimes the one, sometimes the other, mineral predominates. It is occasionally coloured black with schorl. It occurs resting upon granite, and frequently intermixed with that rock at the line of junction.
4. *Quartz-rock.* It is either splintery, or composed of granular concretions. It rests either upon the granite, or occurs in beds alternating with greenstone or horn-rock.
5. *Primitive flinty slate.* This rock occurs but sparingly in the Hartz, and is generally disposed in beds, alternating with horn-rock and clay-slate.
6. *Primitive clay-slate.* This rock forms beds in flinty-slate, primitive limestone, and green-stone.

*Metalliferous venigenous formations in primitive clay-slate.*

The following principal formations may be distinguished.

a. The veins of this formation contain principally galena or lead glance, native arsenic, red silver ore, with much calcareous spar, and a small portion of quartz.
b. This formation is almost entirely composed of galena or lead glance, with a very small portion of native arsenic, red silver ore, grey copper ore, and blende.
c. In this formation, like the preceding, galena is the predominating ore, and is associated with a small quantity of grey copper ore, iron pyrites, copper pyrites, red iron stone, brown iron ochre, and red silver ore.

7. *Primitive limestone.* It occurs but seldom, and in beds, in clay-slate.

B. *Transition Rocks.*

The following rocks of this class are met with in the Hartz, viz. limestone, greywacke, clay slate, whet slate, alum slate, transition flinty slate, transition trap, and transition porphyry.

1. *Limestone.* It occurs in beds, often of considerable thickness, in greywacke, and transition clay slate.
2. *Greywacke.* Greywacke and clay slate are by far the most abundant rocks in the Hartz. It sometimes contains glance coal, (*blind coal,*) and mineral pitch; and

occasionally petrifactions of species of the genera hysteriolites, and trochites.

3. *Clay-slate.* This rock is distinctly stratified, and sometimes occurs in elliptical and globular concretions, which have a concentric lamellar structure. It alternates with greywacke, and both rest on the primitive rocks already described.

Both greywacke and clay slate contain very considerable metalliferous formations. The following are the principal ones.

*a.* A very thick bed of copper pyrites, iron pyrites, galena or lead glance, and brown blende, with compact heavy spar, and a very small quantity of quartz, and calcareous spar.

*b.* Veins of galena or lead glance, of which the following formations have been ascertained.

α. Galena, associated with much calcareous spar, and splintery quartz, and small portions of iron pyrites, sparry iron stone, grey copper ore, and brown spar.

β. Galena, associated with sparry iron stone, calcareous spar, heavy spar, and quartz ; with a minute portion of grey copper ore, brown blende, iron pyrites, and copper pyrites.

γ. Galena, with splintery quartz, and a smaller portion of calcareous spar, sparry iron stone, iron pyrites, and copper pyrites. In the upper parts of the veins, the calcareous spar is sometimes dissolved and carried away. The galena, or lead glance, is converted into white, black, and earthy lead ores ; by the decomposition of the copper and iron pyrites, there are formed varieties of ochry brown iron stone, malachite, azure copper ore, and copper green, and by the decomposition of the sparry iron stone, compact and fibrous brown iron stones, and ores of manganese.

δ. Galena, with much brown blende, splintery quartz, and calcareous spar; and occasionally small portions of copper and iron pyrites.

ε. Galena, with amethyst, large foliated calcareous spar, copper pyrites, and brown blende.

*c.* Veins of copper ore, which are distributed in the following formations.

α. The principal vein-stone, of the veins of this formation is quartz, which occurs in such quantity as occasionally to fill up the veins from side to side. It is in granular concretions, which are so loosely aggregated, that they can be separated by the mere pressure of the finger ; hence in mines in this formation the quartz is dug out by shovels. This condition of the quartz in these veins shews us the possibility of sandstone, and even of sand, being in many cases original chemical formations, and not mechanical deposites. The ores associated with the quartz are copper pyrites, malachite, copper green, copper black, tile ore, and brown iron stone. There sometimes occur, embedded in the loose sandy quartz, blocks of compact quartz, also portions of heavy spar, and small strings of brown spar, and red iron stone ; and rarely fluor spar.

β. This formation consists of azure copper ore, and copper-green, with much fluor spar, and sometimes small portions of brown spar, and red ironstone.

γ. Copper pyrites, and splintery quartz, with small portions of calcareous spar, iron pyrites, and galena or lead glance, are minerals of this formation.

*d.* Veins of iron-stone, of which the following formations are known to the miners.

α. Red hematite, and heavy spar.

β. Compact red iron-stone, with much calcareous spar.

γ. Compact red iron-stone, with much quartz, and a small portion of iron flint.

δ. Compact, fibrous, scaly, and ochry red iron-stone, with specular iron ore or iron glance, and quartz, and calcareous spar.

ψ. Sparry iron-stone in the lower part of the veins, but brown iron-stone in the upper parts.

*e.* Veins of manganese occur but rarely ; and of this metal the only formation in the Hartz is that in which compact grey manganese ore is associated with heavy spar.

4. *Whet slate.* This mineral occurs in thin beds in the clay slate.

5. *Alum slate.* It occurs in beds in clay slate.

6. *Transition flinty slate.* It occurs in beds in greywacke and clay slate. It passes into clay slate ; and in the mountains of the Hartz we find all the intermediate varieties between perfect flinty slate, and well characterised clay slate. It is worthy of remark, that this mineral, which, according to the Huttonian view, must have been in a state of fusion, occurs inclosed in clay slate, and exhibiting the gradation we have just mentioned.

7. *Transition trap.* The trap rocks, which are greenstone, and amygdaloid, alternate in beds with greywacke and greywacke slate.

8. *Transition porphyry.* The transition porphyries have a basis either of clay-stone, felspar, or horn-stone, and occur in beds in greywacke, or in masses resting upon it.

### C. *Flœtz Rocks.*

Flœtz rocks surround the Hartz on every side, and are spread from thence over the hilly parts of Lower Saxony. The following are the flœtz rocks met with in the Hartz : Old red sand-stone, clay porphyry, alpine lime-stone, older gypsum, variegated sand-stone, newer gypsum, and third flœtz sand-stone.

1. *Old red sand-stone, or the first flœtz sand-stone.* This well known rock, the *dunstone* of English mineralogists, occurs in considerable abundance, and in this country contains beds of coal.

2. *Clay-stone porphyry.* This rock occurs in beds which alternate with the red sand-stone. The beds vary in thickness from a few inches to many fathoms. It passes into the bounding sandstone, a fact illustrative of the cotemporaneous formation of the two rocks.*

3. *Alpine lime-stone, or first flœtz lime-stone.* This limestone occurs in considerable abundance, and generally rests on the red sand-stone.

4. *Older gypsum, or first flœtz gypsum formation.* This formation, which is principally composed of foliated granular gypsum, and compact gypsum, also contains selenite, rounded cotemporaneous portions of radiated gypsum, stinkstone, and sometimes fibrous gypsum. It rests on the preceding formation.

5. *Variegated, or second flœtz sand-stone.* This formation, which is probably identical with the *red ground* of English mineralogists, rests upon the older gypsum.

* It may be noticed, that German mineralogists mention the occurrence of porphyry and trap rocks in red sand-stone as a new discovery, although both these facts were stated so early as the year 1800, by Professor Jameson, in his *Mineralogical Travels,* a work known to continental writers by the translation of it which appeared in Germany many years ago.

6. *Newer gypsum, or second flœtz gypsum formation.* The principal rocks in this formation are foliated granular, fibrous, and radiated gypsum. It rests on the variegated sand-stone, and sometimes even alternates with it.
7. *Third flœtz sand-stone.* This sandstone has generally a grey or white colour, and contains subordinate beds of slate clay, indurated marl, and coal. It appears to rest upon the newer gypsum and the variegated sand-stone.

D. *Alluvial Rocks.*

The rocks of this class are calc-tuff, loam, clay, brown coal, bog iron ore, peat, and rolled masses, of different kinds.

The following works may be consulted, as affording accurate and extensive details in regard to the natural history of the Hartz.

1. *Erfahrungen von innern der gebirge nach beobachtungen gesammlet und herausgegeben* von F. W. H. von Trebra. Fol. 1785.
2. *Beobachtungen über den Harzgebirge nebst einem Profilrisse als ein Beitrag zur mineralogischen naturkunde* von G. S. O. Lazius. 2 vols. Hanover, 1789
3. *Bemerkungen über den Harz* von J. C. Friesleben, 2 vols. Leipzic, 1795.
4. Hausmanns *Norddeutsche Beiträge.* 1806.
5. *De la richesse minerale*, par A. M. Heron de Villefosse. 4to. 1816.

See the article Brocken.

HARVEY, William, M. D. the celebrated discoverer of the circulation of the blood, was born at Folkstone in Kent, on the 1st of April 1578, was educated at the school of Canterbury, and sent to Cambridge in 1593, where he studied six years as gentleman commoner of Caius College. His medical studies were prosecuted at the university of Padua, where the most eminent of his instructors was Fabricius ab Aquapendente. This anatomist explained to him the structure of the valves of the veins; a subject which he had greatly improved, and which afterwards led Harvey to views unparalleled by any in physiology for their beauty and profundity. At Padua he took the degree of M. D. and returned to England in his 24th year. At 30 he was elected Fellow of the Royal College of Physicians of London; and in about a year after succeeded Dr Wilkinson as physician to Bartholomew's hospital. On the 4th of August 1655, he delivered, by appointment of the College of Physicians, the Anatomical and Surgical Lecture of Lumley and Caldwell; and there is reason to believe, that on this occasion he gave a modest intimation of his great discoveries, as he left a manuscript, *de Anatomia Universa*, dated about this time, which contains the outlines of his doctrines. Twelve years elapsed before he published them to the world. His fame, in the mean time, gained ground, and the estimation in which he was held by his professional brethren gave it solidity, as well as brilliancy.

It was in 1628 that he published his *Exercitatio Anatomica de Cordis et Sanguinis motu*, at Frankfort, a centre from which it was most readily diffused through Europe, by means of the great book fairs which were annually held in that city. In no point of view can this work be too highly praised as a specimen of the most ingenious and solid speculation, and of striking experimental inquiries, arranged in luminous order, and accompanied with apposite illustrations. It still continues unrivalled for importance as an original publication. An account of the great doctrines which it establishes is given in our article Anatomy (*History of*,) to which we beg leave to refer.

But illustrious as the merit of Harvey was, and respectably as it was supported by the cordial admiration of his colleagues, his opinions were represented by a herd of opponents as precipitate innovations; and the inference drawn by the confiding multitude was, that the author of them could not be a safe medical practitioner. His practice as a physician actually fell off, furnishing a striking proof of the precarious and humbling conditions of a medical reputation. The bigotted abettors of old established systems, after injuring his name by whispers and innuendoes, attacked him at last by controversial writings, and thus put it in his power to vindicate the truths which he had discovered, and refute the Galenian errors which had maintained their ground for ages.

Dr Primrose of Oxford was his first opponent. He maintained that the blood was carried to the different parts of the body, not by the impulse of the heart, but by the power which all the living organs have to attract the substances fitted for their nourishment. Four years after this, he was attacked by Æmylius Parisanus, a physician of Venice, with great pomp of words, in a barbarous and obscure style of eloquence, in which he supported a strange medley of ancient opinions and peculiar original dogmata. Dr Harvey was saved the irksome task of replying to a tortuous and confused tissue of unmeaning words, by the zeal of his liberal admirer and genuine friend Sir George Ent, a physician of the highest reputation, who, in an *Apology for the Circulation of the Blood*, replete with learned and acute argument, and enlivened with eloquence and wit, completely exposed the futilities of that author.

In a few years after this he met with a more able and liberal minded opponent in Riolan of Paris, who had entertained a fanciful doctrine of his own upon the motion of the blood, which could not stand if Harvey's views were established. In answer to Riolan, Harvey wrote two treatises called *Exercitationes*. Every modern anatomist who looks back to these disputes, smiles not only at the obstinacy with which the true doctrine of the circulation was resisted, but at the gross ignorance betrayed by its opponents, in particulars of anatomical structure which are now familiar to the youngest tiro in the science. Riolan soberly maintained, that in the adult subject the left auricle of the heart was a solid mass, possessing no cavity capable of containing blood.

Dr Plemp, professor at Louvaine, was another adversary; but, finding that the experiments with which he intended to assail the doctrines of Harvey contributed powerfully to their support, he with manly candour ranked himself among his converts.

Harvey, in his first publication, did not acknowledge any regular continuation or anastomosis betwixt the small arteries and the veins, furnishing a tubular passage for the transmission of the blood, but believed that this fluid was first diffused by the terminations of the arteries among the interstices in the texture of the different organs, and was from these absorbed by the veins; and it was not without apparent reluctance that he was afterwards induced in this particular to admit the doctrine which is now universally established.

After the great discovery of Harvey was placed beyond the reach of controversy, attempts were made to detract from his merit, by showing that it was not original. Obscure passages and accidental expressions in the writings of ancient and modern authors were distorted by miserable envy, for the purpose of proving that Harvey, now acquitted of heresy, was chargeable with plagiarism. A singular circumstance occurred to give a temporary triumph to calumny. Harvey, having maintained some degree of intimacy with the Venetian ambassador at the court of London, who had heard and admired his lectures, gave him a physiological manuscript just before his departure, which the ambassador presented to Paulus Sarpius, a learned monk of his own country. After the death of this religious person, when his manuscripts were explored, a story was circulated, that the discovery of the circulation belonged to Paulus, who had communicated it either to Fabricius, or to Harvey. This unfavourable impression was easily credited, and a considerable time was required before it could be effaced.

Harvey, however, was not one of those ill-fated men of genius, who are denied all due honour till the enjoyment of it is put out of their power by death. He was caressed at court, and warmly esteemed by his scientific brethren. By what means, or at what period he was introduced to royal notice, we are not informed: but a letter from James I. of England was found among his papers, dated 1623, *i. e.* 15 years after he had connected himself with the London College, from which it appears that he had been for some time extraordinary physician to the king, and had been actively employed about the royal person. Seven years after this, in the reign of Charles I. he was promoted to the office of physician in ordinary. He was also employed to accompany the young Duke of Lennox in his continental travels.

During the civil wars, Harvey accompanied the king in his different military movements; and, after the battle of Edgehill, retired with the royal family to Oxford. In three years after this, he was appointed warden of Merton college, instead of Nathaniel Brent, who had revolted to the Presbyterian cause.

The circulation of the blood was not the only subject in which Harvey was eminent. He also made important discoveries on the subject of generation; and, at the age of 73, at the pressing request of Sir George Ent, published his work, entitled *Exercitationes de Generatione Animalium*, which contained many experiments on incubation, and the reproductive functions of viviparous animals, ingeniously contrived, and executed with much labour. One of his favourite conclusions was, that impregnation is not accomplished by the contact of the semen of the male with the embryo in the body of the female, but by a pecular stimulus communicated by it to the vagina, and by sympathy to the other female organs, and which he compared to contagion for the peculiarity of its effects;—a conclusion which he considered as supported by this fact, that a single impregnation of a female fowl was sufficient to impart a prolific quality to *ova* not yet formed.

Harvey dissected the body of Thomas Parr, so celebrated for longevity, having lived to the age of 153, and his account of the appearances which he found is delivered in his own words in the editions of his works.

Several letters written by him to men of science are also preserved and published, all of which breathe the same chaste philosophical spirit; and the latest of them shew that he retained, in extreme old age, the same admirable vivacity of intellect for which he was distinguished through life. His *Anatomia Universalis*, and some other writings not intended for publication, are preserved in manuscript in the British musuem. Some of his manuscripts, however, and most particularly those containing his extended views and experiments on generation, were, to the great detriment of science, destroyed by the licentiousness of the Parliamentary troops, when they occupied his house in London.

When Charles I. fled from Oxford, Harvey went to London, where he practised but little as a physician, spending a great part of his time in a rural retreat at Lambeth.

Having now attained to the summit of professional eminence, he received, in 1652, a splendid testimony of the esteem entertained for him by the College of Physicians. A bust of him was executed by their orders, and placed in their hall, accompanied by a complimentary inscription. He, in his turn, gave a proof of his affection for that learned body, by presenting them with a hall, and his excellent library.

In two years after, when Dr Prujean resigned the situation of president of the college, Harvey was chosen his successor; but, on account of his age and infirmities, he delicately declined that honourable charge. He continued till a very late period of his life to officiate as a lecturer. He attended the meetings of the college when important business was agitated; and, in the year 1656, he bequeathed to them his patrimonial property. Loaded with various increasing infirmities, he died on the 3d of June of the following year, aged 79, and was buried at Hampstead, where a monument, with a figure and suitable epitaph, is erected to his memory.

The College of Physicians, in 1766, published a beautiful edition of his works in one large quarto volume, to which is prefixed an account of his life by Dr Lawrence. Harvey wrote with great perspicuity, and a flowing eloquence. His works are not in the slightest degree tainted with a spirit of hostility. His controversial antagonists, even those who wrote with petulance and asperity, are treated by him in temperate and civil language. His candour, cheerfulness, and goodness of heart, were conspicuous in his whole life, as well as in his writings, and exhibit a worthy pattern for future imitation. (*H. D.*)

HARWICH is a town of England, in the county of Essex. It is situated at the north-east extremity of the county, on a point of land bounded on the east by the sea, and on the north by the estuaries of the Stour and the Orwell. The town consists of three principal streets, with various lanes branching off in different directions. The chief buildings are the chapel, built by the Earl of Norfolk about the beginning of the 13th century; the town-hall, rebuilt about 53 years ago; the school-house, and the custom-house. Its market place is inclosed, and is neat and clean. The town is walled in, and the streets are paved with a kind of clay from a petrifying spring in the neighbourhood, which makes it as hard as stone.

The inhabitants of Harwich are principally employed in ship-building and other maritime occupations. Several third rates and other large vessels have been built here. The harbour, which is independent of the bay, is spacious, deep, safe, and convenient; and a light-house has lately been erected on a hill below the town for guiding vessels into it.

The North Sea fishery gives employment to about 3000 tons of shipping, and 500 sailors belonging to this port. The people too receive much support from the Dutch packet boats, which, in time of peace, carry on a great intercourse between Harwich and the continental ports.

During the bathing season, Harwich is frequented by much company, who find here tolerably good accommodation. Bathing machines have been for some time introduced; and there are two hot and two cold salt water baths, with a steam or vapour bath, and a large bathing place, with a machine for throwing the hot or cold water on any part of the body. The buildings, which have commodious dressing rooms, stand in a large reservoir, containing many hundred tons of sea water, which is renewed every tide, so that the baths are continually supplied with fresh sea water by a contrivance on the principle of a natural syphon.

On the opposite side of the bay in Suffolk stands Landguard fort, which is built on a point of land united to Walton Colness, but so encircled by the sea at high water as to become an island nearly a mile from the shore. It completely commands the entrance to the harbour of Harwich, and was erected for this purpose in the reign of James I.

Harwich was made a burgh in the reign of Edward II.

It is governed by a mayor, 8 aldermen, 24 burgesses, a recorder, &c. and sends 2 members to parliament.

The following is the population, &c. of the burgh of Harwich for 1811.

| | |
|---|---|
| Number of inhabited houses | 564 |
| Do. of families | 910 |
| Do. employed in agriculture | 72 |
| Do. in trade and manufactures | 178 |
| Males | 1519 |
| Females | 2213 |
| Total population in 1811 | 3732 |

See Morant's *History, &c. of Essex*; Dale's *History of Harwich and Dover Court*; and the *Beauties of England and Wales*, vol. v. p. 330. For an account of Harwich Cliff, see ESSEX, vol ix. p. 206, col. 2.

HASSELQUIST, FREDERICK, a celebrated Swedish botanist, was born at Toernvalla in East Gothland, on the 3d Jan. 1722, old style. Having been left an orphan at an early age, he was for some time supported by his maternal uncle; but upon the death of this his only friend, he was obliged to support himself by teaching, even for some time after he entered the university of Upsal in 1741. In 1746, he procured a royal stipend or scholarship, and such was his progress in botanical acquirements, that he became a favourite pupil of Linnæus; and was inspired with such an ardour to examine the botany of distant countries, that though affected with a pulmonary complaint, he resolved to examine the natural history of Palestine. In 1749, he read lectures on botany in Stockholm; and having received the offer from the Levant Company of a free passage to Smyrna, he set sail on the 7th August, and arrived in that city on the 27th of Nov. 1747. During the winter, he made an excursion to Magnesia, and on the 13th May he arrived at Alexandria, and afterwards visited Rosetta and Grand Cairo. In March 1751, he proceeded to Damietta, from which he sailed to Jaffa, where he began his examination of the natural history of Palestine. On the 23d May he set sail for Cyprus, and after visiting Rhodes and Stanchio, he returned to Smyrna in the end of July. His laborious exertions had now begun to impair his strength, and though he tried a milk diet, and a winter's repose at Smyrna, yet his health gradually declined, and he died on the 9th February 1752, in the 31st year of his age.

During his travels and illness, Hasselquist had unfortunately contracted a debt of about 350*l.* sterling, and upon his death his collections and MSS. were seized by his creditors at Smyrna. As soon as the Queen of Sweden was informed of this event, she redeemed that valuable deposit, and put it under the care of Linnæus. The MSS. papers of Hasselquist were published in 1757 in Swedish, under the title of *Iter Palestinum*, in one vol. 8vo. with a biographical preface by Linnæus, and his correspondence with the author. His work has been translated into several languages, and appeared in English in London in 1766. Hasselquist is also the author of several memoirs in the Transactions of the Academies of Upsal and Stockholm, from 1750 to 1752. See the preface to his *Iter Palestinum*; Haller's *Bibliotheque Botanique*; and Rees's *Cyclopædia*.

HASTINGS, is a burgh and market town of England, in the county of Sussex. It is situated near the eastern extremity of the county, in a valley that forms a beautiful amphitheatre, sloping on the south to the sea, and flanked on the east and west by lofty hills. The town consists of two parallel streets, the High Street and Fish Street, running north and south, and separated by a rivulet called the Bourne, which supplies nearly the whole town with water, and runs into the sea. The town is well paved, and contains many handsome houses. The principal public buildings, are the two churches of All Saints and St Clement's, the town-hall and market-place, and a custom-house, with an establishment of 12 riding officers. The two churches are very ancient buildings. St Clement's is large and lofty. The town-hall was built in 1700, and has the market-place under it. There are here two excellent free schools, founded for the education of 130 scholars; and also a barrack for foot soldiers. The remains of an ancient castle are still visible on a high rocky cliff to the west of the town. The ruins resemble in form two sides of an oblique spherical triangle; having the angles rounded off. The base or south side towards the sea completes the triangle, and is formed by a perpendicular crag about 400 feet long. The east side is a plain wall about 300 feet long, and the north-west side is about 400 feet, the whole area being about 1⅕th acre. The walls are about eight feet thick. A little to the west of the crag, are the remains of a priory of Black Canons.

Hastings is one of the cinque ports. It had formerly a good harbour and a considerable trade; but as the harbour is choked up with sand, it now carries on merely a small coasting trade with London. Immense numbers of mackarel, herrings, soles, &c. are caught here, and forwarded by land carriage to the London market. The only way to secure ships is to draw them up on the beach, which is here called the Stade. At the west end of it is a fort mounting eleven 12-pounders. Boat building is carried on here to a considerable extent; and considerable occupation is given to the inhabitants by a lime company, which employs nine sloops of 40 tons burthen, in bringing the chalk from the Holywell pits at Beachy Head, from April to November. About 120,000 bushels of lime are annually made at the kilns, which are situated to the west of the town.

Like other towns upon the coast, Hastings draws considerable advantages from sea-bathing. Twenty bathing machines stand to the west of the town, close to a newly formed walk called the *Parade*. The beach is here admirable; and convenient warm baths have been established some time ago by subscription. At the distance of two miles from the town is a large broad stone, on which William the Conqueror dined when he landed here. It is called the "Conqueror's Table."

The following is the statistical abstract for the town in 1811:

| | |
|---|---|
| Number of inhabited houses | 665 |
| Do. of families | 789 |
| Do. employed in agriculture | 45 |
| Do. in trade and manufactures | 479 |
| Males | 1739 |
| Females | 2109 |
| Total Population in 1811 | 3848 |

East Long. 41′ 25″, North Lat. 50° 52′ 10″, according to trigonometrical observations. See the *Guide to the Watering Places* 1805; and the *Beauties of England and Wales*, vol. xiv. p. 184.

HASTINGS, BATTLE OF. See ENGLAND.

HAT, is the name of a piece of dress worn upon the head by both sexes, but principally by the men. The use of hats seems to have been first introduced among the ecclesiastics in the 12th century, and it was not till the year 1400 that they seem to have been pretty generally adopted.

As the art of making common hats does not involve the description of any curious machinery, or any very interesting processes, we shall not enter into minute details upon the subject. It will be sufficient to convey to our readers a very general idea of the method which is employed.

The materials employed in making hats, are the fur of hares and rabbits freed from the hair, together with wool and beaver. The beaver is reserved for the finest hats.

The fur is first laid upon a *hurdle* made of wood or wire, with longitudinal openings; and the operator, by means of an instrument called the *bow*, (which is a piece of elastic ash, six or seven feet long, with a catgut stretched between its two extremities, and made to vibrate by a bowstick,) makes the vibrating string strike and play upon the fur, so as to throw the fibres together, while the dust and filth descend through the chinks of the hurdle. A sieve or searce has sometimes been used for the same purpose.

After the fur is thus driven by the bow from one end of the hurdle to the other, it forms a mass called a *batt*, which is only half the quantity sufficient for a hat. The *batt* or *capade*, thus formed, is rendered compact by pressing it down with a *hardening skin*, (a piece of half tanned leather,) and the union of the fibres is increased by covering it with a cloth, and allowing the workman to press it together repeatedly with his hands. The cloth being taken off, a piece of paper, with its corners doubled in, so as to give it a triangular outline, is laid above the batt. The opposite edges of the batt are then folded over the paper, and being brought together and pressed with the hands, they form a conical cap. This cap is next laid upon another batt, ready hardened, so that the joined edges of the first batt rest upon the new batt. This new batt is folded over the other, and its edges joined by pressure as before; so that the joining of the first conical cap is opposite that of the second. This compound batt is now wrought with the hands for a considerable time upon the hurdle, being occasionally sprinkled with clear water till the hat is *basoned*, or rendered tolerably firm.

The cap is now taken to a wooden receiver, like a very flat mill-hopper, consisting of eight wooden planes, sloping gently to the centre, which contains a kettle filled with water acidulated with sulphuric acid. In this liquor the hat is occasionally dipped, and wrought by the hands, and sometimes with a roller, upon the sloping planks. The hat is thus fulled or thickened for four or five hours; knots or hard substances are picked out by the workman, and felt is added by means of a wet brush to those parts that require it. The beaver is laid on at the end of this operation, and in the case of beaver hats, the grounds of beer are added to the liquor in the kettle.

The hat is now to receive its proper shape. For this purpose the workman turns up the edge or rim to the depth of about 1½ inch, and then returns the point of the cone back again through the axis of the cap, so as to produce another inner fold of the same depth. A third fold is produced by returning the point of the cone again, and so on till the whole resembles a flat circular piece, having a number of concentric folds. In this state it is laid upon the plank, and wetted with the liquor, the workman pulls out the point with his fingers, and presses it down with his hand, turning it at the same time round on its centre upon the plank, till a flat portion, equal to the crown of the hat, is rubbed out. This flat crown is now placed upon a block, and by forcing a string, called a *commander*, down the sides of the block, he forces the parts adjacent to the crown to assume a cylindrical figure. The rim now appears like a puckered appendage round the cylindrical cone; but the proper figure is now given to it by working and rubbing it.

The hat being dried, its nap is raised or loosened with a wire brush or card, and sometimes it is previously *pounced* or rubbed with pumice, to take off the coarser parts, and afterwards rubbed over with seal skin. The hat is now tied with a pack-thread upon its block, and is then dyed, by being first boiled with logwood, and afterwards immersed in a saline solution, consisting of a mixture of green copperas and blue vitriol.

The dyed hats are now removed to the stiffening shop. Beer grounds are now applied on the inside of the crown, for the purpose of preventing the glue from coming through; and when the beer grounds are dried, glue, (gum Senegal is sometimes used,) a little thinner than that used by carpenters, is laid with a brush on the inside of the crown, and the lower surface of the brim.

The hat is now softened by exposure to steam, on the *steaming* bason, and is then brushed and ironed till it receives the proper gloss. It is then cut round at the brim by a knife fixed at the end of a guage, which rests against the crown: The brim, however, is not cut entirely through, but is torn off so as to leave an edging of beaver round the external rim of the hat. The crown being tied up in gauze paper, which is neatly ironed down, is then ready for the last opnseratio of lining and binding.

Hats are frequently made of straw, or of the chips and shavings of wood woven or plaited together, to form ribbons of narrow widths; and these are wound spirally round a block, and sewed together in a cylindrical form, so as to form the hat. The rim or border is made in a similar manner, and sewed to the hat afterwards.

The manufacture of straw hats gives employment to vast numbers of the poor inhabitants of Hertfordshire and Bedfordshire. They select the whitest and most regular straws, and cut them exactly into lengths; the straws are then whitened, by inclosing a great number of bundles in a large box, leaving a considerable space in the middle, into which a cup filled with sulphur is placed, and this being lighted, the box is shut close, and covered up with a wet blanket, to keep in the vapour of the burning sulphur, which insinuates itself through all the bundles of straw contained in the box, and renders them whiter, and of a more delicate colour. After this preparation, the straws are split lengthwise into several segments by a wire fitted to the interior capacity of the straw, and having four, six, or eight leaves, sharp on the upper edges, and projecting radially from the wires. The straws will easily split in the proper manner when the wire is forced through them. For the convenience of holding this tool, the wire is bent at right angles, about an inch below the part where the leaves project from it, and this bent part is fixed in a handle. The slips of straw are now softened in water, and plaited together by children, with great rapidity and exactness. The most simple plait is that of three straws; but this is only for very coarse articles, and the slips of the straws are very broad. Sometimes whole straws are employed, being first pinched flat by softening them, and drawing them through the fingers. The most esteemed plait is that of six straws, and is more or less valuable as it is finer or coarser; and after the plait is finished, it is passed several times between a pair of small wooden rollers, to render the ribbon flat and solid. Of these ribbons the hat is formed, by winding them, in a spiral direction, round a proper shaped wooden mould or block with a little overlap, and sewing them fast together; and when it is thus finished, the whole is passed over with a hot iron, to smooth down the seams, and the block is then taken to pieces, to withdraw it from the hat.

The Society of Arts have lately published a description of a machine for ironing down the hats upon the block. For this purpose the block is fixed upon a vertical spindle, so as to turn round horizontally; and the pressure is given by a heated steel plate, fixed in the middle of a long lever, the fulcrum of which is supported with an universal joint, at the top of an iron stem rising up from the table upon which the machine is placed. The opposite end of the lever has a handle, with which the workman presses the steel plate down upon the straw, and rubs it sidewise to smooth it down, at the same time he turns the block and hat round upon its spindle, by means of cross arms provided for that purpose, to present every part to the action of the steel. An iron box is formed just over the steel plate to receive a red hot heater, and this is kept in by a lid. It is stated as a great advantage of this machine, that the pressure of the lever being considerable, the hot steel plate can be quickly passed over the straw, and does not therefore injure the colour.

The importation of straw hats from Germany and Italy is very considerable. They have the reputation of producing the best articles of that kind at Leghorn, from whence more than 12,000 dozen have been imported in one year. Mr Corstoul, in a memoir to the Society of Arts, has shewn the practicability of producing an adequate substitute for this article in England, by plaiting the straw of rye, which he cultivated on a poor sandy soil in Norfolk, sown at the rate of two bushels per acre. He found that the produce of four square yards, when manufactured, was ten yards of Leghorn plait, of four different qualities, and weighing one ounce.

Chips or shavings of wood are also used for making hats; and some hats of this substance are woven altogether in one piece, or they are woven in wide pieces, which are afterwards made up into the figure of the hat. Sometimes the chips are only used as the fabric of the hat, and are woven in with silk, which also covers the chips, and forms the exterior surface. A patent was granted in 1808 to Mr Thomas, of London, for an ingenious machine which weaves the whole hat in this way, and of the intended figure, without any seams. PLATE CCLXXXVIII. Fig. 7. is an elevation, and Fig. 8. a section of this machine, in which A is the block or mould, upon which the hat is to be formed, and so put together in pieces as to separate for the purpose of taking off the hat. It is fixed upon a square stem B, which rises and falls into a square tube D, by the action of a pinion *a* upon a rack which is fixed to the stem. The tube D is supported upon a pivot at the lower end, and is embraced at about half its length by a collar E, in the frame or pedestal EFF, which sustains the whole machine, but permits it to turn round upon the pivot, that the workman who sits with the machine before him, may bring every part of the block towards him. He can turn it round by applying his foot to the circular board or wheel *e e*, which projects from the axle or tube D at the lower end. The top of the tube D carries a cylindrical wooden box G, large enough to contain the block A without touching it; and upon the upper edge of this cylinder is fixed a projecting flaunch or circular plate. Around the circumference of the plate, a circle is described, and a row of holes pierced at equal distances, so as to divide the circle into 72 parts, and each hole receives a wire *h*. Immediately within the row another circle is made, and divided into the same number of holes; but the wires *i* which pass through these latter holes are interspaced between the former. Each wire has an eye formed through its upper end, for the reception of a slip of chip, marked *k l*, of which there will be 144 in number, radiating from the centre of the block, to which they are all made fast by a plug; and after passing through the eyes of the wires *k* and *l*, the slips hang down, and have small leaden plumbets *m*, *m* appended to them, to stretch them straight.

The lower ends of the wires *i* are all jointed to a circular ring of wood *o o*, which fits upon the external surface of the cylindrical box G, and slides freely up and down thereupon; in like manner the interior wires *k* are jointed at the lower ends to a similar ring *i i*, which is connected with the former ring *o o* by two small cords, which pass over pulleys fixed in the flaunch *g*, and consequently when either the rings *i* or *o* are pulled down the other must be raisde up, and *vice versa*. To draw down the lower ring *o*, it has two wires *p*, *p* (Fig. 7.) joined to it at the opposite sides, and these descend to the treadle *r*, upon which the workman places his foot; and the action of this pressure is to divide the whole number of shreds of chip into two sets *k* and *l*, one of which is depressed, and the other elevated. The weaving is performed by passing a knitting needle filled with silk in the space or angle between *k* and *l*, until it has made a whole circuit round the block or crown of the hat; then, relieving the pressure upon the treadle *r*, the weights *m* cause the wire *h* and ring *i* to descend, and the other set of wires *i*, and their ring *o*, to ascend, by which means the situation of the chips *k* and *l* become reversed, *l* being the uppermost, and *k* the lowest. In this situation the needle is again passed round in the opening between them. This done, the treadle *r* is depressed to restore them to the position of the Figure, and the needle is again passed; and thus the operation is continued until the whole is woven together; the chips radiating from the centre forming the warp, and the silk the weft, running in circular or rather spiral lines, and passing alternately over and under every chip. In some cases two needles of silk are employed, one preceding in one direction, and the other in the opposite direction, or one passing over any chip whilst the other passes under it; and in this way the whole surface of the hat is of silk, the chips being all covered. When the crown of the hat is finished in this way, the cylindrical part is done by raising up the block by its rack and pinion; and at last the block is taken to pieces to get the hat off.

For farther information on this subject, see Nollet, *Art du Chapellier*, or *Mem. Acad. Par.* 1765; *Hist.* p. 132; Gerard, *Mem. Acad.* 1770; *Hist.* p. 116; Trousier, in Rozier's *Journal*, vol. xxvii. p. 71; Monge on Felting, in the *Annales de Chimie*, vi. p. 300, or in the *Repertory of Arts*, vol. iii. p. 351; Chaussier, in the *Journal Polytechnique*, or in Nicholson's *Journal*, vol. i. p. 399, or in the *Repertory of Arts*, vol. x. p. 275; Tilstone's patent for making hats of kids' hair, in the *Repertory*, vol. i. p. 1; Dunnage's patent for water proof hats in imitation of beaver, consisting of silk, mohair, cotton, inkle or wool, in the *Repertory*, vol. iv. p. 302. Burn's patent for a new material for hats, in the *Repertory*, vol. ix. p. 167; Dunnage's patent for ventilating the crowns of hats, *Id.* vol. ix. p. 167; Boileau's patent for straw hats, *Id.* vol. xi. p. 97; Chapman's patent for taking off the fur or wool from skins for hats, *Id.* vol. vi. p. 374; Messrs Ovey and Jepson's patent for hats, *Id.* vol. xiii. p. 373; Messrs Walker and Alphey's patent for water proof hats, *Id.* vol. xvi. p. 217; *Transactions of the Society of Arts*, vol. i. p. 29, vol. xxiii. p. 226, vol. xvi. p. 237, and vol. xxv. p. 154; Nicholson's *Journal*, vol. ii. p. 467, 509, vol. iii. p. 22, 23, 73, vol. iv. p. 236; Sarazin, *Mecanique propre à carder et melanger les laines et poils servant à la fabrication des chapeaux*, in the *Archives des Decouvertes*, *pour* 1812, vol. v. p. 189; Guichardiere *sur un nouveau moyen de fouler les chapeaux*, in the *Archives des Decouvertes*, &c. *pour* 1815, p. 198. See also our article ENGLAND, vol. ix. p. 11. for an account of the hat manufacture in England.

HATCHING, is exclusion of the young from the eggs of animals, either by the temperature of the circumambient air, artificial heat, or the incubation of birds.

Nature has adopted some remarkable distinctions in the mode of propagating animals. Some are brought to perfection in the womb of the mother; others, originally concentrated in eggs, are discharged either in that state, where the future concourse of the male is required to excite the vital spark, or where the latent embryo will be unfolded by the simple application of heat. To the first class belongs the offspring of all quadrupeds; the second includes many of the amphibious tribes, especially toads, frogs, and newts; and the third, the whole class of birds, numerous fishes and reptiles, and most of the insect, molluscar, and vermicular tribes. Hatching and incubation have therefore different meanings, or the former, which applies to every kind of evolution of the nascent being, may be said to include the latter. Most animals that produce eggs, leave them simply to the care of nature, and certainly never recognise their offspring after birth, at least with some exceptions, of which there is a prominent example in the crocodile. But in so far as we can yet ascertain, all birds impart their natural heat to their eggs by incubation, and watch the developement and subsequent growth of their young. Some distant analogy may therefore be conceived to subsist between gestation and incubation, in the respective period necessary for each, according to the genera and species of animals. The period of gestation is generally, perhaps universally, longer in the larger viviparous tribes; and incubation is protracted, in proportion to the size of the bird. One irreconcileable difference, however, subsists, in there being no known method of accelerating the former, while exclusion of the young from the egg may be promoted, by augmenting the intensity of the temperature. We are yet unacquainted with the process undergone by the egg of the largest of the feathered race, the ostrich: some assert that its exclusion is left entirely to the effects of the sun; while others maintain that it is aided by the incubation of the female. That of the swan requires incubation during 42 days; that of the domestic hen 21; and that of the linnet 14. But we are told, that the period is somewhat abridged in the warmer climates; that the egg of the common fowl has been brought out in 13 days, by the aid of artificial heat; and that, by the diminution or interruption of the temperature, it has been retarded for six weeks. It appears, that the heat of 104° of Fahrenheit's thermometer is required to hatch the eggs of all birds, the largest and smallest, and that the surface of the skin of the mother imparts it to that extent. Thus nothing more is required for the evolution of fecundated eggs, than the simple application of any kind of heat.

These facts have been a long time established beyond controversy, whence they could not escape the notice of the ancients, as they now attract the consideration of the most unlearned observers. Instead of abiding by the ordinary course which nature has herself committed to the parent, mankind, for the sake of deriving more profit from their own contrivances, have resorted to the means of hatching birds by artificial heat. The earliest information concerning this process, is probably obtained from Aristotle in these words: "Although incubation be the common method employed by nature for bringing out eggs, it is not exclusive; for we see that in Egypt eggs will be hatched of themselves in the earth, if covered over and heated by litter." And he farther remarks, "that when heated in certain vases wherein they are deposited, they hatch of themselves." Diodorus Siculus expresses his admiration of the contrivance; and Pliny, who lived a century after Diodorus, remarks, that "eggs are excluded of themselves quite naturally, and without the aid of incubation by fowls, as in the dunghills of Egypt." Nevertheless, on comparing this with other passages of his works, it is obvious that Pliny could not have been ignorant that the application of simple heat was effectual. He and Suetonius relate, that Livia, the wife of Augustus, who had before been married to Tiberius Nero, became pregnant, and desiring, with all the ardour of a youthful female, to discover of which sex her offspring would be, took an egg, that had undergone partial incubation, and kept it warm in her bosom. When obliged to desist, it was always committed to one of her women, that the same invariable heat might be preserved. Her object was successful; and the latter biographer informs us, that "from this egg a cock was hatched with a very remarkable crest." Pliny therefore concludes, "It is probably on such principles, that a method was not long ago devised, of placing eggs in straw heated by a slow fire, a man being occupied in turning them at different intervals until their chickens were hatched." In another work of the ancients, the *Geoponica*, there is a whole chapter ascribed to Democritus, treating of "how it is possible to hatch eggs without the aid of fowls;" and the principle is analogous to the employment of dunghills. The eggs are to be placed in jars, observing to mark the date of deposition on the shell of each, on purpose to ascertain when the 20 days necessary for their exclusion shall have elapsed. Then the shell is to be broken, and the chickens supplied with food. It is unnecessary to insist farther on the practice of the ancients; but as Herodotus passes over that of the Egyptians in silence, some authors have dated its commencement between his era and the age of Aristotle, which were not remote from each other.

This branch of industry, though continued to the present day, as we shall have a future opportunity of illustrating, is not peculiar to Egypt. It was adopted at Naples in the fifteenth century, where there was a palace belonging to King Alphonso II. containing an oven that could hatch 1000 chickens. Francis I. of France, is said to have made experiments on the same subject at his chateau of Mont Trichard, in the sixteenth century; and Thevenot, at a later period, affirms that one of the Grand Dukes of Tuscany, obtained an Egyptian to superintend his proceedings; and also refers to the same process being adopted in Poland.

The art however seems to have been practised on the most extensive scale in Egypt, to which country we are constantly referred for details on the art of hatching birds by artificial heat. The Royal Academy of Sciences at Paris, indeed, esteemed this subject sufficiently interesting for particular inquiry, and from the investigations which they made, as well as from the accounts of various travellers, we have obtained the following information.

A rectangular edifice of brick or clay, called a *mamal*, is constructed, half sunk in the earth. Niebuhr describes one at Cairo, as being in a manner implanted in a hillock. It consists of two stories communicating with each other, and down the middle there is a passage, probably for the attendants. Each side of the passage is partitioned into 5, 6, or 8 chambers, or any other number, as no general rule seems to be preserved, and in these the eggs are deposited. At the outside of one angle of the building there is a furnace or fire-place, and this being filled with a mixture of cow's and camel's dung, the ordinary fuel of that country, the heat is conveyed to both stories by means of flues during 3 or 4 hours daily, at different intervals; but after ten days fire is no longer supplied, the oven being sufficiently heated. Lest the heat should be too great, ventilators are used; but those who conduct the process have no other rule, than to render the temperature equivalent to that of the baths of the country, and, if it is greater at first, they affirm, that it will occasion no injury. When the oven is converted to use, the floor of the compartments is covered with a mat, above which there is a bed of straw, and then a layer of eggs. Niebuhr says, a second tier of eggs covers the first. Mr Browne, if we rightly recollect, affirms, that the eggs are deposited in such a manner as not to touch each other. All are turned twice each day, and four times during the night. Towards the eighth or tenth day, they are examined with a lamp, and those which appear unimpregnated are rejected, and in fourteen days the whole are transferred to the upper story. At length, on the twentieth and twenty-first day, exclusion takes place; and as the chickens can subsist two days without food, their owners have sufficient time to receive them, or they are sold to others.

The number of mamals distributed throughout Egypt in the beginning of the last century was 386, according to Father Sicard; and the number of eggs hatched in each is said, by him and other travellers, to amount to 40,000, 50,000, or even 80,000 eggs, a fact almost incredible. But in the arrangements necessary to encourage and preserve such a branch of industry, a circle of several villages must bring to the mamal all the eggs belonging to that particular district. The inhabitants are liable to penalties if they dispose of them elsewhere; and the proprietor of the mamal is also limited by certain restrictions. He is entitled to select those eggs which he deems sufficient, and is responsible for a produce corresponding to only two-thirds of the number. Thus the owner of 3000 eggs receives only 2000 chickens; but as unreasonable profits would sometimes be derived from the surplus, he is entitled to redeem the chickens at a certain price from the proprietor of the oven. Dr Graves, in a paper in the *Philosophical Transactions*, says, that 200 pounds of litter are daily required for heating the mamals; and Pococke observes, that it is scarcely possible to enter them on account of the smoke.

The success of this process is supposed to result more from the nature of the climate in Egypt, where it is practised only during certain seasons, than from any particular ingenuity. Sudden alterations of weather may be destructive of the progeny; and an instance is given, where the occurrence of a shower cooled the atmosphere so much that 4000 chickens, nearly matured, perished in one oven. It is affirmed, that the inhabitants of a village called Bermé, situated on the Delta, are almost exclusively the managers of the process, which is transmitted from father to son, and preserved secret among them. At appointed times, they disperse themselves throughout Egypt, to take care of the ovens.

The modern Chinese are well acquainted with the method of hatching chickens by artificial heat. Mr Barrow mentions, that even those families practise it who have a permanent abode on water. They deposit the eggs in sand, at the bottom of wooden boxes, which are placed on iron plates kept moderately warm. Thus, while a new brood is obtained, the old birds continue laying nearly without interruption.

M. de Reaumur, an ingenious naturalist, devoted much time and attention to the subject of hatching eggs by artificial heat, which he seems to have been desirous of introducing into France under the superintendence of a Bermean. He adopted different methods of accomplishing this, which are copiously detailed in a work on the subject, that has been translated into several European languages. Two plans were principally followed; the first, which was analogous to that of the Egyptians, consisted in raising a superstructure above three bakers ovens, for containing the eggs. A small carriage on wheels, or rollers, was formed, in which were several drawers, or shelves, whereon the eggs were placed in successive rows, or strata, that is, one layer on each. The carriage could be brought at pleasure on its wheels to any part of the surface, and the state of all the eggs could be ascertained on pulling out the shelves, or drawers, in which a thermometer likewise lay, for indicating the heat. By means of this simple apparatus, Reaumur succeeded perfectly in hatching chickens; and he acquaints us, that a nun, to whom he entrusted his first experiment, in the oven of a convent, obtained 20 from 100 eggs. He conceives that a suitable oven, twelve feet square and four feet high, with a stove in the centre, could be erected at little expence, which would necessarily be heated to 104°. Instead of thermometers, the temperature may be ascertained by melting a piece of butter, as large as a walnut, with half as much tallow in a phial. When it flows like a thick syrup on inclining the phial the proper heat is obtained.

The second, though a less efficacious plan, adopted by Reaumur, consisted in burying casks of eggs in a dunghill, the warmth of which might promote exclusion. Here, however, he was opposed by uncommon difficulties; and he acknowledges that, had the former expedient been first devised, he should never have resorted to the latter. His experiments were originally made by depositing the eggs simply in the dunghill in an oblong cavity, covered by two planks. Most of them advanced favourably during eight or ten days; but after this they became putrid, disseminating an infectious effluvia, and not one produced its young. On employing casks, Reaumur suspended three flat baskets or sieves at intervals within them, containing one or two layers of eggs, along with thermometers. However, the temperature of the dunghill being subject to continual variation, occasioned great embarrassment; and the author conceives that the experiment may be more successful by resorting to several, which may possess different degrees of heat. To preserve it permanently equal is very difficult; and turning the eggs is also attended with trouble. In the course of his experiments, Reaumur found, that, though the temperature should be regularly 104°, the expanding embryo could exist at from 115° to 122°; and that an egg, during the period of total developement, loses about a fifth or sixth of its weight. He found that a humid and mephitic vapour arising from the dunghill injured the nascent young more than heat. He therefore devised a new kind of oven, heated in the same manner as the casks by a dunghill, but resembling the superstructure he had used on the baker's oven. This was a rectangular box or case, six or seven feet long, between 21 and 40 inches broad, and about 8 inches high. It was immersed in a dunghill, leaving one end open, and the eggs were placed on a carriage or tablet moved in upon rollers. By observing proper precautions, Reaumur succeeded in hatching about three-fourths of the eggs he employed.

From the brief abstract now given, a general idea may be formed of the two different methods; but M. de Reaumur's work itself must be consulted for the details. As it is not uncommon, we shall proceed to give an account of other expedients suggested or adopted by a more recent naturalist, the author of the *Ornithotrophie Artificielle*; more especially as we do not know that they have ever been alluded to in any English work.

This author employed a circular oven of earthen-ware as a model of his great plan, heated by a cylinder of boiling water passing through its centre and resting on a fire-place below. This model, which proved sufficient for practice, is 28 inches high, by 24 in diameter; and an inch thick in the sides. The top is arched; and some inches below the commencement of the arch are four holes opposite to each other, two inches in diameter, for ventilators; because in all these experiments ventilation must be strictly attended to; as also other four near the bottom, of one inch in diameter, two of which penetrate the sides of the oven horizontally, and two obliquely. All have cork stoppers. There is a door half way up the side of the oven, six or seven inches square, which may be opened to admit the hand for internal operations, with a hole and a cork stopper of an inch diameter in the middle. This oven, which, it will be observed, is of a cylindrical form, is closely luted to an earthen-ware table, two feet and a half square, and two inches thick, with a hole in the centre for receiving the column or cylinder of hot water. Below the table, and between its feet, there is a small stove, also of earthen ware, about ten inches deep and seven in diameter, which, besides a door on hinges like that of a common stove, six inches by five, has other two openings. One of these is in the centre of the top, three inches in diameter, to admit the base of the metal cylinder for water; the other is in that side opposite the door, nearly three inches in diameter, and three inches lower than the former. Its use is to carry off the smoke from a grate of live coal whereon this stove is to be placed. But one of the most essential parts, the one indeed where the chief merit of the contrivance lies, consists in the means of heating the oven by a hollow tin cylinder, three inches in diameter, let down into the hole at the top of the arch above, and resting on the stove below, which is situated on the grate. By the boiling of water contained in it, the requisite heat is obtained; and its degree is regulated by the ventilators. The cylinder must be closely luted to all the three apertures through which it passes, that is, the top and bottom of the oven, and the top of the stove; but it is necessary that about two inches should intervene between the top of the stove and the table or bottom of the oven. A moveable lid of block tin, with a hole of an inch diameter in the centre, covers the top of the cylinder, which projects a little above the oven. In practice, it is found more convenient to increase the cylinder to the diameter of four inches, and some enlargement of the stove is also advantageous. The eggs may be deposited on cards or small shelves, three or four inches broad, ranged around the interior, and separated by intervals of three or four inches high, so as to contain above 300.

Should the reader understand the preceding description, he will easily comprehend the mode of enlargement of all the parts, when real service and operations on an extensive scale are required. A circular brick building, arched above, seven feet eight inches high to the spring of the arch within, seven feet of internal diameter, and eight inches thick in the wall, is to be erected. Ventilators, as before, are in the sides; and the door is four feet high, glazed in the upper part. Ten successive tiers of shelves, a foot broad, project from the whole internal circumference, leaving an interval of seven inches between them; and as 44 or 45 eggs occupy a foot square, these shelves will contain 8000. The cylinder of water must be a foot in diameter, projecting above the building, and entering a stove below, over a furnace which is now to be sunk in the ground. It is necessary to keep a thermometer constantly immersed in it; and a hygrometer is also required to ascertain the humidity of the interior of the edifice, which is to be lined all over with lambskins, and covered externally by woollen stuffs. Moveable skylights in the roof admit fresh air into the building. The advantage of using hot water is, the equal and uniform diffusion of temperature throughout the oven, which, at the edges of the shelves, should be 106°, and will be indicated by the thermometers deposited there.

After selecting the eggs, they are to be laid on a thin bed of very dry rubbed straw, and turned three or four times daily. The ventilators are to be opened twice a-day. On the sixth day it will be seen on inspection what eggs should be removed as unproductive, and this examination ought to be repeated on the fifteenth. Towards the nineteenth day it is proper to stretch mattings over the edges of the shelves, to guard the young brood, which will appear on the twentieth or twenty-first, from falling over. The period of exclusion is sometimes accelerated or retarded; the operator should continue removing the shells, and aiding the weaker chickens to free themselves; but the remaining eggs are to be withdrawn as unproductive only on the twenty-third day.

With regard to the actual practice which the inventor of these methods followed, it appears that in two experiments on fifty eggs each, when the model was used, the first had but indifferent success, from the heat having been kept too low: but, in the second, chickens were obtained from the whole impregnated eggs, except three or four. Eight broods were attempted in the large oven, each quantity of eggs consisting at a medium of from 2000 to 3000, and the experiments were made at different seasons. At an average the product did not exceed one in six, while, in trying natural incubation at the same time, about two-thirds of the eggs were hatched. The dryness of the internal air proved injurious, and chickens of larger size were procured, by obtaining an artificial humidity from the evaporation of water in vessels.

It is generally understood, that chickens hatched in this way are not equal in strength and size to those procured by the regular process of nature; many are maimed, and it is said that monstrosities are frequent.

When the young brood has escaped, the heat of the oven may be reduced to 95° or 90°, and they may be fed, though they can subsist a day or two without meat. They may then be consigned in great numbers to the care of capons, trained on purpose. But as capons are very rare in this country, and as on the continent it was found more convenient to prosecute the process without the intervention of other animals, *artificial mothers* have been contrived. These are of different kinds, but one of the best is a low cage, of two or more stages, stuffed within, and lined with feathers: or there is another equally useful, consisting merely of two opposite shelves, near the ground, stuck over with feathers below, under which the animals may creep at pleasure. See Reaumur *Art de faire eclore et d'Elever en toute saison des Oiseaux Domestiques*; and *Ornithotrophic Artificielle ou art de faire eclore et d'Elever la Volaille par le moyen d'un chaleur Artificielle.* (c)

HAVANNAH is the principal town in the island of Cuba. It is situated on the north coast of the island, about 45 leagues from Cape Sable, and 80 coastwise from St Antonio, in a fertile and agreeable tract. It is built in a semicircular shape, the shore forming the chord, and is nearly two miles in circuit. The town is, upon the whole, regularly built, but the squares are irregular, and the streets narrow; some of the principal ones being paved with iron-wood, which is very durable. Near the middle of the town is a spacious square, enclosed by uniform buildings. The houses are disfigured with heavy balconies and wooden railings, and are by no means elegant. The town contains 11 handsome and richly ornamented churches, two hospitals, and other public buildings. The Recollects church has 12 beautiful chapels, and in the monastery are cells for 50 fathers. The church of St Clara has seven altars, adorned with plate; and the nunnery contains 100 women and servants. The church of the Augustines has 13 altars, and that of St Juan de Dios. 9. The arsenal is a very superb edifice. The harbour, which is about a league in breadth, is capable of containing all the navies of Europe; and it is so safe that they could lie without cable or anchor. There is generally a depth of six fathoms of water in the bay. This harbour is strongly fortified, both by nature and art. The entrance to it is through a very narrow channel, about 1200 yards long, and confined by rocks. The entrance is guarded by platforms and various works, mounted with artillery. The mouth of the channel is also defended by two strong forts. The fort on the east side, situated on a rock, is called the Morro. It is of a triangular form, and is fortified with bastions and 40 pieces of cannon. The other fort on the west side, and adjoining to the town, is of a square form, and is called the Punta. The other forts are El Fuerte, a square fort, mounting 22 pieces of cannon, the battery of the 12 apostles, and the shepherd's battery mounting 14 guns. As the town can only be attacked on the landside, it is strongly defended in that quarter; but the forts are commanded by several eminences, of which an enemy would readily take advantage. The Punta, the El Fuerte, and in a great measure the Morro, are commanded by the Cavannas, on a part of which the Morro is built. The north side of the eminence, on which the church of the suburb called Guadaloupe is built, flanks the Punta gate, while its south-east side commands the dock-yard. It is said that the works cover such a vast extent, that 15,000 men, who are the most that could be employed, are not sufficient to invest them. There are no fewer than 800 cannon mounted on all the works. An enemy's squadron can only anchor at the foot of the castle of St John D'Ulua. This celebrated fort contains no other water but that of the cisterns, which have lately undergone a great improvement, having been subject to split, from the discharge of artillery. The town was taken by the Buccaneers, under Captain Morgan, in 1669, and on the 13th August 1762 by the English, under Lord Albemarle and Sir George Pocock. The Morro was in this case taken by storm. It was, however, restored to Spain, at the peace of Paris in 1763.

The Havannah is the most important of the Spanish settlements in America, and is considered as the key of the West Indies. All the ships that came from the Spanish settlements, and formerly the galleons and flota, assembled at the Havannah.

There are large dock-yards at the Havannah for building ships of war. The masts, the iron work, and the cordage, are brought from Europe. The other materials are obtained in abundance in the island.

The trade of the Havannah consists in skins, tobacco, wood, sugar, dry confections, and generally of all the productions of the island of Cuba. Humboldt gives the following statement of the trade of the Havannah: Exportation in native produce eight millions of piastres, of which 31,600,000 kilogrammes (69,678,000 lb. avoirdupois), or 6,320,000 piastres in sugar (valuing the chest of sugar at 40 piastres), 525,000 kilogrammes (1,157,625 lb. avoirdupois), or 720,000 piastres in wax (the arroba at 18 piastres), 625,000 kilogrammes (1378,125 lb. avoirdupois) or 250,000 piastres in coffee (the arroba at five piastres. The exportation of sugar, which was next to nothing before 1760, amounted in 1792 to 14,600,000 kilogrammes, in 1796 to 24,000,000 of kilogrammes, and from 1799 to 1803, at an average, to 33,200,000 kilogrammes annually. In 1802 the harvest of sugar was so abundant, that the exportation rose to 40,880,000, kilogrammes (90,040,400 lb. avoirdupois); so that this branch of trade has been almost tripled in ten years. The customs of the Havannah amounted, between 1799 and 1803, at an average, to 2,047,000 piastres annually; and in 1802 they exceeded 2,400,000 piastres. The total amount of the trade is 20,000,000 piastres.

On the 19th January 1796, the city of the Havannah was honoured with the remains of the illustrious navigator Columbus. In consequence of an order contained in his will, his body was removed from the Carthusian convent of Seville, and deposited, along with the chains with which he had been loaded at Cuba, on the right of the high altar of the cathedral of St Domingo. When this island was ceded to the French, his descendants directed that the brass coffin, in which the whole was contained, should be removed to the Havannah, which was done on the 19th January 1796. The coffin was carried down to the harbour in procession, and under the fire of the forts, was put on board a brig, which conveyed them to the Havannah, where it was deposited without any monument. The city is supplied with water by the small river Lageda, which has its origin in the hills on the south-west side of the town. One of the three streams into which it divides itself runs into the sea to the east of the town, while the other two flow through the city. The population of the Havannah has been recently stated at 25,000; but Morse informs us, that an intelligent traveller has lately estimated it at 70,000. There are no fewer than 3000 cabriolets in the town. The position of the house of Don Antonio Robredo at the Havannah, according to the newly published observations of M. Ferber, is West Longitude 82° 5′ 47″, and North Latitude 23° 8′ 16″. See our article Cuba.

HAVERFORDWEST, called *Hwlffordit*, is a town of South Wales, and the capital of the county of Pembroke. It is situated on the side of a very steep hill on the banks of the river Daugleddy or Cliddy, which forms a bay for packets and vessels, and which is crossed by a good stone bridge. In the upper part of the town there are some good houses; but from the irregularity of the avenues, from the narrowness of the greater part of the streets, and from the confused manner in which the houses are piled one above another on the steep declivity of the hill, it has a very singular and unpromising appearance to a stranger. The principal public establishments are three churches, St Mary's, St Martin's and St Thomas's, a custom-house, a free school, a charity school, an alms-house, and a good quay, at which vessels of large burden can unload. The castle, when seen from the bridge, has a stately appearance; but since the sessions have been held here, it has been greatly disfigured by part of it being converted into a county gaol. The walls are of great thickness. It was strongly fortified with towers, and is said to have been built by Gilbert Earl of Clare.

At a short distance to the south of the town, is a priory of black canons, endowed by Robert de Haverford, lord of this place. The walk to it from the town is pleasant, and the ruins have a venerable aspect. The chapel is the best preserved part.

The market here is one of the largest and most abundant in Wales, and fish are to be had in the greatest plenty and variety. There is likewise a very large corn market, and there is a great fair for horses and cattle on the 7th of July on St Thomas's day, who is the tutelary saint of the upper town. Near this town there is a cotton mill, which gives employment to about 150 persons. It is the principal manufacture in the county. A considerable number of independent gentry reside at Haverford. The town is a county of itself, and it sends one member to parliament, who is elected by freeholders and burgesses, and inhabitants not receiving alms, to the amount of 500. The inhabitants draw their chief support from travellers who go from Milford Haven to Waterford, Wexford, Cork &c.

The following is the population abstract for the town in 1811.

| | |
|---|---|
| Number of inhabited houses | 630 |
| Number of families | 691 |
| Do. employed in agriculture | 32 |
| Do. employed in trade and manufactures | 290 |
| Males | 1257 |
| Females | 1836 |
| Population in 1811 | 3093 |
| Increase since 1801 | 213 |

See Malkin's *Scenery*, *Antiquities*, and *Biography of South Wales*, vol. ii. chap. 26. p. 293.

HAVRE de Grace is a seaport town of France, in the department of the Lower Seine. It is situated at the mouth of the river Seine, in a marshy soil, intersected with creeks and ditches. It is defended by lofty walls, and ditches furnished with sluices, and has a citadel with bastions, which is one of the most regular in the kingdom. It contains two churches, an hospital, poors-house, arsenal, magazines, and storehouses, for the construction and manning of ships. There are no fewer than forty streets, adorned with six fine fountains. Four of these streets terminate in the great square. The harbour, which has a long pier connected with it, is capable of containing from 600 to 700 vessels. It has a depth of water sufficient to hold ships of war of 60 guns. There is here a fine dock-yard, several rope-works, and manufactories for tobacco, lace, starch, vitriol, earthen ware, paper, tiles, and bricks. The tobacco manufactory was established by the French East India Company, and at one time there were 60 tables furnished with a wheel, and attended by seven persons. Each of these made 90 pounds of tobacco in a day, and, including Caudebec, Harfleur, and Fecamp, the annual value of this manufacture was 170,000 francs. It has, however, greatly declined, but still employs about 400 workmen. The rope-works were lately eight in number. There is here also a refinery of sugar, and another of oil, both for burning and painting.

In time of peace, Havre carries on a great trade with the United States of America and the West Indies, and takes a great share in the herring and whale fisheries. About 600 vessels used to return loaded with the merchandise of other countries; viz. 60 from Martinique, 18 from Newfoundlandland, 40 from Marseilles, 65 from the coast of France from Bayonne to St Malo, 10 from St Maurice, 15 from Lisbon, 20 from Holland, 260 from England, and more than 60 from other countries of the north.

Havre was founded in 1509 by Louis XII.; and, after the battle of Marignon, Francis I built a large tower to defend the harbour, and gave it the name of Franciscopolis. The walls of the harbour were scarcely begun, when an irruption of the sea destroyed about two-thirds of the town, and almost all the inhabitants, on the 15th January 1525. Twenty-eight fishing boats were carried into the ditches of the castle of Graville. Population 19,500. East Long. 0° 6′ 38″; North Lat. 49° 29′ 14″.

HAWARDEN, commonly called HARRADEN, or Hording, is a town of North Wales in Flintshire. It is a thriving place, and is situated on a small river running into Chester New Channel. The streets are well paved, and the houses well built. The church is a plain good building, and is remarkable only for having an annual revenue of about 3000*l*. Between the town and the river Dee, the remains of the castle of Peny Llwch stands upon an eminence. It was a place of great strength, and is supposed to have been built before the Norman conquest. It was demolished by order of the Parliament in 1680. By the exertions of the Glynne family, the form of the castle has been rendered visible, by the removal of great quantities of rubbish. It seems to have been of a pentagonal shape, with a strong square entrance gateway. The keep, or citadel, consisting of a circular tower, nearly entire, was placed at an angle. The deep ditches now form picturesque ravines filled with fine trees. On a mount, called Freeman's Hill, to the west of the church, are traces of an encampment; and at the distance of about two miles from the town, are the remains of Culo castle, a double fortress, with a square area and two round towers. They stand on the edge of a deep wooded dingle, and are covered with ivy. In the neighbourhood of the town, particularly near Buckden hill, there is a manufactory of earthen ware. There is also a large iron foundery, from which articles of cast and wrought iron are sent to Chester, and thence to different parts of the kingdom. Hawarden Park, the seat of the Glynne family, is near the town. The house, built in 1752, is a handsome structure.

The population of the town and parish, in 1811, was—

| | |
|---|---|
| Number of inhabited houses . . . . . | 832 |
| Number of families . . . . . . . . | 901 |
| Ditto employed in agriculture . . . . | 398 |
| Ditto in trade and manufactures . . . . | 427 |
| Total population in 1811 . . . . . . . | 4436 |

See Pennant's *Tour in Wales*, vol ii. p. 88. 92; and *The Beauties of England and Wales*, vol. xvii. p. 672—683.

HAWICK, is a town of Scotland, in the county of Roxburgh, situated at the confluence of the rivers Tiviot and Slitrig, on the west road between London and Edinburgh. It is distant from Edinburgh 47 miles, from Carlisle 44, and from Berwick 42. The river Tiviot runs close by the town, and the Slitrig runs through it, dividing it into two nearly equal parts, which are connected together by two stone bridges, one of which bears evident marks of antiquity. In August 1767, the Slitrig suddenly rose to a great height, occasioned by a cloud bursting at its source, and in its course swept away fifteen dwelling-houses and a corn-mill. Hawick is a burgh of barony of very ancient origin. It is independent of the superior, and enjoys almost all the privileges of a royal burgh, except that of sending a representative to parliament. The date of its original erection into a burgh of barony is not known, the records of the burgh having been destroyed, and the town itself repeatedly burnt, during the Border wars between the English and the Scots; the last instance of which occurred in the reign of Queen Elizabeth, in the year 1570, and is recorded by Stowe, in his *Chronicles of England*, who says—"The seaventeenth of April, the Earle of Sussex, lieutenant-generall in the North, with the Lord Hunsdon, lord governor of Barwike, and warden of the east marches, and Master William Drewry, high marshal of Barwike, with all the garrison and power of the same, began a journey into Scotland, and the same night came to Warke, twelve miles from Barwike, and so the next morrow entered into Tividale; and, marching in warlike order, they bīet, (burnt) overthrew, rased, and spoyled all the castells, towers, and villages of their enemies, till they came to the castell of Mosse, standing in a strōg marish belōging to the L. of Buckcluch, which likewise was rased, overthrowne, and brent, and so marched forward, and brent the whole countrey before them till they came to Crailing." After mentioning a great many other places which they burnt, Stowe proceeds thus—"The nineteenth, the armie divided into two partes, the one parte whereof passed the river of Tivite, and brent the castell of Ferniherst, and all other castells and townes belonging to the Lord of Ferniherst, Huntill, and Bedrell, and so passed to Mint, where both the armyes mette agayne, and so brent on bothe sides the river, till they came to a *greate towne called Hawike*, where they intended to have lodged; but the Scottes had unthatched the houses, and brent the thatch in the streetes, and themselves fledde with most parte of theyr goodes; but, by the industrie of the Englishmen, the timber was also burned with the thatch, saving one little house of stone of Drumlanricke's, wherein my lord lay that nighte."

Drumlanricke's little house of stone is supposed to be that which is now the Tower Inn, belonging to his Grace the Duke of Buccleuch, which has long been celebrated for the excellent accommodation afforded to travellers. The walls of the oldest part of this building are, in some places, no less than seven feet thick. It has been lately very considerably enlarged, and is now one of the most commodious inns in the south of Scotland. The oldest charter of the town now extant, is a charter of confirmation granted by James Douglas of Drumlanrick, then baron of the barony of Hawick, in 1537, which declares the town to have been from of old a free burgh of baronie, and proceeds on the narrative, that "the charters and evidents of the said town and burgh, through the inroads of the English and thieves in the by past times of enmity and war, had been lost and destroyed;" and this charter imposes on the grantees thereof the singular burden "of maintaining one lamp or pot of burning oil before the great altar of the parish church of Hawick, in time of high mass and evening prayers, on all holidays throughout the year, in honour of our blessed Lord and Saviour Jesus Christ, for the souls of the barons of Hawick, founders of the said lamp, and their successors." This charter was confirmed by a royal charter, granted by Queen Mary in 1545. The church is beautifully situated on a circular eminence in the middle of the town, and the church-yard commands a fine prospect of the surrounding country. The town is well paved and lighted, and has a plentiful supply of excellent spring water, which is conveyed to the town in leaden pipes. It has a respectable town-house, in which the burgh and justice of peace courts are held. A new line of road is just now making to the town from the west, which will form a fine approach, and already a very handsome new street is begun to be built along the sides of it. At the west end of the town there is an artificial mound of earth, of a conical form, of considerable height, called the *Mote*, which, according to tradition, was formerly used for holding courts of justice. The mail coach from London to Edinburgh, by Carlisle, passes through the town every day, and it is at present (1816) in contemplation to establish a mail coach between this place and Berwick. The town is governed by two bailies, who, with the advice of the town council, have the sole management of the revenues and affairs of the burgh. The bailies are chosen annually, by a poll of the resident burgesses. The town council is composed of 15 standing councillors, so called from their continuing in office during life, who are elected by the bailies and standing council: and of 14 trades councillors, or quarter-masters, who are chosen annually, two by each of the seven incorporated trades of the burgh. Its revenue, which consists chiefly of the rents of a large common belonging to the burgh, is about 400*l.* per annum. The poor of the town and parish are supported by a rate, one-third whereof is paid by the proprietors within the burgh, and two-thirds by the heritors and tenants of the landward part of the parish. Besides the established church, there are three places of religious worship in the town, viz. the Burgher, Antiburgher, and Relief meeting houses. There is an excellent public library in the town, which was begun in 1760. There was also lately established a subscription library, by the tradesmen of the place, and there are besides two or three circulating libraries. A branch of the British Linen Company Bank has been long established here, and a savings bank was instituted in January 1815, in which there was deposited, during the first year, 870*l.*, by 183 different individuals. In 1776, a farming club was instituted in Hawick for the discussion of questions connected with agriculture. It is composed of most of the respectable farmers, and several of the landed proprietors of the district. This club holds its meetings regularly on the first Thursday of every month. It is believed it was the first association of the kind established in Scotland, and it has the merit of having originated many very important improvements connected with agriculture. There is here a weekly market on the Thursday, and four annual fairs, which fall on the 17th May, 17th July, 21st September, and 8th November, besides a cattle tryst, at which considerable numbers of black cattle are presented for sale in passing from Falkirk tryst to Newcastle and Carlisle fairs. In 1811, the population of the town amounted to 3036, and the town contained 349 inhabited houses. Since that time no census has been taken, but the population and number of houses during the last five years has very considerably increased; and at present, in 1816, (including the population of Damside in the adjoining parish of Wilton, which may be reckoned the suburbs of the town,) it is estimated to exceed 4000. There are in the town three skinneries, one tannery, and two breweries; and a very considerable trade is carried on in the manufacture of carpets, lambs wool stockings, Scots blankets, thongs, and gloves. The manufacture of lambs wool stockings, in particular, from the introduction of machinery, has of late years made very rapid progress, and is still on the increase; it was first begun in 1771. In 1791, there were manufactured only 3505 pairs of lambs wool stockings, and 594 pairs of cotton, thread, and worsted hose. The number of persons then employed in the trade was 14 men, and 51 women, who were chiefly employed in spinning the yarn. The yarn, however, is now all spun by machinery. There are at present employed for this purpose 7 carding mills, which all go by water, containing 44 engines, or scribbling and carding machines, 100 spinning jennies, and upwards of 500 stocking frames. The greatest part of the spinning jennies are at present wrought by the hand; but jennies of a new construction, to go by water, have, within the last twelve months, been introduced with success into four of the carding mills. The quantity of wool annually spun into yarn is upwards of 12,000 stones, of 24 lbs. to the stone, three fifths of which are manufactured into stockings, and the other two fifths sold in yarn to manufacturers in other parts of the country, for the purpose of being made into stockings. The quantity of stockings annually made by the manufacturers in the town exceeds 328,000 pairs. The number of persons in the town and neighbourhood employed in the different branches of this manufacture, is about 1000. This place has been long celebrated for its extensive nurseries, carried on by Archibald Dickson & Sons here, and at Hassendeanburn in the vicinity, where they were first begun in the year 1729. The nursery grounds in the occupation of these gentlemen now extend to upwards of 100 acres, cropped with all sorts of foreign and native forest and fruit trees, flowering shrubs, and evergreens, &c. These nursery grounds are very ornamental to the place, extending along the side of the turnpike road to the east and west of the town, for the distance of upwards of a mile and a half. In the cropping and cleaning season, they afford employment for not fewer than 90 men, women, and children; but at other seasons men only are employed in them. A very extensive business in the seed line is also carried on by A. Dickson & Sons. The position of Hawick, as estimated from Captain Colby's observations on Wisphill, is North Lat. 55° 26′, and West Long. 2° 47′.

HAWK. See Hawking and Ornithology.

HAWKES' Temperaments of the musical scale. In the years 1798, and 1805, Mr William Hawkes published two pamphlets for recommending the adoption of an irregular douzeave scale, wherein 9 of the Vth, viz. upon C, G, D, A, E, B, ♯F; and upon F and ♭B should each be flattened $\frac{1}{5}$th of a major comma, or be of the value $355.7984272\Sigma+7f+31m$; two of the Vths, viz. on ♯C and ♭E perfect, or each $=358\Sigma+7f+31m$; and consequently, the resulting or wolf Vth, on ♯G, $=365.8141552\Sigma+7f+30m$. Many particulars concerning the notes and temperaments of which system, may be seen in the *Philosophical Magazine*, vol. xxvi. p. 173; xxviii. p. 304; xxx. p. 5;

xxxvi. p. 47; and vol. xxxvii. p. 129, in which last page the *beats* of each of its 68 tempered concords are calculated, by Mr John Barraud, brother to the chronometer maker.

In 1807, Mr Hawkes contrived, and in 1808 took out a patent for his methods of extending the scale of organs and piano-fortes to 17 notes in the octave, (see the *Phil. Mag.* vol. xxxvii. p. 325); and in 1810, he published a third musical pamphlet, in which his object (as afterwards explained by letter to Mr Farey, see *Phil. Mag.* vol. xxxvii. p. 321.) was to recommend, for the tuning of this his patent instrument, a regular dixseptave system, in which 16 of the fifths, viz. on C, G, D, A, E, B; ♯F, ♯C, ♯G, and ♯D; and on F, ♭B, ♭E, ♭A, ♭D, and ♭G, should be each flattened the 1-318th part of the octave, (or $\frac{1}{6}$th of Mercator's comma), or each of the value 356.068514Σ+7f+31m, and the resulting or wolf fifth ♯A to F, is of course =367.246346 Σ+7f+30m. The *beats* of each of the 102 concords in this system, have been calculated by the Rev. C. J. Smyth of Norwich, and published in the *Phil. Mag.* vol. xxxvii. p. 323, to which table we shall refer instead of copying it; because from Mr Liston's *Essay on Perfect Intonation*, p. 23. and 142. it appears, that Mr Hawkes has since (by letter to Mr Liston we have been informed) changed his former opinion, and now recommends the Vths for his patent instruments to be flattened $\frac{1}{6}$ of a major comma, in which terms Mr Liston has given its temperaments in p. 22. It may be proper, however, to add, that, in this new system, each of the 16 fifths above mentioned, will be =356.165356 Σ+7f+31m, and the wolf fifth on ♯A =366.181084Σ+7f+30m.

Mr Hawkes' patent piano-fortes are furnished with 24 strings in each octave, although 17 only are of different sounds, that is, all the long keys have two unison strings, from one to the other of which the hammers shift, at the same time that they do so from the 5 short-key notes tuned *flats*, to the five others tuned *sharps*, or *vice versa*; it seems, however, to us, that 7 of these strings might probably be dispensed with, by allowing rather more space on each side the long-key strings A, B, C, D, E, F, and G, and making their hammers rather wider, so that after the shifting sidewise of the key-board necessary to cause the short-key hammers to move from ♯A, ♯C, ♯D, ♯F, and ♯G, to ♭B, ♭D, ♭E, ♭G, and ♭A respectively, or *vice versa*, the hammers of the long-keys may still continue to strike the same strings.

The objections which were so forcibly urged in Dr Kemp's *Musical Magazine* against the defect of these instruments, in not being able to give *flat* and *sharp* notes at the same time, or quickly succeeding each other, as composers not unfrequently direct, seem to operate fatally against their introduction to general use. We have lately heard, that the organ which Mr Hawkes caused to be put up, a few years ago, in Christ Church, Blackfriars Road, in Surrey, has been either removed or altered to a common organ. We are aware, however, that this may have arisen from injudicious attempts at tuning this organ, according to one or other of the systems that we have mentioned in this article, instead of applying the Mean Tone *System*, which alone, or one exceedingly near to it, (in the perfection of its major third), seems applicable to this noble instrument. (ϱ)

HAWKING, or Falconry, is the art of catching wild fowls by means of hawks, or other birds of prey, tamed, and properly tutored for that purpose.

The art of falconry appears to have been known both to the Greeks and Romans. It was in high repute in almost every part of Europe during the 12th century, but after the invention of fire arms, it gradually declined.

Mr Pennant has not been able to find any accounts of the art of falconry in England before the year 760, in the reign of King Ethelbert, who sent to Germany for a brace of falcons that would fly at cranes. The art was much practised till the Usurpation, when it fell into disuse.

The birds which are generally trained to this art, are the jer-falcon, the pergrine, and the goshawk. By starving them, and keeping them awake, and never leaving them alone, they are rendered quite tame; and, by a regular system of severe instruction, they become so familiarized to the falconer, that they obey all his commands. They are taught to settle on his fist, to spring at game, and to bring back the prey to the falconer. For an account and other particulars of the history of falconry, see Beckmann's *History of Inventions*, vol. i.; and Shaw's *General Zoology*, vol. vii. part i. See also Ornithology.

HAYMAKING. See Agriculture.

HAYDN, Joseph, the most celebrated composer of music among the moderns, was the son of a wheel-wright, and born in 1732 at Rohrau in Austria, 36 miles from Vienna towards the Hungarian frontier. His father, though ignorant of the principles of music, which are much more generally disseminated among the lower ranks of Germany than in Britain, played a little on the harp, which was accompanied by the voices of himself and his wife. Joseph having been conducted, at a very early age, by a relation to Haimbourg, was instructed in the elementary parts of education; and a chapel-master of Vienna, having accidentally heard his voice, took him, when only eight years old, to replace one of the boys in his choir. Here he remained apparently exposed to severe discipline; and as his voice was constantly improving, the chapel-master became anxious to preserve it. He explained the means of doing so to Haydn, now a youth of about fifteen, who thought of nothing but music; and having gained his ready assent, the day and hour were fixed. But the accidental arrival of his father in Vienna, prevented their purpose from being effected. His voice soon broke, and Reuter, the chapel-master, ashamed of the reproaches which he had incurred, and exasperated at the disappointment, found a pretence for discharging him from the choir on a winter's night, which, from absolute poverty, he was obliged to pass in the street. Next morning, being observed by Spangler, a poor but friendly musician, he obtained a lodging from him in a hay-loft, adjacent to a single apartment which his own family occupied, and also a share of their frugal subsistence.

Here Haydn followed the bent of his early propensities, in practising on a wretched spinette; but it is said, that after some time had elapsed, a lady of rank, who had seen one of his compositions, desired to know the author. Haydn's extreme poverty hardly enabled him to obtain sufficient clothing to appear before her; and she had some difficulty in believing that he was the individual for whom she sought. He was compelled to account for his necessities, by relating, in as delicate terms as possible, his adventure with Reuter; and, in testimony of her esteem, she presented him with the works of Matheson, Bach, and other celebrated composers. According to some writers, his patroness was a niece of Metastasio the dramatic author, the real owner of the hay-loft; and they add, that he continued to instruct her in music and singing during three years.

Haydn now earned a scanty subsistence by the exercise of his talents. He was organist to an ecclesiastical establishment, with a salary of 12*l.* yearly. He had occasional employment elsewhere in the same capacity, and he sung, and played on the violin. At about the age of eighteen, he composed a quartett for Baron Furnberg, and afterwards some trios, which were surreptitiously printed. In the year

1759, his patroness obtained for him the appointment of music master to Count Marzin, with an annual salary of 25*l.*; and here he composed the first of those symphonies which have gained him so much celebrity. There appears to be some ambiguity respecting the chronology of Haydn's compositions. His *Opera Prima* consists of six quartetts, wherein all the rudiments of his fine genius are sufficiently developed; but it is reported, that the first time his name appears is to trios and harpsichord sonatas, in a German catalogue of 1763.

In the year 1760, Haydn was appointed sub-chapel master to a German potentate, the prince of Esterhazy, who was himself a siklful musician; and on the death of Werner, who was the principal, and from whose disposition and abilities he derived much advantage, he was promoted to fill his place. In this new situation, he had an ample opportunity, and sufficient encouragement, to pursue his talent for composition in its utmost latitude. Works of various descriptions flowed from his pen in rapid succession; and the particular taste of his patron led to the composition of those which no preceding musician had attempted. He overstepped all the limits which had fettered others; and, in adopting a new and peculiar, though unaffected style, he taught the public the variety of which music is susceptible. Yet this was not accomplished without exciting the jealousy of his cotemporaries. It has been affirmed, that he silenced his adversaries by publishing compositions wherein their own style was introduced, to betray its inferiority. In order to gratify the prince, he composed music with uncommon distributions of the parts or the performers; such as the *Echo*, which consists of a double trio for two violins and a violoncello, each set of performers being in a different chamber, but within their mutual view. Profiting by this singularity of taste, he composed another piece, called the *Adieu*, on occasion either of a quarrel in the orchestra, which induced all the band to give in their resignation, or, what is less probable, because the prince treated some of Haydn's warmest exertions with marked neglect. This was a symphony ingeniously devised, so that one instrument should regularly close after another; and as the music gradually terminated, each performer saw written before him, "Put out your candle, and go about your business." All obeyed in succession, and a solitary instrument finished the whole.

Haydn's time was principally occupied in musical composition; he generally dwelt with the prince of Esterhazy, at Eisenstadt in Hungary, and accompanied him during two or three months of the year, which were spent at Vienna. Here he became acquainted with the Chevalier Christopher Gluck, an eminent composer for the opera, Mozart, and others. The former advised him to travel in France and Italy, from which he predicted the greatest advantage in dramatic compositions; but the moderate finances of Haydn seem to have deterred him from following his counsel. His fame, however, had extended far beyond the sphere of his residence; and he was employed to compose an instrumental oratorio on the seven last sentences of our Saviour, for some religious ceremony, in a cathedral at Cadiz, which was hung with black, while a single lamp glimmered over the audience. Twelve years later, Haydn, without changing any of the instrumental parts, had words adapted to it. Many of his compositions are quite unknown in Britain, particularly a multitude of pieces for the bariton, a kind of small violoncello, with five strings above the bridge, and others behind the hand, to be touched by the thumb, played on by the Prince of Esterhazy, and to which the inhabitants of this country are strangers.

By the advice of Baron Van Swieten, Haydn visited London; and his residence there may be regarded as one of the most fortunate periods of his life. His great and steady patron the prince of Esterhazy had died in the same year, 1790; and while he left him his usual salary, he also dispensed with his discharging the duties of the situation. He seems indeed to have held him in great estimation; for when Haydn's house at Eisenstadt was burned down during his absence at Vienna, the prince directed another to be built, having exactly the same size, appearance, and accommodation.

In London Haydn experienced the most gratifying reception; he remained there eighteen months, and returned to the continent in the year 1794. He now began to be treated with those honourable distinctions due to his transcendant genius. He was created Doctor of music by the University of Oxford, and other literary and musical associations soon followed the example. At this time a concert on a liberal and expensive plan was established by Salomon, the late leader of the opera, where all the first performers were engaged; and each performance was announced to commence with an overture, expressly composed for it by Haydn. Twelve symphonies, which stand unrivalled, were thus produced; and, as is well known, these were afterwards ingeniously reduced to quintetts by Salomon. Some of them, or the whole, have since been adapted as trios for the piano-forte, violin, and violoncello. Haydn also composed and published several other works while in London; several of which are dedicated to the amateurs of this island: and a still more essential result was, the universal diffusion of a taste for his music.

During his absence from Germany, a tablet, or obelisk, had been erected in honour of him at Rohrau, the place of his nativity, by Count Harrach; and on returning to the continent, he composed the oratorio of the *Creation*, in 1795, which is esteemed among the finest and most elaborate of his works. But his other compositions of the same kind, the *Seasons*, *Stabat Mater*, *The Last Words of Christ*, and *The Return of Tobit*, have not been all equally successful; partly, it is supposed, from the want of coincidence between the music and the words. The last, however, which was written in 1775, is performed annually at Berlin, for the benefit of the widows of musicians.

While Haydn approached that period of life when the faculties usually decline, he was loaded with honours, and his vigorous invention continued to be unimpaired. He received honorary degrees from the academies of Stockholm and Amsterdam in 1798 and 1801; and in the following year, on a vacancy occurring in the National Institute of France, he was elected a member, at which time our countryman Mr Sheridan was one of the candidates. He was also chosen a member of the Phil-Harmonic Societies of Layback and St Petersburgh, and of the Children of Apollo at Paris, in 1805, 1807, 1808. Nay, the last struck a medal, bearing his portrait, and invited him to the capital, with an offer of a sufficient sum to defray his expences. But this was not all; for prince Kurakin, the Austrian ambassador at Vienna, presented him with a letter from the Phil-Harmonic Society of Petersburgh, full of gratitude and admiration of his works, and accompanied by a large gold medal, weighing above half a pound, struck in honour of him, and bearing his portrait, with the most flattering legend. He is also said to be the hero of a Spanish Poem on music.

But Haydn was now little more than sensible of the distinctions he received. He bent under the weight of years, and ceased entirely to compose about 1803. It was not without regret, however, that he witnessed his own decay. He feelingly deplores it in a vocal quartett, beginning, "My strength is enfeebled, death awaits at my gate." Indeed he was so much weakened, that it became necessary to construct a piano for him, remarkably light and easy in the touch. We have even heard those who knew him well declare, that he relapsed into a second childhood.

Haydn dwelt constantly at Vienna, and confined himself to his house and garden after the year 1806. The seventy-third anniversary of his birth had been celebrated by a concert in one of the theatres, conducted by the son of Mozart; and, in 1808, a great musical association of that city resolved to close the performances of the season with the *Creation.* Haydn, though withdrawn from the world, consented to be present. He was received by the Princess Esterhazy, and others of distinguished rank, in the hall of performance, and carried, amidst the sound of trumpets and loud acclamations, to a particular part of the gallery which was appropriated for him. He was overwhelmed by this mark of approbation; and upon retiring, which he did very early, signified that he felt it was for ever. This great composer expired on the 31st of May 1808.

Haydn's personal appearance betrayed no indications of genius. His stature was large, and his features coarse. But he was mild and complacent in manners; modest and unassuming; and universally beloved in private life. He was never tainted by jealousy, and, unlike those who proclaim their own merits by undervaluing the works of others, he was always ready to approve where approbation was due. Handel's chorusses he thought sublime, though his music might be defective in melody. He entertained the highest opinion of Mozart, declaring his death a public calamity: and when invited to be present along with him at the coronation of the Emperor Leopold at Prague, he observed, "Where Mozart is present, Haydn ought not to appear." Haydn indeed was too reserved. That innate modesty, and his moderate finances perhaps, prevented him from attaining some distinguished situation in his own country, which his talents merited. The Emperor Joseph is justly reproached with neglecting to place the first musician at the head of his orchestra; but probably it is there, as it is in many other countries, that men of real genius are superseded by those who have none. He enjoyed a competency in his later years, but his total fortune did not exceed 250*l.* at the period of his first visit to Britain. He was married many years, but not happily: and he had long been separated from his wife. Two brothers, Michael and John, survived him. The former, who had considerable merit as a composer, died master of the band to the court of Salzbourg; the latter died in the service of the Prince of Esterhazy.

Haydn's compositions exist in the most astonishing variety. They are calculated to amount to 842, including those of every description: and the following is said to be an abstract of a catalogue furnished by himself in the year 1805. Symphonies, 118; various pieces for the baritons, 163; instrumental pieces of from five to nine parts, 20; marches, 3; trios for two violins and a bass, 21, and 3 for two flutes and a violoncello; 6 solos for violin with tenor accompaniments; 3 concertos for violin and violoncello: 1 for the double bass; 2 for horns; 2 for the trumpet; 1 for the flute; 1 for the organ; and 3 for the harpsichord; 66 sonatas for the piano forte, and 83 quartetts. Another unfinished quartett was found at his death, to which some portion that was wanting has been supplied; and it was performed at a grand concert in commemoration of him at Berlin in October 1809. This assembly was opened by an eloquent eulogium on his merits. He also produced 34 compositions of church-music; 5 oratorios; 19 or 20 operas; 13 airs in 3 or 4 parts; 42 simple songs and duetts; 40 canons. Besides these, he wrote preludes and basses for 365 Scotch airs; and composed above 400 minuets, dances, and waltzes. At his death there were found 46 unpublished canons, framed to ornament his apartment; not being rich enough, he said, to purchase pictures, he had himself made tapestry to cover the walls.

Amidst such an infinity of works, the whole of which have probably never been heard by any one individual, it is difficult to determine where the preference is due. But the fertility of imagination is conspicuous throughout, and Haydn's compositions are ever new. Perhaps he has been less successful in the vocal than the instrumental departments. None has ever equalled his distribution of music in the orchestra, or called forth the single and combined powers of instruments in an equal degree. Here he has excelled all his predecessors, his cotemporaries, and successors; and those pieces which he has written for a full band stand unrivalled, whether we attend to the unity of design, the relation of parts, or that sudden burst of grandeur which amazes the auditor. Next to the symphonies, Haydn's quartetts seem to be most admired; they are written with apparent simplicity, but almost all of them present considerable embarrassment, unless to skilful performers. This composer is one of the few who presents perpetual novelty, who never imitates himself, and who adapts intimately and exactly the music to those instruments for which it is designed. None of his music is tedious or languid, unlike some modern compositions, whose authors, ignorant that they are producing nothing more than preludes or voluntaries, suppose they have taken up an inexhaustible theme. His minuets and trios are perhaps devised with more ingenuity, and more calculated to please than any that have appeared, and he is particularly successful in variations on an air, and in modulations. Yet it is vain to affirm that equality pervades his works; and it will not appear surprising if inferiority be sometimes discovered in such a multitude. We should remark, as a very extraordinary fact, that the lapse of years had no effect in diminishing the quality of his compositions. The first quartett of the first opera, and his last which he wrote, are excellent, though there be some difference in their style. Hadyn ventured far and was successful; many have endeavoured to follow the same course with doubtful approbation. Perhaps had Mozart not been prematurely cut off, he might have approached to him in excellence; but as yet Haydn is entitled to be designed the first of modern masters. (*c*)

HAYLING, Isle of. See Hampshire.

HEAD. See Anatomy.

HEALTH. See Aliments and Longevity.

HEARING. See Anatomy.

HEART. See Anatomy, and Physiology.

HEADLEY, the Rev. Henry, an English poet and critic, whose highly promising talents were unfortunately lost to the world at the early age of 23, was the son of a clergyman in Norfolk, and was born at Irstead in that county in 1766. He was educated at the grammar school of Norwich under Dr Parr, and was admitted a commoner, and elected a scholar of Trinity College, Oxford. At the university, the living example of Thomas Warton, then the Senior Fellow of Trinity College, seems to have communicated to Headley an enthusiasm for the elder school of English poetry. While combining this pursuit with his classical studies, he published his poems and other pieces in the year 1786; and in the following year, at the age of 22, he published Select Beauties of Ancient English Poets, with Remarks. In his poems, though marked by elegance and sensibility, there was no promise of transcendent genius; but his Remarks on the Elder Poets displayed an extent of reading, a comprehensiveness of views, and a perspicuity of taste, which were justly regarded with wonder in so young a writer. He cannot, indeed, be said to be wholly free from partiality and exaggeration, in estimating the elder writers, whose beauties he complains of being neglected; but still, as a critic, he deserves to be remembered in English literature. Mrs Cooper, in her neat Biographies and Selections, led the way in preserving the memory of our early poets; Warton contributed immense industry in illustrating our literary history; Percy restored to us our ballad poetry; but in the selections and criticisms of Headley, there is a classical taste and condensation of materials, more elegant than what we meet with in any of his fellow labourers in the same pursuit. His critiques are like the portraits of a master, flattered indeed, but done with general truth and animation. His life was too short to have many events. Some months after leaving Oxford, he married, and retired to Matlock in Derbyshire, in a spot where the wild scenery accorded with his romantic turn of mind. But the symptoms of a consumptive tendency, which had before appeared in his delicate frame and constitution, began now to make rapid advances; and being warned to try the benefit of a warmer climate, he had the resolution to take a voyage to Lisbon, unaccompanied by any one he knew. On landing at Lisbon, far from feeling any relief from the climate, he found himself oppressed by its heat. A few days would have probably terminated his life, when a Mr De Visme, to whom he had received a letter of introduction from the late Mr Windham, invited him to his healthful villa, near Cintra, allotted spacious apartments for his use, procured for him an able physician, amused him with his elegant books, and gave him every chance of benefiting from the change of climate. But his malady was incurable; and having returned to Norwich in the month of August, he expired there, in Nov. 1788, in the 23d year of his age. (*z*)

# HEAT.

Heat is a term which was originally employed to express the effects produced by a peculiar condition of bodies, when they communicated the sensation of warmth. It was also perceived that hot bodies, or those that had the power of communicating warmth, possessed other properties, such as that of expanding the substances to which the warmth was imparted, of converting certain solids into liquids, and certain liquids into the state of vapour, and many other operations of great importance in the system of nature. Philosophers soon began to speculate upon the cause of these phenomena, and, with a degree of inaccuracy, to which we are liable in the infancy of our scientific pursuits, they employed the same word to signify both the *cause*, and the *effect* produced. It was commonly said, that *heat* occasioned the warmth and expansion of bodies, and likewise that *heat* was excited in bodies by the addition of some peculiar kind of matter, or by a certain modification of their particles. The more precise nomenclature of the moderns has tended to correct this error, and has led to the invention of a new term, *caloric*, to designate the *cause*, while the word *heat* is, strictly speaking, only applicable to the *effect*. As, however, in all the older authors the former phraseology necessarily exists, as it is still adopted in popular language, and as there is no danger of falling into any error, since the distinction has been so fully pointed out, the word *heat* is frequently employed in its double sense, even by the latest and most correct writers, and it will be used in this way in the following article.

We have already given some account of the nature and effects of caloric under the head of Chemistry; but it is an agent of such extensive importance in the operations of nature,—it produces such powerful effects both upon organized and unorganized matter,—it is so intimately connected with the existence of life, both animal and vegetable,—and is so essential to all the processes by which we act upon the bodies around us, when we convert them to our support or utility,—that it well deserves to be farther discussed, and made the subject of a separate article. The importance of the object has produced a consequent share of attention to it from the modern experimentalists; and there is perhaps no one topic on which more curious, and, we may add, more unexpected results have been obtained, than have ensued from the researches into caloric. The names of Black, Crawford, Rumford, Pictet, Gay-Lussac, Prevost, Dalton, and Leslie, among many others which will be afterwards referred to, must suggest the recollection of the many ingenious and elaborate trains of experiments, that have occupied the attention of philosophers during the last 50 years. It will be to an account of what has been done in this period that we shall principally confine ourselves in the following pages; for the experiments and hypotheses that were published before this time, are rather to be regarded as curious historical records of opinions, than as affording much that is important in the actual advancement of knowledge.

We shall arrange our observations on heat under four heads: 1*st*, The properties of heat; 2*d*, The effects of heat; 3*d*, The sources of heat; and, 4*th*, The nature of heat. In the course of the article, we shall take an opportunity of tracing the gradual developement of the leading opinions that have successively prevailed on these topics, as well as the most important experiments by which they have been supported.

## SECT. I.

### *On the Properties of Heat.*

It might, at first view, appear more regular to begin by investigating the nature of heat, before we described its properties and effects; but it is so difficult to ascertain its nature, and the knowledge which we possess, or rather the conjectures which we form concerning it, are so entirely derived from the observations that we are able to make of its properties and effects, that the order of treating the subject which we have adopted, will be found, we apprehend, the most convenient. For the present, we may consider heat, or caloric, to be a principle or power existing in bodies, which gives rise to many of their most important actions, and modifies their effects upon other substances.

The *properties* of caloric are of three kinds: Those that are strictly mechanical, or such as may be conceived analogous to the laws of gravitation or impulse; chemical, or those that tend directly to effect a chemical change in bodies; and a third class, which may be regarded as specific, and which do not bear an exact resemblance to either of the two former.

Among the mechanical properties of caloric are its radiation, reflexion, and refraction, which bear a very near resemblance to the same affections of light. Some obscure intimation of the radiation of heat may be met with in the authors of the latter part of the 17th and beginning of the 18th centuries, but the subject was not much attended to until the time of Scheele. This distinguished philosopher, in his investigation of the nature of fire, performed some new and decisive experiments, which completely established the existence of this property, and shewed how it differed from the power which hot bodies possess of communicating warmth by contact. He found, that when glass is interposed between the face and a quantity of burning fuel, although the light passes through without interruption, the heat, at least for a certain space of time, is entirely stopped. Heat, he observed, radiates through air, without communicating any warmth to it, and its passage does not appear to be interrupted by any currents in the atmosphere. He found, that a transparent mirror, which concentrates the rays of light, does not produce any increase of temperature in the focus until it has absorbed a sufficient portion of heat, but it then becomes a radiating body, and emits heat in certain directions. The conclusion which may be deduced from Scheele's experiments is, that caloric is sent off in rays from all hot bodies, and moves through the air with great velocity, but that in this transmission it does not necessarily communicate warmth to it, and is not diverted from the straight course by any currents or motion of the air itself: (*On Fire*, p. 70, *et seq.*) His experiments also tended considerably to elucidate another point respecting heat, which had been the subject of much controversy, whether it was not identical with light, or only differing from it in consequence of some slight modification of its properties. Heat and light are so frequently observed in connection with each other, emanating from the same sources, and produced, as it would appear, by the same agents, that the opinion of their identity was generally adopted, at the commencement of the last century. Some distinguished experimentalists had indeed embraced the contrary doctrine, and some facts were brought forward in its support. Instances perpetually occurred, of high degrees of heat being produced, which were not accompanied by light; and, on the other hand, it was found, that there were some luminous bodies which were not hot, and especially, that the moon's rays might be concentrated by a lens, or mirror, so as to produce a very brilliant light, yet that no sensation of heat was excited. These, however, and some other analogous facts, were not deemed sufficiently conclusive to establish the point. Some authors regarded heat and light as the same substance in different states; while those, who did not admit their materiality, conceived that they depended upon the same affection of matter, but differing in its degree or intensity. Scheele's experiments seemed to prove, that heat and light, when closely united together, as in the rays of the sun, or of a burning body, may be completely separated, so that the specific effects of each may be obtained distinct from the other. We have already referred to his observation of the manner in which a sheet of glass permits the light to pass through it, while it intercepts the transmission of the heat; and he also found, that if rays composed both of heat and light, as they were sent off in combustion, be received upon a glass mirror, the heat is absorbed, while the light alone is reflected.

The distinct nature of light and heat is rendered still more probable, by some late experiments of Dr Herschel's, in which he separated them from the state of combination in which they exist in the sun's rays. He was led to observe that the differently coloured rays possess different powers of producing heat; the least refrangible rays, those which excite the sensation of red, possess the greatest heating power; and the power diminishes, until we arrive at the violet, or most refrangible rays, which excite the least heat, the intermediate colours possessing an intermediate power in this respect. But he not only discovered that the rays of heat and of light were thus very differently affected by the prism; he farther found, that the effect upon the thermometer was most considerable in a point beyond the red-making rays, entirely out of the limits of the spectrum, and, of course, in a spot on which no part of the luminous ray was received. Beyond this point, where the temperature was at its maximum, the heat gradually diminished, until it was no longer perceptible: (*Phil. Trans*, 1806, p. 286. *et seq.*) From these experiments, the results of which were verified by Sir H. Englefield, who employed an apparatus of rather a different kind, we learn, not only that heat is emitted in rays from the sun, but that solar heat may be obtained separate from light; and although, like light, it is possessed of the power of being refracted, yet it possesses this power in a different degree. In Sir H. Englefield's experiments, where the blue rays raised the thermometer to 56°, the green to 58°, the yellow to 62°, and the red to 72°, the space beyond the prismatic spectrum elevated it to 79°, and it sunk to 72°, when returned into the red rays: (*Journ. of Royal Inst.* i. p. 203.) Similar results were obtained by M. Berard; but he observed, that the maximum of heat was at the very extremity of the red rays, when the bulb of the thermometer was completely covered with them; and that beyond the red extremity, where Herschel found the heat to be a maximum, it was only 1-5th above that of the ambient air. See APPENDIX to this article.

The radiation of heat was exhibited in a still more decisive manner by Pictet, who seems to have undertaken his experiments on the subject at the suggestion of Saussure. This distinguished naturalist was led to form some speculations concerning caloric, from certain atmospherical phenomena, which he noticed during his travels among the Alps, where he conceived that the communication of heat could not be accomplished by the contact of the heated body. He refers to an experiment of Mariotte's, which was published in the Memoirs of the Academy of Sciences for the year 1682, in which he states, that "the warmth of a fire reflected by a burning mirror is sensible at its focus." Lambert also informs us, in his *Pyrometrie*, that he placed a burning body in the focus of a concave mirror, and that he was able by means of it to inflame another body, placed in the focus of an opposite mirror, at the distance of above 20 feet. In this experiment, Lambert distinctly marks the difference between what he calls "luminous heat" and "obscure heat," and attributes the effect to the latter principle, *i. e.* to heat, properly so called, in opposition to light.

Saussure repeated the experiment in conjunction with Pictet; and, in order to prevent the interference of the action of light, they employed a ball of iron, heated to a degree short of what would render it luminous in the dark. They used tin mirrors, that were placed more than 12 feet from each other: and, when the iron ball was put into one focus, they suspended a thermometer in the other, and observed the instrument to be very perceptibly affected, more than another thermometer, equally near the ball, but out of the focus. The former was raised from 4° to 14½° of Reaumur; the latter from 4° to 6½° only: (*Voyages dans les Alpes*, § 926.) The result of this experiment is easily explicable, upon the supposition that heat, whatever be its nature, radiates in straight lines; that it impinges against solids that are opposed to its course; and that, according to circumstances, it either raises the temperature of this body, by being united to it, or is reflected from its surface. The heated ball, in this case, emitted rays of heat in every direction: those that were contiguous to the mirror fell upon it; but, owing to its polished surface, were reflected in straight lines to the other mirror, and were again reflected from this, according to the laws of mechanical impulse, into the focus in which the thermometer was suspended. This thermometer received the effect both of the rays that were sent off by the iron ball, on the side contiguous to it, and of those which were on the contrary side of the ball, next to the mirror; whereas the thermometer not in the focus, only received heat from the side of the ball opposed to it. Pictet's apparatus is shewn in Plate CCLXXXVIII. Fig. 9. See Description of Plates.

M. Pictet still further prosecuted these experiments, and varied them in different ways, so as to repel the objections that might be urged against the conclusions which he derived from them. In order to separate the light from the heat, and to shew the distinct operations of each, he placed a lighted candle in one of the foci, and noticed its effects upon a thermometer placed in the other focus. He then interposed a plate of glass between the candle and the thermometer; and he found, as he had expected, that although the light passed as before, a considerable portion of the heat was intercepted in its passage from one mirror to the other; in this way confirming the results that had been formerly obtained by Scheele. But, in order to remove more effectually all suspicion that the effect in this case depended upon the rays of light, he placed a small flask of boiling water in the focus, from which we may be confident that no light could be emitted: and this he found to radiate heat, and to raise the thermometer very perceptibly. The experiments of Pictet may therefore be considered as completely establishing the point, that heat is sent off in right lines from bodies, where light cannot be supposed to be present. He also rendered the radiating power of caloric still more obvious, by shewing, that when rays of heat impinge against a body, if it have a polished surface, they are reflected from it; but, if the surface be such as not to admit of reflection, they enter into it, and raise its temperature. In pursuance of this idea, he found, that when the bulb of the thermometer which he employed was blackened, it rose more rapidly, or absorbed more heat, than when its surface was clean and bright, thus proving, that the heat from boiling water was, in this respect, similar to the heat in the sun's rays, or that emitted during combustion: (*Essay on Fire*, § 51, *et seq.*) We have already referred to the experiments of Dr Herschel, in which he analysed the sun's rays, and separated the part which produces heat, from that which excites the sensation of colour. These experiments proved, in a very decisive manner, the radiating power of the calorific part of the solar beam; and he afterwards made experiments of a similar kind, upon different species of heat, extricated from bodies on the surface of the earth, such as burning fuel and red hot iron. *Phil. Trans.* 1800, p. 316.

An interesting train of experiments, on the manner in which heat radiates, or escapes from the surfaces of bodies, was performed by Rumford, in which he shewed, with his usual address and dexterity, the different effects which are produced by a difference in the nature of the radiating surface: (*Phil. Trans.* 1804, p. 89 *et seq*) By a singular coincidence, nearly about the same time that this essay was published in the *Phil. Trans.* a still more complete view of the subject was taken by Professor Leslie. They both supported their peculiar opinions by a number of well contrived and well executed experiments, which led to many curious and unexpected results, and which have, in some measure, altered our previous notions respecting the nature of heat, or at least respecting some of its most remarkable properties. It had been before known, that the nature of the surface of a body materially affects its power of admitting caloric to enter into it; and this power was now extended to the emission or radiation of heat.

There is so much similarity between the experiments of Rumford and Leslie, that it will not be necessary to refer to both of them, considering the narrow limits to which we are confined in this article; and as those of the latter are generally the most decisive, and, for the most part, performed with the most accurate instruments, we shall principally employ them in our examination of the subject.

Professor Leslie's researches illustrate, in a striking manner, the effect of the peculiar nature of the surfaces of bodies, both upon the emission and reception of radiant heat, bodies of equal temperatures discharging and absorbing it in very different degrees. When a body sends off rays of heat, we may conceive that it parts with a portion of caloric that was previously united to it; and that when it receives the rays of heat, a quantity of caloric becomes combined with it, which was before in a free state. These two operations, although the reverse of each other, seem to exist in the same proportion, and in all respects to bear an exact ratio to each other. Professor Leslie employed in his experiments a species of air thermometer of a new construction, which, besides possessing the advantage of being an instrument of great delicacy, and being sensible to very minute variations of heat, has also the useful property of indicating, at all times, any variation that occurs in the temperature of the portion of air in which it is immersed, and of adapting, as it were, its own scale to this new temperature, so that the apparent effect is the same, whatever be the actual temperature at which the experiment is performed. It was from this property that he gave to his instrument the name of *differential thermometer*, as not indicating the actual degree of heat, but only the degree in which it differs from that of the atmosphere. (It is shewn in Plate CXLI. Fig. 1.) Rumford employed an instrument very similar in its nature, which he called a *thermoscope*.

In ascertaining the quantity of heat emitted from the surfaces of bodies, Professor Leslie generally examined the rays after they had been reflected by concave mirrors. Those which he used were composed of polished block tin; and by means of a mould, upon which they were formed, they were made to constitute portions of the parabolic curve. The substance from which the heat was emitted was boiling water, contained in a cubical canister of block tin. This was provided with a thermometer to ascertain its temperature; and the apparatus being placed in the focus of an elliptical tin reflector, the effect was noticed upon the differential thermometer, situated in the opposite focus. The canister had four sides of equal dimensions; and these being prepared in different ways, either polished, or left rough, varnished, or covered with paper, or some other substance, afforded an opportunity of accurately examining and comparing the effect of different kinds of surfaces on the radiation of heat: (*Inquiry*, p. 17.) The apparatus is shewn in Plate CCLXXXIX. Fig. 11. Professor Leslie begins by ascertaining what was the effect of the canister of boiling water, when simply placed in the focus of the reflector, in what length of time the maximum of heat was produced, and how long the process of cooling occupied. He likewise observed the effect produced on the thermometer, by employing water of different temperatures, and also by the degree in which the temperature of the water exceeds that of the temperature of the air of the chamber in which the apparatus is situated. The vessel that contained the water was a cube of six inches; and when it was at the boiling heat, and was placed at the distance of about three feet from the mirror, the rise of the differential thermometer was equivalent to what would have been 14.5° of Fahrenheit's scale. He also found that the greater was the excess of the heat of the water above the temperature of the room, exactly in the same proportion was its action on the thermometer. Hitherto the vessel had been employed with its uncovered side turned towards the reflector; and he next proceeded to contrast with this the effect of the other three sides of the canister, one of which had a plate of glass cemented to it, another had writing paper pasted on it, and the fourth was covered with a varnish of lamp black. The effect produced by these different surfaces was very singular, and was, to the experimentalist himself, very unexpected. The uncovered side, which had the usual polish of a metallic surface, produced an effect upon the thermometer equal to 12°, the side to which the glass had been applied to 90°, that covered with paper to 98°, while the varnished side was equal to 100°. From these experiments we arrive at the important conclusion, that heat radiates from a polished metallic surface with not quite $\frac{1}{8}$th part of the energy that it does from a surface that is covered with some substance, which takes away the effect of the polish. *Inquiry*, p. 18.

An experiment, which may be regarded as the reverse of the above, was afterwards tried. Here the thermometer was made to receive heat from the canister, its bulb being first left in its usual state, and afterwards covered with tin-foil carefully applied, so as to admit of a degree of polish. It was then found, that the coated thermometer, analagous to the polished side of the canister, received only about $\frac{1}{5}$th as much heat as when the instrument was without the metallic covering. The power of surfaces in absorbing heat, seems therefore to be intimately connected with that of radiating it, materially influenced by the nature of the surface, much less, when consisting of polished metal, and greatly augmented when covered with paper, varnish, or any other not-metallic substance. These experiments seemed to indicate, that the power of radiating and of absorbing heat was in an inverse ratio to that by which heat is reflected from surfaces; and this point was afterwards made the subject of direct experiment by Professor Leslie. He had already found, that the polished surface of the canister was a bad radiator, and that the coated thermometer, in consequence of its polish, was equally unfitted for absorbing heat. The next object was to examine, whether these surfaces, which were the least fitted to radiate and absorb it, were not as much superior in their reflecting, as they were defective in their radiating, power. The tin reflector was removed, and in its place was substituted one of glass, while the canister of boiling water, and the differential thermometer, were placed as before in the respective foci. In order to produce the greatest action upon the mirror, the varnished side of the vessel was opposed to it; but the effect produced by reflection in this case was not considerable. No important alteration was produced, by removing the metallic coating from the back part of the mirror, or by roughening it with emery; but when the anterior surface of the glass was covered with Indian ink, no heat was sent off from it. On the contrary, when the front of the mirror was coated with tin-foil, the thermometer rose ten times as much as it did from the effect of the naked glass. These experiments, when compared with each other, lead to the following conclusions: That when the rays of heat strike against polished glass, a large portion of them is absorbed, and tends to raise the temperature of the glass itself; but when they impinge against polished metal, few of them enter the metal, and nearly the whole are reflected. *Inquiry*, p. 21.

Professor Leslie having now fully established the connection between the radiating and the absorbing power of different kinds of surfaces, afterwards proceeded to vary the effects in different ways, and to compare them with each other under different modifications. We have mentioned above, that the polished side of the canister, when opposed to the mirror, produced in the differential thermometer a certain rise, which we have called equal to 12, that of the varnished surface being estimated, as a standard of comparison, at 100. When the tin was rubbed with a small quantity of mercury, an effect was produced equal to 14, and when completely coated with it equal to 20. As the brilliancy in this case appears not to have been less than from the pure tin, we must conclude that there is either a different radiating power attached to different metals, independently of their mechanical properties, or that an amalgam of tin and mercury was formed of a soft consistence. It was afterwards found, that when a metal loses its brilliancy by oxidation, the radiating power is increased in the same proportion: a fresh surface of lead raised the thermometer only $\frac{1}{4}$th as much as the lead when covered with a layer of minium. This effect of oxidation might perhaps have been predicted from the preceding experiments; but the alteration caused by simply scratching or roughening the metal, seems more remarkable. If the perfectly smooth surface produced on the thermometer an effect equal to 12, by rubbing it with a file or with sand, so as quite to destroy its polish, an elevation took place equal to 26, or rather more than twice as much as the former. It was afterwards found, that when the tin canister was coated with an animal substance, such as jelly, if it was spread upon it only to the thickness of a fine film, it raised the thermometer to 38; but when laid on so as to form a thick coating, the effect was about twice as great, or near 80. The effect in this case, was not found, however, to bear an exact ratio to the thickness of the coating; nor was a difference in the thickness of the coating observed to have any effect, except when an animal substance was used, or something of a similar nature, for metallic coatings seemed to act merely from their surface. Some experiments were made upon the effect of colour, in modifying the radiating power of surfaces; but the results are not sufficiently uniform to prove any thing very decisive on this point. Although the most considerable effects were produced by lamp-black, yet, as has been mentioned above, writing paper was found to be nearly as powerful. We have already had occasion, more than once, to refer to the relation which exists between the radiating and the reflecting power of bodies, a fact which, although contrary to what might have been expected upon a transient view of the subject, is yet established by numerous and decisive experiments. Thus scratching the surface of the mirror, diminishes its reflecting power as remarkably as it augments its radiation; and also a layer of animal matter spread over the face of the canister, diminished its reflecting power to about 1-3d, as was determined by the thermometer. *Inquiry*, p. 76. *et seq.*

Professor Leslie was afterwards led to confirm, and very much extend the views which Scheele originally suggested respecting the power of certain substances to retain the caloric which falls upon them by radiation, when they are such as not to send it off again by reflection. In this case, the body receiving the heat, experiences an elevation of temperature, until after some time it becomes itself a source or centre of heat, which emits it to other bodies. It was in this way that heat was separated from light, as we have already related, the light passing without interruption through a plate of glass, by which the transmission of heat is, for a certain time at least, entirely obstructed. When the heat is emitted or radiates from its new source, its progress is then found to be varied from that which it originally possessed, and to be entirely directed by the condition of the surface from which it last escapes. This property of heat was illustrated by a series of experiments, in which screens of different kinds were interposed between the mirror and the canister, to which we have so often referred: (*Inquiry*, p. 26, and 17.) A sheet of tin was found entirely to intercept the heat, and a plate of glass a considerable portion of it; but what constitutes a curious difference between the effect of heat and light is, that the quantity of heat intercepted varies greatly, according to the vicinity of the glass to the radiating body; more heat being transmitted when the glass is near the canister, than when it is more distant from it. But, perhaps, some of the most curious of all Professor Leslie's experiments were those in which he employed two screens of tin, one side of each of which was covered with the black varnish, the other being left uncovered. When these tin plates were laid together, with both their painted sides in contact, and of course the bright sides both external, little heat passed through them, because the side nearest the canister was not adapted to receive caloric, nor the other to radiate the little which might have been received; but when the varnished sides were placed externally, the quantity of heat that passed through them was considerable, because here the varnish enabled the one plate to absorb, and the other to radiate caloric with facility. When only one plate was used, intermediate effects were produced. Several circumstances that were noticed by Professor Leslie, led him to conclude that the rays of heat, like those of light, where they proceed from a near object, are sent off in lines that have a sensible divergence. The radiation of heat seemed to be entirely suspended, by having the heated body immersed in water; and it appears probable that it cannot exist in any medium except air. *Inquiry*, p. 92.

We have already alluded to the experiments of Count Rumford, which were published almost immediately after those of Professor Leslie, and which so generally agree with them, that although they are both numerous and ingenious, it will not be necessary to give any minute description of them. Like Professor Leslie, Count Rumford found, that polished metal radiates heat in a much less degree than a metallic surface, at the same temperature, but covered with paint or varnish; that a covering of linen, flannel, paper, or in short of any animal or vegetable substance, tends to promote the emission of heat; and he farther found, that the radiation and absorption of heat bore a direct ratio to each other, and likewise an inverse ratio to the power of reflection. In one particular, indeed, the Count's experiments had a different result from Professor Leslie's; this latter experimentalist compared the radiating effect of various metals, and conceived that they differed from each other in this respect, while Rumford could not perceive any difference between them; upon the whole, however, we are disposed to regard Professor Leslie's results as the most correct. Count Rumford, according to his usual custom, deduces some important practical conclusions from his experiments, which are the more valuable, because some of them are precisely contrary to the previous ideas that were entertained upon the subject. In putting heated bodies into vessels or tubes, our object is sometimes to retain the heat as long as possible: but in others, on the contrary, we are desirous that the heat should be quickly dispersed through the contiguous air. If we wish to confine the heat, we must employ metal, and have its surface highly polished, a fact fully proved by the above experiments, but directly contrary to the conclusion that might seem to follow from the superior conducting power of a metallic body. On the other hand, if the object be to cool the vessels with their contents, or to transfer their heat to the surrounding medium, we must cover them with paint or varnish, or with some kind of soft coating, not of a metallic nature. As an example of the two cases, we shall mention that of tubes conveying steam, which may, in the one instance, be for the purpose of transporting heat from one vessel to another, and where, of course, it is an object that none should be lost in the passage; here we must use bright metallic tubes, which will radiate as little as possible. But if, on the contrary, we introduce steam tubes for the purpose of warming an apartment, here we wish to promote the radiation as much as possible, and we should therefore use the tubes unpolished, and varnished, painted, or even rusted. In the same way bright metallic vessels should be employed, when we wish to preserve the heat in fluids, where they are used for the purposes of cooking or manufactures, while the opposite plan is to be followed, when the object is to promote their cooling. (*Phil. Trans.* 1804, p. 177, *et seq.*) On the cooling of bodies we shall have occasion to speak more at large, in a subsequent part of the article.

We must now advert to a train of phenomena, connected with the radiating power of bodies, although perhaps depending upon a different principle, and leading to some new ideas respecting the nature of heat, the radiation of cold. By the radiation of cold we mean simply to express the fact, that when a cold body is placed in the focus of a concave mirror, a thermometer will fall that is suspended in the focus of an opposite mirror. This singular circumstance was first noticed by the members of the Florentine Academy, and was very distinctly described by them, although they were so much surprised at the effect, as almost to doubt the accuracy of their own experiment. (*Saggi di nat. Esper.* p. 176.) They do not seem to have made any atttempt to explain it; no farther notice was taken of it at the time, and it appears to have been almost forgotten, when Pictet, in the course of his experiments, to which we have referred above, after having ascertained the radiation of heat and its reflection by his apparatus, placed a vessel filled with ice in one of the foci, and observed the thermometer in the other focus instantly to sink several degrees; when the ice was removed, the thermometer rose again to its former elevation. By adding nitric acid to the snow, and thus producing a more intense cold, he found that the effect on the thermometer was augmented. *Essay on Fire*, § 69. See our article COLD.

The apparent radiation of cold has been since confirmed by Professor Leslie, and what may, at first view, appear still more remarkable, it seems to be acted upon by bodies in the same manner with radiant heat. It is promoted and retarded by the same kind of surfaces which promote and retard the radiation of caloric, and also in the same proportion. The canister, which had been employed in the former experiments, was now filled with ice or snow, and its different sides in turn exposed to the mirror, the differential thermometer being, as before, suspended in the opposite focus. The cold produced by the varnished side was the greatest, while that from the uncovered side was the least, the glass and the paper being intermediate between the two, exactly in the same manner as when the vessel had been filled with boiling water. The results also were similar when the thermometer was covered with different substances, so as to affect its power of absorbing heat, and also when the surface of the mirror was changed, so as to change its power of producing reflection. For example, when the thermometer was coated with a leaf of metal, it fell less, and when coated with varnish, more than in its ordinary state. And with respect to the mirror, the reflection of cold was most considerable from the bright metallic surface, less when a mirror of glass was employed, and still less when it was varnished. Here the power of the mirror in radiating cold, was exactly in the inverse ratio of its reflecting power, just as is the case with the radiation of heat. Lastly, the interposition of screens of different kinds, and with different surfaces, between the ice and the mirror, had effects which were precisely analogous to those mentioned above; so that under all circumstances, Professor Leslie found the strictest coincidence between the two kinds of radiation: (*Inquiry*, p. 23.) It may be proper to mention, that experiments of a similar nature, and with similar results, were performed on the radiation of cold by Count Rumford. They are such as sufficiently establish the facts, and might be esteemed valuable, were they not, for the most part, superseded by those of Professor Leslie. *Phil. Trans.* 1804, p. 170.

The general conclusions that may be deduced from the experiments of Pictet, Rumford, and Leslie, are, that bodies possess a power which generates cold, or reduces actual temperature; and that this power is emitted in right lines, and may be reflected, condensed, or intercepted, in its passage from one body to another, like the rays of radiant heat. It also follows the same laws with respect to the action of surfaces upon it, and bears the same relation to their reflecting property. Certainly the most obvious inference would be, that cold, like heat, depends upon the presence of a real material agent, capable of being transferred from one body to another, and subject to similar laws of radiation and reflection; but this supposition is so strongly opposed by many other considerations, which seem to prove, in the most decisive manner, that cold is merely a negative property, and signifies nothing more than the abstraction of heat, that we are compelled to look out for the explanation of the phenomena upon other principles: these we shall afterwards endeavour to elucidate.

We have very few remarks to make respecting the two other mechanical properties of heat, its reflexibility and its refrangibility. The reflection of heat has been abundantly proved by the numerous facts that we have stated, in which the concave mirrors were employed, as well as in all those where the nature of the surface absorbing the rays of heat affected this property; for it has been shewn, that in as much as the surfaces were unfavourable for absorption, they were, in the same proportion, favourable for the reflection of heat. The refraction of heat, as distinct from light, was clearly exhibited in Herschel's experiments; by its passage through the prism, it was diverted from its straight course like light, only in a greater degree, as the calorific rays are found to be dispersed over a larger space than the spectrum formed by the visible rays. The rays proceeding from a candle, or from burning fuel, were also found to be capable of refraction, like those of solar heat. We may conclude that the solar heat consists of rays of different degrees of refrangibility, although no other difference has been detected in their nature, as is the case with the differently coloured rays of light. This conclusion follows from the fact, that the space occupied by the rays after they have passed through the prism is greater than before they entered it. See Appendix to this article.

Before we conclude our account of what we have styled the mechanical properties of heat, we shall offer a very few remarks upon the velocity with which it moves. That the velocity must be very great, is a point of which there can be no reasonable doubt; yet it will be found very difficult to assign the actual velocity. It is perhaps the most probable conjecture, that heat, when radiating from a body, moves at the same rate with light; yet we know of no decisive arguments from which this can be inferred, as more than a conjecture. Pictet made some experiments upon this subject; but they only prove that no perceptible interval elapses in the passage of heat through about 70 feet, a space much too small to prove any thing important.

The second class of properties, which we announced as belonging to heat, are its chemical properties, or those that tend directly to produce a chemical change in bodies. We shall, however, postpone the consideration of these to a future part of the article, because we shall then be better prepared to determine, what properties ought to be regarded as chemical, after we have made ourselves aquainted with the effects of heat, as well as with the other properties that have not yet been considered, which we have styled *specific*. These we shall now proceed to examine.

The specific properties of heat may be classed under two heads: its tendency to diffuse itself equally among bodies, or its mode of communication from one body to another; and the peculiar manner in which it passes through bodies. Whatever be our opinion respecting the real nature of heat, it is almost impossible to enter into any investigation concerning it, without using language that would seem to imply, that it proceeds from the operation of a material cause. If, therefore, we fall into these forms of expression, it must be ascribed, not to our decidedly adopting this hypothesis of the nature of caloric, but to the extreme difficulty of avoiding them, although they must be admitted to be incorrect. With this preliminary caution, we may be allowed to say, that heat differs from other bodies, in its tendency to diffuse or distribute itself uniformly through all kinds of matter. When any substance possesses a different portion of free caloric from the substances in its vicinity, either in immediate contact, or connected with it by the intervention of a third substance, the superabundant portion of heat will have a tendency to pass from the first to the second, and the one will give and the other receive heat, until they arrive at a common temperature. This is one of the most familiar occurrences, and one of which we perpetually avail ourselves in the arts of life. If we wish to impart heat to a body, we bring it near a substance that is hotter than itself, when it immediately begins to receive heat, and continues to acquire it, as long as it remains in its new situation, or until it shall have experienced some change, which renders it incapable of the farther reception of heat. When, on the contrary, we wish to cool a body, we remove it into the neighbourhood of one which is cooler than itself, when an operation the reverse of the former will ensue; the cold body will abstract heat from the warmer, until the common temperature be gained.

The cause of this tendency in heat to fly off from bodies, or to pass from one to the other, and thus to diffuse itself among them, is attributed to its possessing an inherent repulsive power. The particles of all kinds of ponderable matter are necessarily attracted to each other, and consequently, under all circumstances, they have a tendency to be drawn and held together, unless some counteracting cause prevents their union. This is equally exemplified in the attraction which prevails between large masses of matter, by which the planets are kept in their orbits, called the attraction of gravitation, and the attraction which exists between the individual particles of matter, and influences many of the minute operations of nature, under the denomination of chemical attraction. The repulsive power, which appears to be an inherent quality of heat, may be regarded in general as the cause of its diffusion among bodies; but the manner in which it is distributed, or the particular law which it follows in passing off from one body, and attaching itself to others, seems to depend upon a different principle, or at least to be modified in a way that cannot be referred to repulsion. It has been conceived, that the phenomena might be explained upon the idea, that there is a combination of the two powers of repulsion and attraction, the heat escaping from a body, in consequence of the repulsive power that exists between its particles, while, at the same time, it is attracted by the particles of the body into which it enters. And perhaps this kind of double operation will serve to explain most of the facts, or at least will enable us to announce them in language which implies no contradiction, and gives an idea of their relation to each other. The equal distribution of heat, as it has been called by some writers, or the equilibrium of caloric, as it has been styled by others, constituting one of the specific properties which we enumerated above, has been the subject of much observation and experiment, and has also given rise to much hypothetical discussion.

The law by which bodies of different temperatures become the one hotter and the other colder, or by which the equilibrium of heat is produced, was first laid down by Newton, and may be thus expressed in general terms; that the heat lost by the one body, and gained by the other, is in proportion to the excess of the temperature of one above the other; or, stating it in a more scientific manner, that the difference between the temperatures diminishes in a geometrical ratio, while the times increase in an arithmetical ratio. The external circumstances which influence the rapidity of the equalizing process, are the radiating power of the bodies themselves, their conducting power, and, provided they are not in contact, the nature of the medium which is interposed between them, and the mechanical changes which take place in the medium, relative to its position with respect to the heating and cooling bodies, constituting currents. These principally operate in what are styled the elastic fluids; but they have also considerable effect in the action of liquids. The hypothesis which is commonly adopted, and which appears satisfactorily to account for this peculiar property of bodies, was proposed by M. Prevost. It is founded upon the following data. Heat is conceived to be a fluid, composed of distinct particles, which pass through space in right lines, and are projected in all directions, with very great velocity. The particles are so far removed from each other, that, analogous to what takes place with respect to light, a number of currents may flow in different directions, without interfering with each other. All bodies, except such as we suppose to be absolutely deprived of heat, send out rays to each other, although generally in very different degrees. Two bodies, exactly of the same temperature, will mutually give and receive heat, and even a cold body will radiate heat to a hot one; but, in the former case, the quantities given and received by each will be exactly the same, so that the temperature will not be changed; and, in the latter case, the one will give much more than the other, until the temperature of the two is equalized. *Phil. Trans.* 1802, p. 443.

This hypothesis appears to have been originally formed, in order to account for the experiment of which we gave an account above, the radiation of cold. When a heated body parts with its caloric to the neighbouring bodies, and raises their temperature, the idea that presents itself, as the most natural explanation of the fact is, that the hotter body has merely given off its superabundant heat to the colder, in consequence of the tendency which heat has to distribute itself uniformly through all bodies subjected to its influence. It may be conceived in this case to pass off, in a greater or less degree, according to the excess of the temperature of the one body over the other, modified by the nature of the surface, and the other circumstances to which we have already alluded. But this simple view of the operation will not explain the radiation of cold, or at least will not explain the apparent reflection of it from a concave mirror. If the cold body acted only by attracting heat from the neighbouring bodies, it would take it from the thermometer, the mirror, and all other contiguous substances; and there seems to be no reason why the focus should be colder than any other part of the atmosphere, equally near the source whence the cold proceeds. According, however, to Prevost's notion, when ice is placed in one of the foci, it sends out radiant heat, which strikes against the mirror, and is reflected into the opposite focus; but these rays being comparatively colder than those which proceed from other bodies in the vicinity, have the effect of generating absolute cold in the second focus, and thus tend to depress the thermometer which is suspended there. A mutual exchange of heat thus takes place between the ice and the thermometer, and the equilibrium is established, by the ice acquiring, and the thermometer losing, each a portion of caloric. (*Journ. Phys.* t. xxxviii. p. 3.) The facility with which this hypothesis explains the radiation of cold, is itself an argument in favour of its validity; and it must be admitted, that it applies equally well to all the other phenomena in which caloric is concerned. An objection has indeed been urged against it, that it does not take into account the effect of the conducting power of bodies, which must have an important effect in the equalization of their temperature. This is not, however, properly an objection against the general doctrine of the reciprocal interchange of radiant heat, but an omission in Prevost's manner of applying it; and it seems that the two operations are not in any degree incompatible with each other. Still, however, M. Prevost's opinion must be regarded rather as a plausible conjecture, which has the merit of satisfactorily explaining the phenomena, than as a theory founded upon any direct experimental proofs. It has indeed been conceived, that Professor Leslie's researches afford considerable support to it, as they tend to establish the existence of a radiating energy in bodies, quite independent of their conducting power; an energy, by which even the worst conductors of heat, under certain circumstances, become the most active radiators of it. Yet this radiation can never be proved to exist, except there be a previous difference of temperature between the bodies; because the thermometer, which is our only measure of heat, and the only index which we possess of its presence, is never affected except by an unequal distribution of it.

Having now described the manner in which heat tends to pass from one body to another, we shall next proceed to the second of its specific properties, the power by which it moves among the particles of the same body; or is conducted, as it is styled, through their substance. As bodies appear under the three states of solids, fluids, and gases, we should consider the power which heat exercises in its transmission through each of these different forms of matter. Our remarks will, however, be chiefly confined to the action of solids and liquids upon heat; for in consequence of the tenuity of gases, or the distance at which their particles are situated from each other, it does not appear that any very notable effects can be attributed to them upon the passage of free caloric, at least in comparison with what we observe in the two other classes of bodies.

When heat, in its uncombined state, radiates through air, or through a vacuum, it moves with a velocity which has not been accurately measured, but which, there is reason to suppose, is immensely great; so that, with respect to any distances near the earth, it may be said to be infinite. Heat also passes through the most dense and solid bodies, as, for example, through metals; but in this case its progress is prodigiously retarded. It is also found to move through these bodies with various degrees of velocity, which do not seem to bear an exact ratio to any other of their properties, and which can only be ascertained by direct experiment. This, in opposition to the rapid transmission of heat through the air, or through a vacuum, has been styled its slow communication; and the power which solids possess, of enabling heat to pass along them, has been called their conducting power. When solids are in contact, and are possessed of different degrees of heat, they immediately tend to produce an equilibrium of temperature; which is not brought about, as in the former case, by radiation, but by the one directly abstracting a portion of heat from the other, conducting this portion through its own substance, and diffusing it equally among its particles. This faculty exists in bodies in very different degrees; but it is found that each individual body always preserves the same degree of this power, unless some change takes place in its chemical or physical condition, when a change is at the same time produced in its conducting power. A familiar but a correct example of the different degrees of this conducting power in bodies, may be noticed in the different effects that are produced upon metal and upon glass. If a rod of each of these substances have one of its ends plunged into hot water, the metallic rod will soon become so thoroughly heated, through all its extent, that it will be impossible to apply the hand to the other extremity, while the glass rod will remain a long time in the water, before the upper end is sensibly affected. Hence we say, that metals are good conductors of heat, and that glass is a worse conductor of heat than metals. As a general principle, it may be stated, that the densest bodies are the best conductors; but to this rule there are many exceptions. Upon the whole, however, the principle seems to hold good in so many instances, that we may infer the existence of a necessary connexion between the density and the conducting power of bodies, and that when the ratio is not correctly maintained, it should be attributed to the interference of some other principle. Thus it is remarked, that the same body, without having experienced any chemical, or any other physical change, except a difference in its state of aggregation, has its conducting power increased or diminished, in proportion to its density, or to the contiguity of its particles. Rumford found that a solid piece of iron is a better conductor than the filings of the same metal; and that wood is a better conductor than saw-dust.

Many experiments have been performed on the conducting power of solids, the object of which was to ascertain the amount of this power, and to learn whether it bore an exact ratio to any other physical or chemical property. Metals, as was remarked above, are some of the best conductors of heat, but they differ considerably among themselves in this respect. Ingenhousz instituted a simple, but ingenious process, for discovering their relative power, which consisted in providing himself with rods of different metals, all of the same diameter, and having a certain length covered with a coating of wax of the same thickness. The other ends of the roads were then plunged to the same depth in a heated fluid; and, according to the quantity of wax that was melted, their conducting power was estimated. The best conductors were found to be silver, gold, tin, and copper, while platina, iron, and lead, seemed to be the worst: (*Journ. Phys.* tom. xxxiv. p. 68.) These experiments prove that the conducting power of the metals is not precisely in the same ratio with their density. Richmann of Petersburg endeavoured to ascertain the same point by a different process. He procured hollow balls of the several metals; into these he inserted the bulb of a thermometer, immersed the balls in boiling water, and observed the effect upon the mercury: (*Comment. Petrop.* vol. iv. p. 241.) The results do not precisely agree with those of Ingenhousz; but although more elaborate, we think them less direct; because in Richmann's other causes besides the mere effect of the conducting power might act upon the thermometer, an objection which does not seem to apply to Ingenhousz's.

A set of interesting experiments was performed by Rumford on the conducting power of various animal and vegetable substances. The plan which he pursued was to provide himself with a glass cylinder, which terminated in a globe of somewhat more than an inch in diameter. The bulb of a thermometer was suspended in the centre of this globe, and was surrounded by the substance to be examined; and the whole apparatus was then plunged into boiling water, and when raised to a certain elevation of temperature, it was immersed in a mixture of ice and water, and the time noticed which was required to bring it down to this degree of heat. The heat from the water must obviously pass through the substance upon which the trial was made, before it could reach the thermometer; therefore its conducting power was estimated by the effect which it produced upon this instrument. He began by observing the length of time necessary for raising the thermometer enclosed in the cylinder, when it was surrounded only with air, and what length of time was also necessary to cool it, by afterwards immersing it in a mixture of ice and water. He then successively introduced into the globe, similar weights of wool, cotton, silk, linen, down, and fur, and compared their effects with air, taken as a standard; the two last bodies were found to be the worst conductors, and linen the best, a fact which agrees with our experience of their effect when used as cloathing; for we know that their only operation, as producing warmth to the body, must depend upon their retaining the heat which is generated in it, and preventing its escape. The Count concludes, that the relative conducting power of these substances was in the inverse ratio of the quantity of air interposed between the particles or fibres of which they are composed. He found that their non-conducting power was not in proportion to the quantity of solid matter which they contain, and therefore could not be from any mutual attraction between the solid matter and the air; for the power bore no ratio to the actual quantity of the substance, but obviously depended upon the manner in which it was arranged.

He performed a direct experiment on silk, which establishes this point. Equal quantities of raw silk, the ravellings of spun silk, and twisted silk thread, were respectively placed in the apparatus; and their conducting powers were found to be in the proportion of 9, $11\frac{5}{2}$, and 13. He afterwards examined how far the air itself in the globe and cylinder might be conceived to be the sole agent, when it appeared, by calculating the space which the different substances occupied, and comparing the effect of the bulk of air which would be left, with the effect of the instrument when entirely filled with air, that the process of cooling was retarded by the mixture of the body with the air; and hence he deduced the conclusion, that the presence of the solid matter impedes the motion of the air, and prevents those currents from being formed in it, which we shall afterwards find to act so important a part in the heating and cooling of fluids: (*Phil. Trans.* 1792, and *Essays*, vol. ii. p. 428.) At the time when Rumford published his Essay, the effect of the radiation of surfaces was not thoroughly understood, and it is entirely neglected in the view which he takes of the subject. It must, however, have had a considerable share in the production of the phenomena; and we may imagine, that the more the particles or fibres of the solid matter are dispersed through the mass of air, the greater number of rays will be interrupted by them. It is also probable there is a real attraction between air and the different substances that were examined, which must have had its share in affecting the nature of the results; but whether the attraction differs in different substances, or whether the attractive power of the air is precisely equal upon all of them, does not appear to be exactly ascertained. Some experiments were made by Meyer of Erlangen, on the conducting power of the different kinds of wood. He procured balls of them, in which he formed a cavity to receive the bulb of a thermometer; the balls were then exposed to the same temperature, and the effects upon the mercury were noticed. The experiments, although performed with apparent accuracy, are defective in not making any allowance of the action of radiation. Lime, fir, alder, and oak, were the worst, while ash, apple, and ebony, were found to be the best conductors of heat. *Ann. Chim.* t. xxx. p. 32.

The different conducting power of bodies produces a great difference in their action upon the nerves in exciting the sensations of heat and cold, although the bodies indicate the same temperature to the thermometer. Thus it is well known, that in the same apartment, when it contains no source of local heat, the different articles of furniture will convey to the hand very different degrees of warmth. Metals feel the coldest, stone or marble is the next in degree, while wood, and still more woollen stuffs, produce little or no feelings of any change of temperature. The effect in this case depends upon the different conducting power of these substances; the human body being almost always warmer than the objects that are contiguous to it, its heat is abstracted by them; but this operation goes on in proportion to their conducting power, *i. e.* to the respective velocity with which they are enabled to remove the heat from our body. It obviously follows, that when we wish to retain the heat in any substance that is warmer than the surrounding medium, we must enclose it in bad conductors of heat; and that exactly the same method must be pursued, if we wish to keep any substance at a lower temperature than the atmosphere, or other contiguous bodies. Thus we envelope ourselves in woollen cloth or furs when we wish to retain our natural warmth; and we should employ the same method to prevent the melting of ice or snow.

We have already observed that one cause, which obviously tends to affect the conducting power of bodies, is their possessing a spongy texture, by which portions of air become, as it were, entangled in its pores, and thus seem to prevent the communication of heat. But we observe a very marked difference in the conducting power of bodies that are perfectly solid, and where no air, or at least no quantity that can be supposed capable of producing any effect of this kind, is present. What is it, in this case, that causes the difference in the conducting power of bodies? Is it an attraction which the heat possesses for the particles of the solid, or do the experiments of Rumford and others lead us to regard the operation as of a more mechanical nature, as if there was something in the arrangement or shape of the particles, which retards the passage of the heat along them? These are questions which at present it appears to be beyond our power to answer. Those cases in which a greater or less degree of density, or of aggregation of the parts of bodies, produces a considerable effect upon their conducting power, would induce us to suppose, that the worst conductors should be regarded as merely the most effectual retarders of heat, and the best conductors as simply those that have the least power in retaining the heat that has been imparted to them. But this view of the subject seems scarcely to apply to metals and other solids of a similar kind. The radiation of the surface may be supposed to have some influence in these cases; and M. Poisson goes so far as to conjecture, that the conducting power of solids, generally, is to be regarded as a kind of radiation from particle to particle, operating at very small distances: (*Journ. Phys.* t. lxxx. p. 434. *et seq.*) Upon this point, however, it does not appear that we have any data which can enable us to form a decided judgment.

Without, however, entering upon any abstruse theory on the subject, for which the present state of our information does not seem to afford a sufficient foundation, we may assume, as the most natural deduction from the facts, that the conducting power of bodies depends principally upon three circumstances. It is affected partly by the mechanical relation of their particles to each other, partly by an attraction between the heat and the particles of which the body is composed, and partly by the radiating power of the heat. The heat which escapes from the surface will tend to draw from the interior a portion of its remaining heat, in order to supply what has been lost from the external parts. There are also other causes, which, although perhaps less efficacious, are not to be neglected. The consequence of adding heat to a body is, to expand it in all its dimensions; but, by this expansion, it appears to acquire a greater capacity for retaining heat, so that it will become more disposed to carry it from other bodies, and to diffuse it over its own substance, and thus to have its conducting power increased. The effect which caloric has in altering the state of bodies, may likewise materially affect their conducting power, according to the nature of this change. Thus, if we throw a certain quantity of heat into a metal, it is reduced to the fluid state, by which its relation to heat, and the manner of conducting it, will be much affected. There is some reason to suppose, from an experiment of Pictet's, that heat passes more readily upwards than in the contrary direction. He enclosed a metallic bar vertically in a vacuum, and, heating it exactly in the centre, observed the effect produced upon thermometers attached to each end; when it appeared, that the one at the upper end was affected sooner than the one at the bottom: (*Essay on Fire*, § 33.) The experiment is ingenious: but there are some points connected with it, which render the result rather dubious.

We now proceed to consider the manner in which heat passes through fluids. Fluids differ essentially from solids in their particles being movable among each other; and this circumstance, as we shall find, acts a very important part in the transmission of heat. Fluids, like solids, are expanded by caloric, and of course become specifically lighter; and therefore, when heat is partially applied to them, in consequence of this alteration of gravity, the parts change places with respect to each other, the lighter or heated part rises to the surface, while the colder part sinks to the bottom. It is obvious, then, that heat may be supposed to pass through fluids in two ways; it may either be transmitted from particle to particle, as is the case with solids, or it may be conveyed by a change of gravity in the substance itself, producing a species of circulation among its parts. Many facts that fall under common observation, shew that this circulation takes place in partially heated fluids, and prove that it is much easier to cause heat to pass upwards through them, than in the contrary direction; but the impossibility of heat being propagated downwards through fluids, was not admitted until after the experiments of Rumford. These experiments, which are perhaps the most ingenious of any which he ever performed, have been generally regarded as sufficient to prove the general principle to which we have already alluded, that when any portion of a fluid is heated beyond the temperature of the remaining part, it rises to the surface, in consequence of its comparative levity; and if the heat be applied to the bottom of the vessel, which is usually the case, the successive portions of the fluid, as they receive the heat, rise in their turn to the upper part, until the whole acquires one uniform temperature. On the contrary, if the heat be applied to the top of the fluid, it is only the upper stratum which becomes heated, the remainder retaining its former temperature. Rumford placed a portion of ice on a certain quantity of boiling water, and found that it was melted in about 3 minutes; but when the same substances and apparatus were used, except that the ice was fixed at the bottom of the water, several hours elapsed, and yet the ice was not completely thawed. To render the operation still more striking, it was so managed that water was made to boil in the upper part of a cylindrical vessel, while the lower part remained full of ice. *Essays*, vol. ii. p. 241, *et seq.*

We have already mentioned the experiments in which it was found that heat passed less readily through solids, when they were of a spongy or porous texture, than through those that were more dense and compact. The same kind of effect was found by Rumford to take place in fluids when substances were mixed with them, which, by their viscidity, or other analogous property, would prevent the motion of their particles, and thus put a stop to the circulation, which we have described as conveying the heat through their different portions. He compared the time which was necessary for a quantity of pure water to change its temperature, by a certain number of degrees, with the same bulk of water when mixed with down or with starch; and he found the times to be as the numbers 6, 9½, and 11. He afterwards went on to shew, that, by increasing the quantity of matter in the fluid, the difficulty of the passage of heat through it was proportionally increased. $\frac{1}{50}$th part of its weight of down added to water produced a retardation equal to 75, while $\frac{1}{12}$th of the same substance produced an effect equal to 95: (*Essays*, vol. ii. p. 221. *et seq.*) The general principle, therefore, appears to be fully established, that fluids transmit heat, or suffer it to pass among their parts, in a different way from that in which heat is transmitted through solids, not by its being given off from one particle and received by another, but by all the particles coming successively to the source of caloric, and individually receiving it from the heating body. Whatever impedes the intestine motions of the fluid, and prevents this circulation of its particles from taking place, stops the passage of heat through it, and confines its effect to the portion which first received it.

The facts brought forward by Rumford may be considered as very decisively proving the general principle; but it has still been questioned, whether there is in fluids that absolute and complete non-conducting power which he attributes to them. Some experiments to prove that they really possess a small degree of a proper conducting power, have been performed by Dr Hope, Mr Nicholson, Mr Murray, Dr Thomson, and Mr Dalton. Their plan was to communicate heat to fluids in a direction different from that in which the supposed currents would act, as by applying it to the upper surface, and by their using every precaution to prevent its being carried downwards by the sides of the vessel containing the fluid, or by any other counteracting cause. The experiments appear, upon the whole, to prove their position, and thus to modify the conclusions of Rumford; but perhaps in all of them there may still be some sources of inaccuracy, which it is very difficult to guard against. The process of Mr Murray appears, upon the whole, to be the most unexceptionable. He formed a hollow cylinder of ice, which served as a vessel in which to contain the subject of his experiment; for ice, as long as it remains unmelted, being a perfect non-conductor of heat, the objection must be removed, which depends upon the conducting power of the vessel itself. The other arrangements made by Mr Murray were very ingenious, and appear to be well adapted for preventing the passage of heat in any manner except through the actual fluid; yet heat seemed to be certainly transmitted from the upper surface to the lower part, so as to affect a thermometer fixed near the bottom: (Nicholson's *Journal*, vol. i. p. 421.) If, then, we are brought to conclude, that fluids possess some degree of conducting power, it next remains for us to inquire, what is the relative degree in which it exists in different kinds of fluids? This, however, is a question, which it is impossible for us to answer with any accuracy; because we have no correct means of learning how far the communication of heat to them depends upon their proper conducting power, and how far upon the motion between their particles. It may be inferred, from some experiments of Rumford's, that mercury is a better conductor of heat than oil or water; and this might be expected to be the case. It is natural to suppose that mercury, so far as it is a fluid substance, conveys caloric, by internal motions among its particles, like other fluids, yet that it still retains its metallic property, and may conduct it from particle to particle.

The subject of the conducting power of liquids has very recently been investigated by Dr Brewster, who has removed every doubt that could remain respecting the existence of this property in fluid bodies, and has pointed out a simple method, by which the conducting power of all transparent fluids may be rendered visible to the eye, and easily measured, without the aid even of a thermometer. The apparatus by which these experiments were made is shewn in Plate CCLXXXIX. Fig. 8. where ABCD is a tin vessel about a foot long, having two openings E, F, in which two pieces of parallel glass are firmly cemented. A heated iron GH is suspended by a wire LM, and a stand RT, having a small circular aperture P, about one-eighth of an inch in diameter, is placed very near the plate of glass F, so as to be seen distinctly by an eye at E. This aperture is capable of being raised and depressed by a finger screw S. The vessel is now filled with water, or any other fluid, nearly to the top, and the eye being placed at E, and the aperture P raised so as to be seen through the upper stratum of fluid, it will appear of a perfectly circular form. Let the heated iron be now suspended, as in the Figure. In a few seconds the upper stratum of fluid will expand, as the heat penetrates the mass, and the circular aperture will have an elliptical form, as shewn at *a*, Fig. 9. By depressing the aperture P, so as to allow the rays which diverge from it to traverse the fluid strata at different depths, the aperture will have the appearance shewn at *b*, *c*, becoming perfectly circular at the point *c*, to which the heat has advanced. These appearances are the necessary consequence of the propagation of the heat downwards, which diminishes the density, and consequently the refracting power of the upper strata. A very curious phenomenon now takes place upon removing the hot iron GH. The uppermost stratum *m n*, Fig. 9. which was formerly the hottest and the least dense, now gives out its heat to the superincumbent air, and to a certain depth *c*, Fig. 10. the fluid diminishes in density, while from *c* to *f* its density increases. If, in this situation, we again examine the circular aperture, it will be found to be extremely elliptical at *a*, Fig. 10. having its larger axis horizontal. The ellipticity will gradually diminish towards *c*, where its form will be circular, and below *c* it will again become elliptical, the larger axis of the ellipse being now in a vertical direction. In these experiments the heat propagated down the sides of the vessel produced no effect, and if it had produced any, it could have been easily distinguished from that which was occasioned immediately below the hot iron.

Now, as all these changes are capable of being accurately measured by a micrometer, we are furnished with the means, not only of ascertaining the relative conducting powers of all transparent bodies, but also of determining the curve of density, whether the variation of refractive power is produced by heat, by pressure, or by the mutual penetration of two different fluids. The optical properties which were developed during these experiments, will be explained in our article OPTICS. Similar results may be obtained in a manner very different, but equally satisfactory. Let AB, Fig. 10. No. 2. be a vessel having a plate of annealed glass, whose section is MN, placed horizontally near the surface *m n* of the fluid, and supported by a glass pillar P. When this vessel is properly exposed to polarised light, no appearance will be seen through the edges MN of the glass; but if a heated iron is suspended, as in Fig. 8. the descent of the heat towards the surface MN, and its propagation through the glass plate, will be marked by beautiful fringes of light parallel to MN. Hence we have another method, and a very direct one, of *measuring the conducting powers either of transparent or opaque bodies*, by the Chromatic thermometer. See GLASS, THERMOMETER; and the *Phil. Trans.* 1816. p. 108.

We have but few remarks to make on the manner in which heat is transmitted through gases. From their physical constitution, especially from the facility with which their particles move among each other, we might infer that heat would be conveyed through them, more in the way that it is through fluids, by the action of currents, than from particle to particle, as in solids. We know also that air, like liquids, is expanded by heat, and that this expansion causes it to become specifically lighter, and thus forms ascending currents of warm, and descending currents of cold air. Rumford endeavoured to prove by experiment, that the passage of heat through air was entirely brought about by these currents, and that it was in itself a perfect non-conductor. (*Essays*, vol. ii. p. 410. *et seq.*) But his experiments, and the reasoning founded upon them, although ingenious, do not decisively prove the point; they only go so far as to show, that whatever impedes the motion of the air, retards its heating and cooling, and that the communication of heat to air is, in part at least, effected by the same means as it is in fluids. Berthollet has indeed advanced some considerations in favour of an opinion the very opposite to that of Rumford's, that air is a good conductor of heat, (*Stat. Chim.* tom. i. p. 467,) but they cannot be considered very decisive, and, in short, the question must be regarded as one which is still open to further discussion.

Before we conclude the subject of the properties of heat, we must make a few remarks upon the cooling of bodies. This process depends upon the combination of a variety of circumstances; partly upon the tendency to radiation, partly upon the conducting power of the substances in contact with the body to be cooled, and partly upon the presence of those currents, which we have described as existing in fluids and gases. Professor Leslie, in the course of his researches, to which we have so often alluded, made some experiments on the cooling of water contained in vessels that had differently radiating surfaces. He found that a globe of polished metal, when filled with boiling water, cooled to a certain degree in 156 minutes, while under the same circumstances, except that the globe was coated with lamp black, the water required only half that time for cooling. In this experiment, however, the cooling depends partly upon radiation, and partly upon the conducting power of the substance of which the vessel is formed; and Professor Leslie attempted to estimate the relative effect of these two operations. From previous trials, he knew what quantity of heat would have been abstracted by radiation alone; and thus it was easy to calculate what portion of the heat was removed by radiation, and what by the conducting power of the vessel. The general result is, that the effect of radiation is more powerful than that arising from the conducting power; for the lamp black, which is known to be a bad conductor, increases the cooling of the water by augmenting the radiation. As might be predicted, from what has been already related, when the globe was immersed in water, the cooling went on at the same rate, whether the surface was clean, or was covered with the black paint. In this case the process depended entirely on the internal currents that were formed in the water, while the surface of the vessel has no effect upon it. *Inquiry*, p. 268. 316.

Both Professor Leslie and Count Rumford performed a number of experiments, similar to the one mentioned above, on the action of the surfaces of vessels in promoting or retarding the escape of heat from bodies contained in them. We arrive at many conclusions which are singular and important; but they so obviously follow from the facts which have been already noticed respecting the radiation of heat, that it will not be necessary to dwell very long upon them. In Professor Leslie's experiments, it was always found that the cooling of water in metallic vessels was accelerated by coating the vessel with paper, paint, isinglass, or other similar substance; and while the coating was comparatively thin, this acceleration appeared to be in proportion to its thickness. So that although in these cases the conducting power must have been injured, yet this defect was more than counteracted by an increase of radiation. It can, however, scarcely be doubted, that were we to go beyond a certain limit, we should find, that, by augmenting the thickness of the coating, the diminution of the conducting faculty would prevail over any advantage which might be derived from the increase of the radiating power. There are several reasons which induce us to suppose that this latter quality is effected principally by the nature of the surface, while the conducting power must depend equally upon the nature of the substance through its whole thickness. It does not appear that any experiments have yet been performed, by which we can learn in what point this balance of power exists. Rumford's general conclusions entirely coincide with Professor Leslie's. He found that the same metallic cylinder, which, when filled with water, required 55 minutes to cool through a certain number of degrees, required only 43 minutes when covered with a layer of glue, 36 when covered with linen, and 34 when coated with a varnish of lamp black. *Phil. Trans.* 1804, p. 90.

When bodies are surrounded either by a fluid or by air during their cooling, the rate of the process will be considerably affected by the motions that take place among the particles of the investing medium. The action of a current of air in promoting refrigeration is too well known to require illustration; and this must evidently be an effect entirely independent of radiation, and in a great degree, at least of the conducting power of the air. Without deciding the question, whether air be an absolute non-conductor, it is rendered probable, both from circumstances that fall under daily observation, as well as from the direct experiments of Rumford and others, that air is not a good conductor of heat, and that one of the most effectual methods of retaining the temperature of a body, is to surround it with a stratum of air, so confined, that no internal motion can take place among its particles.

Hitherto heat has appeared only as a simple substance, capable of being communicated through the parts of solid bodies with different degrees of velocity, according to their conducting power; the presence of the heat being in every case marked by an expansion of the solid body corresponding with the temperature. These views, however, though universally received both among chemists and natural philosophers, have been completely disproved by some recent experiments made by Dr Brewster on the propagation of heat along glass, obsidian, semiopal, muriate of soda, fluor spar, alum, gum copal, rosin, horn, amber, tortoise shell, and other substances. We shall endeavour to lay before our readers as brief and perspicuous an account as we can of the new properties of heat which were discovered in the course of these experiments, without anticipating any of the phenomena, which more properly belong to the subject of optics.

Let a plate of glass, ABDC, (Plate CCLXXXIX. Fig. 1.) having MN (Fig. 2) for its section, be placed with its edge CHD upon a hot iron, or be in any way exposed to a source of heat. The heat will be slowly communicated through the substance of the glass in the direction HGFE, and when the heat has reached E, the temperature will be greatest at H, diminishing gradually towards E. The glass will, therefore, according to the common doctrine, be in a state of expansion, as shewn in Fig. 3. being most dilated at H, and least dilated at E. The case, however, is very different. When the heat has entered the glass at the edge CD, the parts of the glass between the edge and the dark line at G are in a state of expansion, diminishing towards G, and at the same instant the parts of the glass between E and F are thrown into a similar state of expansion, while the intermediate portions between F and G are thrown into a state of contraction, the lines AFB and CGD being the limits between the contracted and expanded portions, where the glass has suffered no mechanical change. These opposite effects, which are shewn in Fig. 4. are distinctly produced before the heat has reached the point F. When the height of the glass plate HE is very small, EF is equal to HG, and the contractions and expansions are almost simultaneously produced; but when HF is two or more inches, EF is always much greater than HG, and the expansion between E and F is less distinctly seen, being spread over a greater space. From these results it follows,

1. That heat, in passing along a plate of glass, *expands a part of the glass, where the heat does not exist in a sensible state.*

2. That the heat also *contracts an adjacent portion of the glass, where it does not exist in a sensible state.*

3. That the heat *contracts a part of the glass, where it does exist in a sensible state.*

4. That the heat *expands an adjacent portion of the glass, where it does exist in a sensible state.*

If the plate of glass ABDC, instead of being heated, is brought to an uniform temperature by immersion in boiling water, and is then allowed to cool in the air, all the effects, which we have described, are exactly reversed during cooling, as shewn in Fig. 5. the parts of the glass which were formerly contracted being now expanded, and *vice versa.*

If the expansion between H and G is either increased or diminished by a variation in the source of heat, the other expanded and contracted portions suffer a similar change; so that there must always be an equilibrium among the forces, by which these opposite mechanical states are produced.

Let the plate of glass ABDC, Fig. 6. be cut with a diamond through its centre O, by a line MN, but not separated into two parts, and in this state let it be placed with its edge CHD on a hot iron, as before. It will now exhibit the very same phenomena as those which we have already described, just as if it had never been touched with the diamond. When it is in this state of contraction in the middle, and of expansion at the edges, let it be suddenly broken through at the line MON, and it will be found that each of its halves ABNM, MNDC, Fig. 6. are thrown into the same state of contraction and expansion as when the plate was unbroken. Between E and *f*, *g* and O, O and *f'*, *g'* and H, the glass will be expanded, while between *f* and *g* and *f'* and *g'* it will be contracted, as shewn in Fig. 7.

Hence, it is obvious, that the contraction and expansion, or rather the phenomena by which they are indicated, are produced by some fluid, which is decomposed by heat into two fluids possessed of opposite polarity, in the same manner as the electric fluid of the tourmaline is decomposed by the action of heat, or the magnetic fluid of a piece of iron by the action of a loadstone. All the phenomena, indeed, which are exhibited during the passage of heat through a plate of glass, are *precisely the same* as the phenomena which take place in the communication of magnetical and electrical polarity; and if we admit the existence of two fluids as the agents by which the phenomena of electricity and magnetism are produced, we are compelled to make the same admission in the case of the propagation of heat along glass. It is not unlikely that the phenomena may be produced by the mutual action of free and latent heat. In our article Optics we shall have occasion to resume this subject at great length, and to give drawings and descriptions of the various optical phenomena which are produced by the singular state, into which glass and other bodies are thrown during the propagation of heat through their substance. Those who wish for full information on this subject may consult the *Philosophical Transactions* for 1816, part i. p. 46—114, and 156—179.

## SECT. II.

### *The Effects of Heat.*

We now arrive at the second of the great divisions into which we proposed to arrange our materials, the effects of heat. The principal of these are four. 1. Temperature, or the production of the sensation of heat; 2. Expansion, or the simple augmentation of the bulk of a body, without altering its condition; 3. A change in the physical state of a body, by which a solid is converted into a fluid, and a fluid into a gas; and, 4. Ignition, or the operation of heat, by which a body is rendered luminous.

1. Temperature is often used rather as a generic term, applicable to all the phenomena that bear a relation to heat, than as a specific term, proper to designate any one of them in particular. It is, however, not unfrequently used to express the power of exciting the sensation of heat, or the effect which it produces on the animal body; and there seems to be some propriety in establishing this restriction, because the word heat, which might otherwise be employed, as we have already remarked, is liable to the objection of being sometimes used to express the *cause*, and at other times the *effect*. The temperature of a body varies according to the quantity of heat which it contains, and may be said to be in the direct ratio of this quantity, although the indication of temperature, which we derive from the sensations, is much too vague to enable us to lay down an exact scale of admeasurement. This proportion of effect, however, only applies to the same body, or to those of a similar kind; for it has been found that the same quantity of heat affects the temperature of different bodies in very different degrees. These different effects depend partly upon the capacity of bodies for heat, and partly upon their conducting power; a point to which we have already referred in a former part of the article. The sensation of temperature is also very much influenced by the state of the nervous system, independent of the quantity of heat in the substance exciting it. It is well known that, when the hand is cold, a body that is applied to it will appear hot, when the same body would excite the sensation of cold, had the hand been previously exposed to a higher temperature. This sub-

ject belongs more to physiology than to natural philosophy in general; we shall therefore only remark, that we seem always to compare our present feelings with our former ones, and to refer our sensations, not to any invariable standard, but to what we have felt just previous to the present impression.

2. The effect of heat upon the sensations, although the one which must have been first attended to, and that which constantly offers itself to our observation, is found to be so inaccurate as a measure of its quantity, that we always have recourse, for this purpose, to the second of its effects, which we enumerated above, expansion. According to one of the characters of heat, which we have already described, that of distributing itself equally among bodies whenever two substances are brought together, which differ in their temperature, the one gives off a portion of its heat to the other, and that which receives it becomes expanded, or has its bulk increased in all its dimensions. This expansion continues as long as the body in question maintains its elevated temperature; but when the heat is withdrawn, it begins to contract, and by degrees it acquires its former bulk. This expansion occurs, with very few exceptions, in all bodies; but it differs extremely in degree. It is by much the greatest in aeriform fluids of all kinds. It is less in quantity, although still considerable, in liquids; while in solids, it is so small as not to be perceived, except by the intervention of an apparatus expressly contrived to render it visible. Not only these general classes of bodies, but many of the individual substances comprised under each of them, have very different degrees of expansive power, which has been frequently made the subject of experiment.

The different gases have been submitted to numerous trials, for the purpose of ascertaining their relative expansion. Priestley paid a good deal of attention to the subject. It was farther investigated by Roy, Monge, and Saussure; and lastly, with much apparent accuracy, by Guyton. (*Ann. Chim.* t. i. p. 256. *et. seq.*) Their results, although various, agreed in the main conclusion, that each of the gases had a specific power of expansion peculiar to itself, and which is uniform for each of the gases at the same temperature. But, notwithstanding the weight of these authorities, a farther examination of the subject by Mr Dalton and M. Gay-Lussac has led to an opposite conclusion, that all the aeriform fluids suffer the same expansion from the same addition of heat. Mr Dalton's experiments indicate, that 100 parts of any gas, in passing from the freezing to the boiling point, increase to 137 parts, which is nearly $\frac{1}{480}$ for each degree: (*Manch. Mem.* vol. v. p. 598.) M. Gay-Lussac's experiments were published a short time subsequent to those of Mr Dalton; but being made without concert or co-operation, they are to be regarded as equally original, and they lead to conclusions so nearly similar, as to afford the strongest evidence of their correctness. (*Ann. Chim.* t. xliii. p. 137. *et. seq.*) The source of error in the experiments that had been performed, previous to those of Dalton and Gay-Lussac, appears to have arisen from a quantity of aqueous vapour that had been mixed with the gases. See Expansion.

The expansion of liquors by heat differs, in many respects, from that of gases; it is less in amount, it varies much in different fluids, and it is found not to be in proportion to the quantity of caloric that is added to the heated body. If we observe the effects produced upon mercury, water, and alcohol, by the same addition of heat, and when they are all at the temperature of 50°, we shall find it to be, in the first of these fluids, equal to $\frac{1}{190}$ of its volume, in the second $\frac{1}{113}$, and in the last $\frac{1}{33}$. The comparative changes in bulk are also found to vary for the same fluid at different temperatures, contrary to what has been observed with respect to aeriform bodies, the expansion proceeding, in a gradually increasing ratio, as the temperature advances. Thus, at the temperature of 50°, the expansion produced by a single degree of heat is less than what would be produced by a single degree of heat at the temperature of 100°. Many accurate experiments, of which we have given an account in our article Expansion, were performed on this subject by Deluc. He found, that in fluids the rate of expansion is frequently irregular near the two extremes of freezing and boiling, and more equable in the middle of the scale; and hence he deduced a practical rule, that those fluids are the best adapted for measuring the degrees of heat, which have the largest interval between the limits of freezing and boiling. The general result of our examination of the expansive power of different fluids leads us to conclude that it has no connexion with their density, but it seems rather to be related to the quantity of heat necessary to convert them into the gaseous state. Thus ether is probably the most expansible, and mercury the least so, of any fluids, because they possess respectively the lowest and the highest boiling points. *Recherches*, t. i. p. 271, 311.

We have hitherto spoken of the expansion of fluids by heat, and their consequent contraction by cold, as of a property possessed by all bodies of this description; but there is one very remarkable exception to the general law, that of water. Water, through a certain range of temperature, like other fluids, experiences the usual augmentation of bulk by an addition of heat; but when it is cooled down to about 40°, it seems to arrive at its maximum of density; and if the cooling process be farther continued, it begins to expand, and continues its expansion until it arrives at its freezing point, when it becomes solid. By employing certain precautions, particularly by avoiding every degree of agitation, it will continue fluid for several degrees below the usual point of congelation, and it still goes on increasing in volume, until its actual solidification takes place. When a water thermometer, therefore, stands at 50°, it is impossible to know whether it be really at the temperature of 50°, or at that of 30°, 18° above, or two degrees below, its freezing point.

This anomaly, with respect to the expansion of water by the abstraction of heat, was one of the discoveries of the Florentine academicians, about the middle of the 17th century; but it was not much attended to, until it was again brought into view by Deluc. He repeated the experiment with more accuracy, and he attempted to ascertain the exact degree at which the expansion commences. This he fixed at 41°; and he farther discovered, that the expansion is nearly equal when water is either heated, or cooled, the same number of degrees above or below 41°: (*Recherches*, t. i. p. 225.) Some circumstances, which were not sufficiently attended to by Deluc, particularly the expansion of the glass in which the water is contained, were afterwards carefully noticed by Sir C. Blagden, and in consequence of these corrections, he fixed the point of greatest density at 39°. (*Phil. Trans.* 1788, p. 125, *et seq.*) Le Fevre-Gineau came to the same conclusion respecting this anomaly in the expansive power of water, by a very different process. He weighed a cylinder of copper in water at various temperatures, and thus obtained the weight of a cylinder of water exactly equal to that of the metal which he employed. The result of this process was to fix the maximum of the density of water at the 40th degree. Dr Hope adopted another method of arriving at the same conclusion, which we have fully explained in our article Expansion. Rumford has since performed a set of experiments upon the same principle, and with nearly the same results. There have been some objections made against these experiments, although they appear so correct, and were so much varied;

but, upon the whole, we conceive the conclusion to be thoroughly established, that the greatest density of water is at about 8 or 9 degrees above its freezing point. The cause of this peculiarity with respect to water is involved in considerable obscurity. It appears to be connected with the increased space, which water, as well as many other substances, occupy, when they assume the crystalline form; and we may conjecture, that some tendency to this state takes place in water before its actual occurrence. See Expansion.

The greater space which water occupies, when in the state of ice, has been long observed, and has been made the subject of some curious experiments, particularly by Major Williams, who, during an intense frost at Quebec, actually burst a cannon, by the freezing of only a comparatively small quantity of water: (*Edin. Trans.* vol. ii. p. 23. *et seq.*) When water is converted into the solid state, it forms spicular crystals, which cross each other at a determinate angle; and thus interstices are left, which cause it to occupy more space. Dr Thomson found, that the specific gravity of ice is to water at 60°, as 92 to 100; and hence we may conceive the great force that will be exerted, when water suddenly expands itself, so as to have its gravity diminished in the above ratio.

The expansion of solids, which we are now to consider, is much less than that of liquids. The same elevation of temperature, which increases the volume of a gas from 100 to 137 parts, increases that of a liquid only to about 104 or 105 parts, while it adds to a solid not more that $\frac{1}{1000}$ of its bulk. A set of experiments on the expansion of metals was performed by Smeaton, when he found, that, in passing from the freezing to the boiling points of water, platina was expanded from 100,000 to 100,087, gold from 100,000 to 100,094 parts, steel to 100,112 parts, copper to 100,170 parts, silver to 100,189 parts, tin to 100,288 parts, lead to 100.287 parts, and zinc to 100,296 parts: (*Phil. Trans.* 1754, p. 612.) It appears that the densest metals are generally the least expansible; but this proportion does not universally obtain.

The expansion of glass, which is a point of great importance to ascertain, as affecting the result of many other experiments, was made the subject of careful examination by Deluc. Supposing its bulk at 32° to be 100,000, at 212° it was found equal to 100,083, an expansion nearly the same with that of platina. From this estimate we learn that glass is expanded about $\frac{1}{200000}$ of its bulk by one degree of heat, and the expansion seems to be nearly uniform, for the same degree of heat, through the different parts of the scale. This equal augmentation of bulk, by equal increments of heat, is supposed to prevail generally in solids; but, from the minuteness of the effect, it is less easy to ascertain this point, than with respect to gases and liquids.

Several of the metals expand at the time they are converted from the fluid to the solid form; and this, as is the case with water, seems to depend upon the occurrence of a kind of crystallization, or regular arrangement of their particles. This is said to be particularly the case with respect to iron, and is the reason why we are able to take such accurate casts, when the melted metal is poured into moulds. It must, however, be observed, that the increase of bulk, which either water or melted metals acquire when they become solid, is no exception to the general law of expansion; for this applies solely to bodies as long as they retain the same state. The only anomaly, therefore, is the expansion of water while it remains fluid.

It is upon the expansive power which heat exercises over bodies that the thermometer is constructed; an instrument, as its name imports, employed for the purpose of measuring the degree of heat, or temperature of substances, to which it is applied, and which, considered in all its relations, may perhaps be regarded as the most useful agent in philosophical researches of which we are in possession. It appears to have been invented by Santorio, the celebrated Italian physician, who devoted so much of his attention to what has been called statical medicine. His instrument depended upon the expansive power of the air, and consisted of a tube, with a bulb of considerable size, the lower end of the tube being left open, and being plunged into a fluid, which was suffered to rise to a certain degree into the tube. As the air in the globe was expanded or contracted by the addition or subtraction of heat, it is obvious that the fluid would sink or rise in the tube, and thus mark the degree of heat. The Florentine academicians had the merit of considerably improving the apparatus of Santorio, by substituting alcohol for air, and by confining it in a tube nearly similar to the one now in use. Halley is said to have been the first who employed mercury, and Newton made the very important improvement of forming a regular scale, by which the observations might be recorded and compared together. It is, however, to Hooke that we are indebted for what may be regarded as a still greater improvement, viz. the formation of fixed points in the scale, by which, at all times and in all cases, thermometrical observations might be compared together, and be, as it were, all referred to one invariable standard. He perceived that water became solid always at the same temperature, and that, under the same atmospherical pressure, the fluid always becomes converted into vapour at the same degree of heat. Hence it follows, that if we immerse a tube containing mercury first into freezing, and afterwards into boiling water, we obtain two stationary and invariable degrees or points in the scale, which will bear the same relation to the temperature of other bodies, whatever be the size of the instrument, or under whatever circumstances the experiment is performed. Having ascertained these points, the numbers which are affixed to them, or the number of degrees into which we divide the interval between them, is entirely arbitrary, and comparatively unimportant.

The thermometric scale in general use in this country was formed by Fahrenheit, in which the cypher or zero is supposed to be indicated by a mixture of common salt and pounded ice. The freezing point of water is fixed at 32°, and the boiling point at 212°, so that the interval between the freezing and boiling of water comprehends 180°. In France, before the Revolution, the thermometer of Reaumur was generally employed. Here the freezing of water is the zero, or the commencement of the scale, and boiling water is assumed as the 80th degree. Since the Revolution, the centigrade scale is employed, which had been previously adopted by Celsius, a Swedish philosopher. Here freezing water is marked 0°, and boiling water 100°. Perhaps none of them are without considerable objections. Fahrenheit and Reaumur's scale are completely arbitrary; while the centigrade has its degrees too large for many purposes, and it has also the defect of beginning too high, so that we have very frequent occasion to employ the terms + and —, which may lead to confusion. Of the three, that of Fahrenheit is certainly the best; both because it is, in a great measure, free from this last objection, and because the degrees are not too large. Nor is it of much consequence that the commencement and termination are so entirely arbitrary; for when we are once accustomed to it, the mind refers to it as a term of comparison, without ever considering the reason for fixing upon the numbers that are employed.

The fluids employed in the formation of thermometers are either mercury or alcohol. Where we wish to ascertain very low temperatures, the latter is preferable, because it cannot be frozen but by the most intense cold, see Cold, whereas mercury becomes solid at — 39°. But for every other purpose, mercury has a decided advantage. Its expansions from the same additions of heat are more uniform; it is also more sensible to slight variations of temperature; and its boiling point is so elevated, that it possesses a range in the upper part of the scale, which is applicable to most practical purposes. Except, therefore, for measuring very low temperatures, mercury is now always preferred. See Thermometer.

A great deal of attention has been paid to the question, whether mercury, or any other fluid used for thermometrical instruments, was an exact measure of the additions of heat? whether the expansion was the same, by adding a certain quantity of heat at the lower as in the higher part of the scale? The experiments of Deluc on this point are regarded as the most correct. He observed the height to which the mercury rose in the tube, by immersing it in two equal portions of water, at temperatures considerably different from each other; then he mixed the two portions of fluid together, and examined whether the thermometer indicated the mean between the two. The result of Deluc's investigation was, that no fluid is an exact measure of temperature; but that, in all cases, the augmentation of bulk is in a greater ratio than the actual addition of heat. Mercury appeared to be the most uniform; but even in this fluid, the temperature of a mixture of two portions, one at the freezing, and the other at the boiling point, was 2½° less than the mean. The real temperature in this case is 122°, but, according to the common graduation, the thermometer stands at 124½°, (*Recherches*, t. i. p 311.) Hence, in order to obtain a precise measure of the increments of heat, we ought to have a thermometer so graduated as to allow for this deviation; and although we are not aware that any instruments have been constructed upon this principle, yet tables have been calculated by which a proper scale might be very easily formed.

The thermometer, however, in its most improved form, is only applicable to a range of temperature below that at which mercury boils; and although this includes most cases that usually fall under our observation, yet we have not unfrequently occasion to measure much higher degrees of heat. Newton attempted to accomplish this point, without any apparatus directly adapted to the purpose, by a species of computation. He ascertained the rate at which bodies cool, compared to the heat of the surrounding medium, at temperatures within the reach of the thermometer, and he then extended the same ratio to the higher degrees of heat. By this very ingenious method he discovered the temperature of red hot iron, and the melting point of many of the metals, with a considerable degree of precision. Since his time, different instruments, called *pyrometers*, have been invented, of which the most valuable, and that which has come into the most general use, was invented by Wedgewood. In the course of his experiments on the manufacture of earthen ware, he perceived that the different kinds of earths, called *clays*, into the composition of which a large quantity of alumine enters, had the remarkable property of contracting by exposure to a great heat, and likewise that this contraction was in proportion to the degree of heat employed. When the clay has once contracted, its bulk remains permanently diminished, so that by applying it to a gauge, previously graduated for the purpose, we can ascertain to what degree of heat the piece of clay in question has been exposed. The gauge by which the contraction of the clay is ascertained, consists of two straight pieces of brass, fixed on a brass plate in such a manner that they are nearer together at one end than at the other; and thus the more the clay has been contracted, the farther will it slip between the brass bars. Wedgewood then proceeded to examine the relation between his pyrometer and the common mercurial thermometer, and he determined that the 0° of his scale was equivalent to the 1077° of Fahrenheit's, were it so far extended. The degrees, the size of which was arbitrary, were each of them equal to 130° of Fahrenheit's; and the highest temperature which he actually measured was 160° of his pyrometer, corresponding to above 21 800° of Fahrenheit, which was found to be the temperature of a particular air furnace which he employed in his experiments: (*Phil. Trans.* 1782, p. 305, *et seq.*) This pyrometer has generally been regarded as a very valuable addition to our philosophical apparatus; but there is one circumstance which unfortunately much impairs its use—the difficulty of procuring the same kind of clay on which Wedgewood operated for the test pieces, as the mass which he originally employed is exhausted; and it does not appear certain, whether the imitation of it that has been since prepared, is possessed of precisely the same physical properties. See Chemistry,

Several other pyrometers have been invented, depending upon different principles, and possessing different degrees of accuracy. Muschenbroek, Ferguson, Ellicot, and Smeaton, have all exercised their ingenuity upon this point; but the only apparatus which we shall farther notice is that of Guyton. In this instrument along rod of platina is fixed in an horizontal groove, formed in a mass of clay that had been hardened by exposure to a strong heat; one end of the rod extends beyond the groove, and presses against another rod of platina, which acts as a lever; its longer arm being extended, so as to form an index, which moves upon a graduated arc. As the rod is more or less expanded by the heat, the index is carried along the scale, and serves to point out very minute variations in the bulk of the metal: (*Ann. Chim.* tom. xlvi. p. 276.) We are not certain whether this instrument has ever been employed in England; but it appears to possess many advantages as an accurate measure of high temperatures. See Pyrometer.

3. We now arrive at the *third* of the effects of heat, the change which it produces in the state of bodies, converting, according to circumstances, a solid into a liquid, or a liquid into an aeriform fluid. The effect of caloric, which we last described, consists in introducing a portion of heat between the particles of bodies, by which they are, to a certain extent, separated from each other, so as to experience an increase of bulk, without having their cohesion materially impaired. If, however, the addition of heat be continued beyond a certain limit, the particles are removed still farther from each other, until at length they are so far separated, as to lose their cohesive power, and to become easily movable among themselves in all directions. By this change of form, the substance in question undergoes a complete alteration in its physical properties, and not unfrequently in its chemical action upon other bodies. The effect is produced by destroying the balance between the expansive power of heat, and the force of attraction: the former tending to remove the particles of bodies to a distance from each other, the latter to retain them in close contact. But although the attractive force is conceived to be very much weakened in bodies when they assume the fluid state, it is not entirely destroyed, but is still exerted with considerable energy.

It is also to be remarked, that after a solid has received an addition of heat, so as to convert it into a fluid, a still farther quantity of heat may be given to it, which has the simple effect of expansion. If, however, we continue to increase the quantity of heat after the expansion has advanced to a certain length, the body again assumes a new form, and becomes a gas; and it now, as before, after this third change, by adding still more heat, suffers merely an expansion in its volume. But the expansion in these three cases, as has been already observed, differs considerably in its degree, being small in the first instance, greater in the second and much more so in the last. This peculiar quality of assuming the different states of solidity, liquidity, and elastic fluidity, may be considered as a property common to all kinds of matter; for it would appear, that if we had the power of producing, at pleasure, temperatures sufficiently high and sufficiently low, every substance that usually appears under the solid form might be vaporized, and every substance that usually appears as a vapour might be rendered solid. When we speak, therefore, of any body being naturally in the solid, or naturally in the liquid state, we mean no more than that, under the ordinary temperature of the atmosphere, or under the circumstances in which it commonly presents itself to our notice, it is solid or fluid.

There is, indeed, another obstacle to altering the state of bodies, besides the difficulty of procuring very high or very low temperatures, that by a great addition or subtraction of heat, their chemical constitution is affected, and they are either decomposed, or are disposed to enter into new combinations. Organised substances in general, both of animal and vegetable origin, when subjected to high temperatures, are converted into their ultimate elements; and, on the contrary, in some cases, a great reduction of temperature causes the constituent parts of certain bodies to separate from each other, before they are brought into the solid form. These, however, are to be regarded rather as incidental circumstances, interfering with particular operations, than as any fundamental exceptions to the general law that has been laid down. It would appear from the experiments of Sir James Hall, that many of these apparent exceptions may be brought under the general rule, merely by employing strong pressure or other mechanical means. Thus it has been supposed impossible to melt the carbonate of lime, because at an elevated temperature the carbonic acid escaped in the form of gas; but when the substance was subjected to strong compression, so as to prevent this escape of gas, the fusion was easily accomplished.

The suddenness of the change which occurs when the body receives so much heat as to convert it into the liquid state, shews that some other circumstance takes place besides the mere addition of caloric. And the same remark applies to vaporization; for here again no indication of the change of state can be observed, until the actual change occurs in its full extent. This point we shall soon consider more at length; but, in the mean time, before we quit the subject of the change of bodies from the solid to the liquid form, we must offer a few observations upon some phenomena that occur when we reverse the operation, and convert them from the liquid to the solid state. All bodies that undergo this change, without having their chemical constitution materially altered, have a fixed point at which they are said to freeze, congeal, or become solid; and except under certain circumstances, this point is invariably the same. This is so much the case with respect to water, that the freezing point of this fluid has been employed as one of the fixed degrees which regulate the graduation of the whole scale.

It is, however, possible, by certain management, to cool water several degrees below its freezing point, without rendering it solid; according to the experiments of Mr Dalton, as low as 5°, or 27° below the usual point of congelation. In order to succeed in giving water this unusual degree of cold, without converting it into ice, it is necessary that it be kept in a state of the most complete rest: for the least agitation either prevents it from falling lower than 32°, or if it be brought down below this point, it instantly begins to freeze, and the fluid part rises to 32°. Black found that by carefully boiling the water, so as to expel from it all the air which is generally dissolved in it, it was less easy to reduce the temperature below the ordinary degree; and Blagden discovered, that when water is thus artificially cooled, no circumstance had more effect in producing its sudden congelation, than introducing into it a small particle of ice. Hence, when the freezing of water has once commenced, it proceeds with so much rapidity in these experiments; and it may perhaps also in some measure, account for the effect which water confined in close vessels has in bursting the vessel when it freezes. In these cases the fluid may probably descend some degrees below the usual freezing point, before the congelation commences; a slight agitation, or other incidental circumstance, then causes the freezing to commence, and the first spiculæ of ice that are formed tend to convert the remaining part of the water into the solid state so rapidly, as to produce a greater expansion, than if the particles had arranged themselves more quietly in the crystalline form.

The effect of a continued addition of heat to a liquid is, as we have remarked above, to convert the liquid into the state of vapour. This, like the former, is a sudden change, and, like it, is attended with a complete alteration in the physical properties of the substance so changed. A certain portion of caloric added to a body, insinuates itself among the particles, and places them so far from each other, as to diminish the attraction which unites them into the solid form, without, however, entirely destroying their aggregation; while a larger portion removes them to a still greater distance, and seems as if it entirely placed them beyond the reach of their mutual attraction. The most obvious property of the body, when in this vaporized state, is its power of expanding itself in an indefinite degree, until its particles be brought nearer together by an external compressing force. If this external force be removed, it quickly regains its former dimensions; and hence we regard it as a body possessed of a perfect degree of elasticity. It is upon the elastic power which different substances possess, when they are converted by heat into the gaseous or aeriform state, that many of the most important operations, both in art and nature, are brought about. The force which different bodies exercise when they are reduced into the gaseous state, and are at the same time subjected to strong pressure, is almost inconceivable; it is, in short, unlimited in its extent, and may be so managed as to produce any assignable degree of effect. Notwithstanding, however, the expansive power which bodies exercise during their conversion from the fluid to the gaseous form; yet when they are finally brought into this state, they are compressible. Thus, although the conversion of water into an aeriform fluid is capable of generating an almost immense degree of mechanical power, in consequence of the greater space which it then occupies, a power of which we take advantage in the steam engine, yet the vapour, when once produced, may be easily compressed into a less bulk, by the weight of a comparatively small quantity of mercury. Farther increments of heat, when added to the gas, only serve to produce a corresponding increase of its bulk; and this increase, as we have already remarked, is equable for the same quantity of heat, and is likewise similar in all the different gaseous bodies.

The point of vaporization, like that of solidification, differs for almost every kind of liquid. There are some bodies that always appear in the state of gas when not combined with other substances, and no degree of cold which has yet been applied to them has been able to deprive them of their elastic fluidity. Yet from analogy we conclude, that these bodies have nothing in their nature essentially different from those which we observe to assume either the liquid or the gaseous state, according to the temperature in which they are placed; and we conceive, that, had we the power of employing a degree of cold sufficiently intense, they might be rendered liquid, or even solid. Ether has the lowest and mercury the highest vapour points of any liquids with which we are acquainted. If we were always immersed in a temperature above that at which ether boils, we should never see it in a fluid state; and if we had not been able to produce a temperature above 670°, at which mercury boils, we should have had no conception of this substance being reducible into the state of a vapour. The terms *fixed* and *volatile*, like *solid* and *liquid*, are therefore to be regarded as merely relative, and as not indicating the absolute quality of the bodies, but pointing out the forms under which they usually present themselves to our notice. But although we regard this as the most correct view of the subject, yet many chemists of eminence have supposed that there is some essential or radical difference between the two kinds of aeriform fluids, and have called them by different names; to those that are easily reduced to the liquid state, the term *vapour* has been exclusively applied, while the others have been called *gases*, or permanently elastic fluids. The discussion of this question belongs more to chemistry, than to the immediate subject of this article; but we shall farther remark concerning it, that when, by the effect of chemical affinity, these gases are reduced to the liquid or solid form, heat is extricated; thus proving that it entered into their constitution, and was necessary to their existence.

An important circumstance connected with the conversion of liquids into the state of elastic fluidity, is, that it is influenced by the degree of pressure to which the liquid is subjected. External pressure thus counteracts the repulsive power of heat, and as it were keeps the particles in a state of forcible approximation. It follows, from this order of things, that if we remove from the surface of a liquid the whole or a part of the weight of the atmosphere, by placing it under the receiver of an air-pump, or by ascending a high mountain, it boils at a lower temperature than under ordinary circumstances. Thus water, which boils at 212° when the barometer stands at 30 inches, boils at about 70° *in vacuo*; and on the top of Mount Blanc, it was found by Saussure to boil at about 187°. As the temperature at which different species of elastic fluids are formed depends so much upon the pressure which is applied to them; so, after the gaseous state has been assumed, the elastic force of the vapour varies according to the degree of pressure under which it exists. Mr Dalton has made this the subject of an extensive range of experiments, in which he determines the height of the the mercurial column which the vapour of water will support at different temperatures. Thus if the vapour of water be taken at the freezing and boiling points, and at 122°, which is intermediate between them, he found that the column of mercury supported in these three cases was equal to 0.2, 3.5, and 30 inches respectively. By making a few experiments, and observing the ratio which the numbers in these cases bore to each other, he constructed a table containing every degree of heat, from 0° on Fahrenheit's scale to 325°; (*Manch. Mem.* vol. v. p. 559.) Experiments of a similar kind have been performed in France by M. Bettancour. As the boiling point of liquids is lowered or raised, according as the atmospherical pressure upon them is diminished or increased, it has been found, that if the pressure be augmented in a very great degree, as is the case when water is inclosed in Papin's digester, it is capable of receiving a much higher temperature than what it can maintain under other circumstances. Water has, in this way, been heated 200° or 300° beyond its usual boiling point; and it has then acquired the power of dissolving many substances, over which it has no action in its ordinary state.

It is upon the property which liquids possess, of being convertible into the gaseous state, that the processes of evaporation and distillation depend. The first of these is performed, when our object is to separate the more volatile parts of a compound, for the purpose of procuring those that are less so; and the second, on the contrary, is done in order to procure the volatile part itself. A minute account of these operations belongs more to chemistry, and to the various branches of chemical manufactures, than to the general view which we are taking of the effects of heat. (See DISTILLATION and EVAPORATION.) In both cases, the separation is effected by the combination of heat with the liquid; in the one, it is sometimes produced by the heat which naturally exists in the atmosphere, aided by a current of air, continually presenting a new stratum to be acted upon; and at other times a quantity of heat is thrown into the substance by the combustion of some kind of fuel. It is, however, necessary, in either case, that a large surface should be exposed to the atmosphere, for the purpose of carrying off the vapour as rapidly as it is produced; for it appears that it is principally at the surface that it is generated. In the process of distillation, artificial heat is always employed, and commonly in a greater degree than where the object is merely to produce evaporation. Here the liquid is confined in close vessels; and the operation depends upon a portion of it, which is nearest the source of heat, becoming converted into vapour, and passing up through the other parts of the fluid in the form of bubbles, constituting what is styled *ebullition*.

We have already remarked, that when a solid is converted into a liquid, or a liquid into an elastic fluid, the conversion is brought about suddenly. The substance in question, before it changes its state, continues to receive heat, is expanded in a certain degree, and has its temperature raised; but if an additional quantity of heat be still given to it, the expansion no longer goes on in the same manner, and the temperature is no longer elevated, but it assumes a new form, becoming, according to circumstances, either a liquid or a vapour. It was formerly supposed, that this change did not depend upon any peculiar or specific action, but that the mere addition of a certain small portion of heat was adequate to effect it. Dr Black, however, perceived the insufficiency of the opinion usually entertained upon the subject, and was induced to investigate it with great assiduity; the result of which was, the establishment of his celebrated theory of latent heat. The fundamental position of this theory is, that when a solid is converted into a liquid, or a liquid into a gas, a much greater quantity of heat is absorbed by it than is perceptible by the sensations, or the thermometer, the effect of which is to unite with the particles of the body, and thus to alter its form. When, on the contrary, the vapour is reduced to the state of a liquid, or a liquid to that of a solid, heat is disengaged from it, without the substance in question indicating any diminution of temperature, either to the sensations, or to the thermometer. This phenomenon is considered to be the reverse of the former; here the heat that escapes is not supposed to have affected the body in the way that free caloric acts, but simply to have maintained it in the state of elastic fluidity, or of liquidity.

We are hence led to regard heat as existing in two states that are essentially different from each other: the one producing temperature and expansion, and of course capable of being measured by the thermometer; the other not manifesting these properties, but uniting itself to bodies, and changing their form. The former we call free or uncombined heat; the latter latent or combined heat. As we are in the habit of conceiving temperature and expansion* to be the most certain indications of the presence of heat, it required a train of minute experiments to establish a position, which appeared, at first view, so much at variance with our ordinary conceptions, as that heat could be communicated to bodies without producing these effects. The following facts may be considered as the ground-work of Black's doctrine. Let a mass of pounded ice, cooled several degrees below the freezing point, be exposed to the heat of a furnace, so that it may receive equal quantities of caloric in equal intervals of time. The ice, as it receives the heat, becomes warmer at each successive interval, until the whole acquires the temperature of 32°; but now, although the heat still remains applied as before, the ice acquires no additional warmth; it still indicates 32° to the thermometer, but it is observed gradually to dissolve. No increase of temperature takes place until the whole is rendered fluid, and then it again begins to grow warmer, and, as before, acquires successive increments of heat, until it arrives at the 212th degree. Here, again, the process ceases; and whatever quantity of heat be sent into the fluid, its temperature remains unchanged; but now the fluid is observed gradually to assume the state of vapour, until the whole of it is converted into the aeriform state. Now there is every reason to conclude, that in this case the ice and water continue to receive equal quantities of heat for the whole period; yet during some part of the process, the thermometer remains stationary. At this very time, however, the change of form occurs; and therefore it is natural to conclude, that it is connected with the absorption of a portion of heat, which, in consequence of its not producing either temperature or expansion, has obtained the name of *latent*. The legitimate inference is, that a certain quantity of caloric, which would otherwise have been employed in producing temperature and expansion, is necessary in the one case for melting the ice, and in the other for vaporizing the water.

What we have now stated may be regarded as the foundation of the celebrated theory of latent heat; which has been universally received, as affording a satisfactory explanation of some of the most interesting phenomena that occur in the system of nature. A number of very important consequences were immediately deduced from it, of which we may enumerate the two following, as those the most deserving our attention:

1. When solids become liquid, and liquids become elastic fluids, a quantity of heat, previously latent, becomes sensible, and may be now measured by the thermometer, although before it was not capable of affecting this instrument. On the contrary, when vapours are converted into liquids, or liquids into solids, a portion of heat, which was previously in the uncombined state, is now absorbed or rendered latent. In the former process, therefore, warmth is produced; in the latter, cold is generated.

2. Substances which are at the same temperature actually contain different quantities of heat. Ice, just before liquefaction, and the water which is formed, are both at the temperature of 32°, and steam is no hotter than the boiling water from which it is produced; so that the water and the steam both contain a large quantity of heat, in the combined or latent state, which they have absorbed in order to cause the fusion of the one, and the vaporization of the other. This property in bodies, of indicating the same temperature when they contain different quantities of heat, is denominated their capacity for heat; while the quantity of heat which they require to bring them to the same temperature is called their specific heat, in opposition to the real quantity, which is styled their absolute heat.

It would carry us far beyond our prescribed limits, were we to give an account of all the experiments which were performed by Black, for the purpose of establishing his theory, and of repelling the objections against it. They consisted, in the first place, in comparing the effect produced by the same quantity of heat upon bodies which possessed different capacities, as ice and water. When the same weight of ice and water, both at the temperature of 32°, were suspended in an atmosphere of 47°, the water rose to 39° in 30 minutes, while the ice required ten hours to become liquid, and to acquire the same temperature. The ice, therefore, was 21 times as long as the water in acquiring the same degree of warmth, and we may conclude that it would absorb 21 times as much caloric. While the number of degrees gained by the water was no more than seven, the number that entered the ice would be 147°; but of these only seven were employed in warming the substance, the rest were expended in melting it. Hence we should say, that when ice is converted into water, 140° degrees of caloric are rendered latent. The same general conclusion was obtained by a different process. When two equal portions of water, at unequal temperatures, are mixed together, the mixture indicates the mean temperature of the two portions; thus a pound of water at 32°, and a pound at 172°, produce a mixture which indicates 102°; but if we mix a pound of ice at 32°, with a pound of water at 172°, the ice is melted, but the temperature of the fluid is not raised. Hence the 140° of heat are all employed in thawing the ice, and thus become latent.

The absorption of heat that takes place when solids are melted, or liquids evaporated, and the discharge of heat that occurs in the reverse operations, are often employed in different processes, for the purpose of cooling or warming bodies. The effect of evaporation in generating cold is well known, both as it affects the sensations, and as it actually reduces the temperature of substances. In hot climates, fluids and various articles of diet are preserved at a temperature considerably below that of the atmosphere, by placing them in vessels, from the surface of which evaporation is continually going forwards; and by the proper management of this process, even ice is formed in considerable quantity, for the purposes of domestic economy, at a temperature some degrees above the freezing point. By means of the evaporation of ether, water is easily frozen at the medium temperature of our climate, and indeed a degree of cold may be generated far below that of the freezing point. A still greater diminution of temperature is produced by a solution of certain salts;† a circumstance which depends partly upon the heat that is rendered latent by the conversion of a solid into a liquid, and partly by the mixture possessing a greater capacity for heat than the ingredients in their separate state. To these two circumstances, the change of state which bodies experience, and the change in their capacity, as depending either upon this alteration in their state, or upon the new combinations into which they enter, we ascribe the increase of temperature which occurs in a variety of chemical operations, where caloric is not introduced from any external source. The heat, which is excited by combustion, is to be attributed

* It will be seen, in another part of this article, that expansions and contractions are produced by heat in glass and other substances, where it *does not exist in a sensible state*. See page 286.—Ed.

† See Walker's experiments on freezing mixtures, *Phil. Trans.* 1801, p. 120; and our article Cold, vol. vi. p. 733, 734.

to the latter cause, the change of capacity in the substances; the products of combustion, particularly the carbonic acid, being supposed to possess a less capacity than the carbon and oxygen before their combination.

The cases in which the conversion of a body from the liquid to the solid form actually produces an increase of temperature, are not very numerous; but there are not unfrequent instances in which the rate of cooling is obviously retarded by this process. And in no operation is this more remarkable than in the natural freezing of water. When water is exposed to the influence of external cold, its temperature sinks in proportion as the heat is removed from it, until it arrives at 32°; the refrigeration is then suspended, but the water begins to become solid, and the temperature remains stationary, until the freezing is completed; then the cooling recommences, and is continued until the ice arrives at the temperature of the surrounding medium. The freezing of water, however, under particular circumstances, affords an example of the actual evolution of heat. This takes place in that case which has been described above, where water has been cooled below 32° without becoming solid; if it be then agitated, or a small spicula of ice be introduced into it, the congelation takes place with great rapidity, and the portion of water which still remains fluid instantly rises to 32°. An experiment of an analogous kind may be performed on the crystallization of salts. By proper management, a warm saturated solution of the sulphate of soda may be cooled for several degrees, without any of it beginning to crystallize; if the vessel be then slightly shaken, the process suddenly commences, and a large part of the salt immediately becomes solid, in consequence of which the temperature will be very sensibly raised. The general law, both in this and the reverse operation, is, that the most powerful effect, either of heating or cooling, takes place when the process is performed with the most rapidity, when the substance that has its state or its capacity changed, has its equilibrium with the neighbouring bodies restored in a short space of time, and therefore most perceptibly affects their temperature.

The same kind of experiments which Black performed, to establish the absorption of heat, when a solid is converted into a liquid, he afterwards made on the conversion of a liquid into an elastic fluid. He also attempted to ascertain the exact quantity of heat which is rendered latent in this operation, in which he was essentially aided by Mr Watt; and the result of their inquiry was, that when water assumes the state of vapour, it absorbs 950° of caloric.* This number he obtained in two ways: 1st, By comparing the heat necessary to raise the temperature of a certain portion of water to the boiling point, with the effect produced by an equal addition of heat in afterwards evaporating the water; and, 2dly, By finding what quantity of caloric was extricated, when steam is reconverted into water by condensation. We have already mentioned, that when water is strongly compressed, as by being inclosed in Papin's digester, its temperature may be raised far above the boiling point, without its assuming the aeriform state. In this case its tendency to evaporation is mechanically prevented, by the particles not being allowed to separate from each other; and therefore, as it cannot alter its form, its capacity remains the same, and its caloric all continues to be in the uncombined state. But if the pressure be suddenly removed from the water, its particles now being at liberty to expand themselves, they unite to a portion of the heat, instantly assume the elastic state, and the remainder of the fluid sinks to 212°.

We have already explained, in a general way, the meaning of the term *capacity for heat*, and the difference between the absolute and the specific heat of bodies; but we must illustrate the subject with a little more minuteness. As a foundation for our reasoning, it may be assumed, that when equal quantities of the same substance, but at different temperatures, are mixed together, the temperature of the mixture indicates that of the arithmetical mean of the two ingredients. This, however, only applies to bodies of the same kind; for when different substances are employed, it is impossible to predict what will be the temperature of the mixture. Thus if a pound of water and a pound of mercury be mixed at different temperatures, the result will not be the mean temperature; but it will be found that the mercury loses 28°, while the water gains only 1°. Water is therefore said to have 28 times the capacity for heat that mercury has, because it requires 28 times as much to produce the same change of temperature; or, to use a different, and perhaps a more correct phraseology, we say that the specific caloric of water is to that of mercury as 28 to 1. Proceeding upon this principle, and taking water as a standard of comparison, numerous experiments have been made on the specific heat of various substances, particularly by Crawford, Irvine, and Wilcke.

The method employed by Crawford was to mix together, at the same temperature, the substance to be examined and water, the specific heat of which is considered as one, being that with which all the rest are compared. He then multiplied the weight of each body by the number of degrees between its original temperature and the common temperature obtained by their mixture, and the capacities will be inversely as the products. (*On Animal Heat* 2d edit. p 96, *et seq.*) It is generally more convenient to employ a definite weight of the substance to be examined, than to measure it by its volume; but when we examine the specific heat of equal volumes of different bodies, we find the same want of correspondence between the results, so as to prove that the capacity for heat is a property which bears no exact ratio to any other physical quality. In the performance of these experiments, much dexterity is requisite, in order to ensure even a tolerable degree of accuracy; and after all, the results of different trials, made upon the same substance, will not always be found to correspond, yet there seems to be no doubt of the correctness of the principle, and, in many cases, we may conceive that we arrive at a near approximation to the truth. See CHEMISTRY.

Mr Leslie has proposed another method of ascertaining the specific heat of bodies; it consists in comparing the time which they occupy in cooling with the cooling of water placed under precisely the same circumstances. The apparatus which he employed was a thin glass globe, furnished with a neck capable of receiving a delicate thermometer. He observed the time necessary for water to cool a certain number of degrees in this globe suspended in the air, then he fills the instrument with another fluid, the specific heat of which he wished to examine, and heats it to the same degree, and suspends it in air of the same temperature, and observes the time necessary for it to cool the same number of degrees. It is found, that, under the same circumstances, water cooled in 70 minutes, while oil required 32 minutes only; therefore, by estimating water at unity, as the standard of comparison, the specific heat of oil will be .46, if we estimate it by bulk, or .5, if we estimate it by weight. *Inquiry*, p. 170.

The great difficulty there is in executing experiments

* The late Mr Southern found, from numerous experiments, that the latent heat of steam at the temperatures 229°, 270°, and 295°, is 942°, 942°, and 950°. See Mr Watt's Annotations on Dr Robison's article STEAM, in Robison's *System of Mechanical Philosophy*, vol. ii. p. 166.—ED.

like those of Crawford's, where the substances are mixed together, and the specific heat calculated from the temperature of the mixture, induced Lavoisier and Laplace to attempt to solve the problem by a new method. They proceeded upon the fact, that when ice is melted, it must always absorb the same quantity of heat, and therefore that the caloric which is disengaged from any body, by a change in its form, or from the union of two or more bodies, may be accurately measured, by placing the substance in such a situation as that all the heat must necessarily pass into a stratum of ice; and from the amount of water produced by the melting of the ice, the quantity of heat given out may be estimated. The apparatus which they invented to accomplish this purpose, they called a *calorimeter*; it consists of three vessels inclosed one within another, so as to leave a cavity between each of them. The substance which is to be the subject of experiment is placed in the innermost vessel; the second is filled with pounded ice, and is provided with a tube at the bottom, through which all the water that is formed is conducted into a suitable vessel, where it may be collected and measured. The outermost space is also filled with ice, in order to preserve the interior of the apparatus at the proper temperature: (*Mem. Acad. Scien.* 1780, p. 368.) This instrument is constructed upon scientific principles, and seems both simple and ingenious; yet we are informed that there are some circumstances which interfere with its practical utility, and we believe it has never been employed except by the inventors. See Wedgewood in *Phil. Trans.* 1784, p. 371, *et seq.*; and CHEMISTRY.

The capacity of gaseous bodies for heat, like that of liquids and solids, varies according to the nature of the individual gas; but the determination of their respective capacities requires a delicacy of experiment, proportionate to the difficulty of operating upon substances of so subtle a nature. It has, however, been attempted by Crawford, and prosecuted by him with much perseverance and ingenuity, and made the foundation of some very important doctrines, both in chemistry and physiology. It must indeed be confessed, that the extreme nicety of the process necessarily makes the conclusions liable to much uncertainty; yet the general results have been, for the most part, acquiesced in, although they have been considerably altered since they were originally brought forward. Of late, however, they have been controverted by MM. Delaroche and Berard, who have published a very elaborate set of experiments, which they performed upon the specific heat of the gases, in which they employed an apparatus of a new construction. It is in fact a calorimeter; but instead of measuring the heat which is extricated by the quantity of ice which it will melt, they endeavour to ascertain what quantity of heat the gas will impart to a mass of water; and for this purpose a current of the gas is sent along a serpentine tube, which traverses a cylinder of water. The instrument appears to us to be very complicated, and to require a great share of manual dexterity in the operator, a circumstance which we always consider as very objectionable: (*Ann. Chim.* lxxxv. 72.) But although their results differ considerably from those of Crawford, they agree with him in the general principle, that the specific heat of the gases is different from each other, whether we attend to their volumes or their weights, and that there is no relation between the specific gravity of the gases and their specific heat. See Description of Plates at the end of the Volume.

Besides the difference in their capacities for heat, which gases possess in consequence of a difference in their nature, this property is also much affected by the degree of compression which they experience, or is in proportion to their density. It is consequently observed, both in experiments performed for the purpose, and in many natural processes, that the sudden condensation of air generates heat; and, on the contrary, that sudden dilation produces cold. Whenever an expansion of air takes place, either from the removal of pressure, or from any other cause, the particles are more widely separated from each other, in consequence of their elasticity being now at liberty to exert itself; and it would appear, that a quantity of caloric necessarily rushes in to supply the vacuity. This, although merely a mechanical view of the subject, appears to be rendered probable by the fact, that the emission and absorption of heat are respectively produced by causes, which can only be supposed to act by bringing the particles of the gas nearer together, or removing them farther asunder. If a thermometer be placed in the receiver of an air pump, and the air be quickly exhausted, the mercury will sink several degrees; and if, on the contrary, air be rapidly condensed by the appropriate apparatus, the mercury is considerably elevated. (Dalton in *Manch. Mem.* vol. v. p. 515.) The heat which is excited by condensing the atmosphere in the barrel of an air-gun is well known; and by employing it in the most advantageous manner, sufficient heat may be extricated to set fire to a piece of tinder. If a part of the apparatus be composed of glass, a flash of light is perceptible, when the stroke of the piston is made with great force and rapidity. The effect of the rarefaction of air in promoting the absorption of heat is well illustrated in Professor Leslie's new method of forming ice. (See our article COLD, for a full account of this process.) In this process, water is placed in a shallow dish over a vessel containing sulphuric acid; the whole being enclosed in the receiver of an air-pump, and a vacuum produced. As the exhaustion proceeds, the quantity of heat abstracted from the water, in order to supply the evaporation, quickly converts the whole into ice. The sulphuric acid, in this case, promotes the effect, by its attraction for the aqueous vapour, which it absorbs as fast as it is generated. A still more striking effect of evaporation has been exhibited by Dr Marcet. He enclosed a quantity of mercury in a bulb of thin glass; this was wrapped up in cotton, which was soaked in the very evaporable fluid, the sulphuret of carbon; the apparatus was then placed under the receiver of an air-pump, and the exhaustion produced, when the mercury was completely frozen: (*Phil. Trans.* 1813, 252.) The ingenious instrument invented by Dr Wollaston, which he called the *cryophorus*, acts upon the same principle. It consists of a glass tube of some length, each extremity of which terminates in a globe about one inch in diameter, and bent at a right angle to the tube; one of the globes is half filled with water, while all the remainder of the apparatus is carefully exhausted of air. If the empty globe be plunged into a freezing mixture, the aqueous vapour with which it is filled is so rapidly condensed, that a portion of the water in the second globe is immediately frozen. *Phil. Trans.* 1813, 71.

The condensible vapours, such as the steam of water, are more expansible than the permanent gases; and it has therefore been conceived, that they will acquire a greater degree of heat when they are permitted to enlarge themselves, by removing from them the pressure of the atmosphere. Mr Watt proved that this was the case, in some experiments which he performed on the distillation of fluids *in vacuo*; a process which has been recommended as an economical project, in consequence of the smaller quantity of caloric which is necessary, under these circumstances, to convert the liquid into a vapour. But this he found was counterbalanced by the greater capacity for heat of the vapour, when in its most rarefied state. By taking off a considerable part of the atmospherical pressure, water could be distilled at a temperature of 100°; but its latent heat then appeared to be 1048°, instead of 840°, the latent heat of steam generated in the atmosphere. With the most perfect vacuum that could be formed, water may be distilled at 78°; but then the latent heat is still farther increased, so as to be about 1300°. Mr Watt estimated, that when water is converted into a vapour, under the ordinary pressure of the atmosphere, it is expanded into about 1800 times its former bulk. *Phil. Trans.* 1784, 335; and Black's *Lectures*, vol. i. p. 190.

Dr Crawford, from his experiments on the specific heat of bodies, was led to form the conclusion, that while their state remains unchanged, their specific heat continues to bear the same relation to their absolute heat. Taking water as the standard of comparison, if we can discover what proportion the specific heat of this fluid bears to mercury at the usual temperature of the atmosphere, we may suppose that the same proportion will exist at all temperatures. Upon this principle was founded the proposal of Irvine, for ascertaining the real zero, or that point of the thermometric scale at which, if it be supposed to be sufficiently extended, bodies would be deprived of the whole of their heat. Thus it had been found by experiment, that the capacity of ice is to that of water as 9 to 10, and the actual quantity of latent heat in water was estimated at 140°; therefore ten times 140°, or 1400° below the freezing point, was supposed to be the temperature at which water is absolutely deprived of all heat (Nicholson's *Chemistry*, p. 16; Crawford *On An. Heat*, p. 435.) The proposal of Dr Irvine is certainly ingenious; but we conceive the problem to be one, which we are still very far from being able to solve with any degree of accuracy. Indeed, the fundamental positions, upon which the whole hypothesis rests, are themselves very dubious, and the experiments which have been performed on the subject by different philosophers, have been attended with such very discordant results, as to show, that either the theory or practice must be extremely imperfect. Besides Irvine's, the principal experiments which were performed, are those of Crawford, Gadolin, Lavoisier in conjuction with Laplace, and Seguin. Of these, Gadolin's seem to have been executed with the greatest care and accuracy, and they approach the most nearly to those of Irvine. His method was to ascertain the capacity of common salt, and also of its solution in water, and then he observed the degree of cold which is produced during the solution. He afterwards examined the quantity of heat which was absorbed by the mutual action of common salt and snow, and the heat extricated by the mixture of sulphuric acid and water; and, by comparing these with the capacity of the bodies before their union, he endeavours, as before, to determine the proportion which their absolute bore to their specific heat. (Crawford *on An. Heat*, p. 457, *et seq.*) Lavoisier and Laplace employed the calorimeter, to measure the quantity of heat disengaged during the mixture of certain substances, comparing this with the capacity of the bodies separately; but it would appear, that their experiments were more liable to inaccuracy than those of Gadolin, and their results are completely at variance with each other: (*Mem. Acad. Scien.* 1780, p. 384, *et seq.*) Mr Dalton has attempted to discover the real zero, by a calculation depending upon his idea of the constitution of an aeriform fluid, and the relation which subsists between its basis, and the caloric which enters into its composition. Without attempting a detail of his hypothesis, we shall merely state his conclusion, that the absolute quantity of caloric in elastic fluids at different temperatures, is in the direct ratio of the cube roots of their bulk at the same temperature: (*Manch. Mem.* vol. v. p. 601.) How far this hypothesis may have any foundation in fact, we do not feel at present competent to decide; but it has been asserted, that experiments made upon this principle at different temperatures, and upon various substances, do not correspond to each other.

From the remarks that have been made, it will appear, that Dr Black's discovery of the existence of what he called latent heat, or of a difference in the capacity of bodies for heat, is a fact completely established by experiment, and one of the most important in the whole range of chemical science. Very different opinions, however, have been entertained respecting the manner of accounting for the fact, and especially the question has been warmly agitated, whether the absorption of heat when a solid is converted into a liquid, is to be regarded as the *cause* or the *effect* of this change of state. Dr Black conceived that it was the cause of the change; that the body in question, as, for example, a portion of ice, being exposed to the influence of caloric, this principle necessarily enters into it, becomes combined with its particles, and is not capable of producing any effect until it be again extricated by the liquid changing its form, or entering into some new combination. Dr Irvine adopted the contrary opinion, and regarded the absorption of heat as the consequence of a change of capacity which the ice undergoes when it is converted into water, which change of capacity necessarily causes it to absorb, and render latent a quantity of heat: (Black's *Lect.* vol. i. p. 194.) Dr Irvine's opinion seems to be supported by the fact, that there actually is this difference of capacity in the substance; but then it does not appear to assign any cause for the change of state which the body undergoes. If we adopt it, we are obliged to assume as a principle, that when the solid is so situated as to receive above a certain quantity of heat, its particles are suddenly forced to a considerable distance from each other, in consequence of something peculiar in its nature and constitution; and that when this separation has been effected, the capacity becomes increased, and the caloric of course absorbed. Dr Black conceived, that the caloric was united to the body by a power similar to chemical attraction; and if we adopt this opinion, it would follow, that at certain temperatures substances acquire different degrees of affinity for heat, and form with these quantities an intimate union, which renders it no longer cognizable by the ordinary means.

4. The last effect of heat, which yet remains for us to consider, is *ignition*. Ignition, or, as it is sometimes called, *incandescence*, is the property which some bodies possess, after being exposed to a high temperature, of becoming luminous, without any chemical change taking place in their composition. In this respect, it differs essentially from combustion, where the body extricates light, but where it is found to have experienced a complete change in its chemical nature. Combustion also differs from ignition in another particular, that, in the former process, the co-operation of the atmosphere, or some other external substance, is necessary; whereas the latter is capable of existing without the intervention of any other body. It has been conceived, that, by proper management, all solids, and even liquids, may be rendered luminous, or brought into the state of ignition; and Mr Wedgewood performed some experiments which lead to the conclusion, that they all undergo this change at the same temperature. Many philosophers have attempted to find out the exact degree at which ignition commences; and although their processes do not furnish precisely the same result, yet they correspond so far, as to render it probable, that it must be somewhere between the 800° or 1000° of Fahrenheit. Mr Wedgewood supposes,

that a body becomes just luminous in the dark at 947°; and that a full red heat, visible in open day-light, takes place at 1077°. According to the intensity of the temperature, the colour of the ignited body is altered. At first, it exhibits what has been called a cherry red; afterwards, the red acquires a yellowish tinge; and, lastly, all colour disappears, and we have only a brilliant white light: (*Phil. Trans.* 1784, p. 370.) It is generally supposed, that aeriform fluids are not capable of being ignited. A quantity of air, heated to such a degree that a piece of metal, when suspended in it, was rendered luminous, was itself quite invisible.

Respecting the cause of ignition, two opinions have prevailed; the first, that light is a modification of heat, and that, at a high temperature, the one becomes converted into the other; the second, that light actually exists as a component part of different bodies, and that, when the body is strongly heated, the light is propelled or disengaged from it. It is perhaps impossible to adduce any direct arguments in favour of either of these hypotheses; but the general relations of heat and light are in many respects so different from each other, that we are induced to adopt the opinion which supposes them to depend upon the agency of principles essentially dissimilar. This, however, we advance as a doctrine which must be confirmed or refuted by future observations and experiments.

## SECT. III.

### *Sources of Heat.*

After having described the properties and effects of heat, we must now give an account of the sources whence it is derived. Those that are usually enumerated are the following: the rays of the sun,—combustion,—a change in the capacity of bodies, and their chemical union,—the mechanical means of producing heat, as friction, percussion, and condensation,—and, lastly, the electric and galvanic discharge. The great source of heat to our world, and probably to the rest of our solar system, is the radiant caloric which is projected from the sun. When a sufficient number of rays are collected into one spot, either by a concave mirror, or by a convex lens, the most powerful heat is excited of which we have any conception; and we are capable of producing effects by it, which we cannot otherwise accomplish. The effect, however, is necessarily confined to a small spot; and therefore it can only be employed in refined operations of analysis, or for the purpose of delicate philosophical processes. It would appear, from an experiment of Rumford's, that the great heat excited in these cases, depends entirely upon the concentration of the rays, and not upon any change in their nature; because, when he directed a certain portion of the sun's rays against a substance adapted for absorbing them, the total amount of heat communicated to it was the same, whether the rays were received on the surface in a diffused state, or brought into a small focus.

The most important supply of heat which we have it in our power to produce at pleasure, is that which depends upon combustion. Nearly all the heat which we employ for domestic and manufacturing purposes, proceeds from the burning of fuel; an operation of a strictly chemical nature, in which a union takes place between the fuel and the oxygen of the atmosphere, the result of which is a combination of the combustible matter with the oxygen, and the extrication of a quantity of heat and light. It has been a much controverted question, whence does the heat proceed in this operation? The discussion is strictly chemical, and must therefore be dismissed with a few observation. A part of the heat liberated probably depends upon the less capacity of the product of combustion, than of the substance supporting it, *i. e.* of carbonic acid, than of oxygen and carbon separately; but there are instances in which the quantity of heat extricated appears to bear no proportion to the bulk of the materials consumed, or of carbonic acid formed; and hence we are induced to conjecture, that heat exists as an ingredient in combustible substances, and is disengaged from them in consequence of the changes of composition that take place. It has been supposed, that, besides what necessarily belongs to it as a gas, oxygen contains caloric as one of its constituents, which is liberated by a kind of precipitation; and the phenomena which attend the detonation of gunpowder lead us to conclude, that caloric also enters into the composition of the nitric salts, and others that possess similar properties. Of the heat produced by a change of capacity, in consequence of an alteration in the state of a body, or of new combinations, we have already spoken at sufficient length in the last Section.

There are few subjects connected with heat which are more inexplicable, than the manner in which it is generated by those means which appear to act mechanically, as friction, percussion, and condensation. The latter of these operations, condensation, has already come under our notice, in treating of the change of capacity which gases experience, according as their particles are compressed together, or allowed to expand themselves; and the same effect, at least to a certain extent, seems to follow from the condensation of solids. A very familiar instance of this occurs in the heating of a bar of iron merely by repeated hammering, where, by a few smart blows on the anvil, the smith is able to produce a sufficient extrication of heat to kindle a match. It is, however, known that iron does not possess this property of producing heat by being hammered, unless it has been previously heated for some time in the forge, and suffered to cool slowly in the air; and that, after it has been hammered, and lost part of its heat, its texture seems to become harder, and it is rendered less flexible than before the operation. The rolling out of metals into thin sheets or leaves, and the drawing of fine wires, likewise excite heat, which is to be referred to the compression the substance undergoes during these various operations. In all these cases there is some reason to suspect, that the bodies have had their capacity diminished, and that the heat, which becomes sensible, is to be assigned to this change. The effect of percussion may perhaps be explained on the same principle, as we may conceive, that, whenever percussion takes place, it must cause a proportionate condensation. It is to be remarked, that liquids seem to be incapable of extricating heat, either by any attempts at condensation, or by any kind of percussion; and as they are supposed to be nearly incompressible, we may conceive that their capacity is not liable to be affected by these means. Gases, however, which are readily compressible, are capable of having heat extricated from them, to a considerable amount, by condensation; and here we suppose that their capacities are changed, and in this way we account for the effect.

This mode of reasoning will not, however, apply to the extrication of heat which is caused by friction. The power of friction in producing heat, in various mechanical operations, is the subject of daily observation, and, if not prevented by different expedients, produces the most fatal consequences. The motion of wheels, and pulleys upon their axes, excites a degree of heat, which would quickly set fire to the machinery, was it not prevented by the application of different lubricating substances, which diminish the friction, by interposing between the hard surfaces a body which readily yields to the impression. The quantity of heat generated in these cases is so considerable, and seems so disproportioned to any effect that can be attributed to a change either in the capacity or chemical nature of the body employed, as to have been always regarded a serious objection to the hypothesis, which regards heat as a substance capable of being transferred from one body to another, like other material agents. The objection was reduced to a more palpable form by Rumford, who estimated the exact amount of the heat which was produced by a certain degree of friction, where all other extraneous sources for its admission were carefully guarded against. A piece of brass was fixed in a machine used for boring cannon, and a steel cylinder was pressed against the brass, with a weight equal to 1000 lbs. and then made to revolve on its axis with a given velocity. After some preparatory experiments, the apparatus was all inclosed in a vessel of water; and after the friction had been kept up for some time, the water was actually brought to the boiling heat. Here a very considerable quantity of heat was liberated, and the only mechanical change effected upon the materials was, that a quantity of brass turnings were formed; but neither these, nor the cylinder itself, appeared to have experienced any change, except a slight degree of compression. Rumford found by experiment, that the capacity of these turnings would not be affected by the operation; and the effect of the compression, which the metal had experienced must have been very inconsiderable. Yet the power of the substance to extricate heat was apparently unlimited; for there is no reason to suppose that any thing like exhaustion was produced, or that the apparatus would not have continued to evolve heat, until its texture had been destroyed, by the brass being all reduced into small fragments. (*Essays*, vol. ii. p. 469, *et. seq.*) Upon this experiment we shall offer some remarks in the next Section, where we treat upon the nature of heat.

The heat excited by the electric or galvanic shock has been commonly referred to a mechanical cause, although upon this point, a considerable diversity of opinions has prevailed. The effect, however, is well known to be very powerful, perhaps even more so than that produced by the convex lens; but it is still more confined as to the extent of its operation. If the two wires, in the interrupted galvanic circuit, be brought nearly into contact, and any substance, in very minute quantity, be placed upon them, it may be subjected to a temperature more intense than can be produced in any other manner; and by this means bodies have been burned or fused that had been before completely intractable. Whether in this operation the heat is, as it were, merely forced out of the wire by the commotion which its particles experience from the passage of the galvanic influence; or whether, as has been supposed, under certain circumstances, heat and electricity can be converted into each other, or may be separated by a kind of decomposition, are intricate questions of theory, upon which it seems at present beyond our power to decide, and which must depend very much upon the opinion that we entertain respecting the nature of heat. The simple facts, however, independent of hypothesis, seem to indicate, that heat and electricity are distinct from each other, whether they are to be regarded as species of subtile fluids, or only as properties of matter.

## SECT. IV.

### *On the Nature of Heat.*

After having made ourselves acquainted with the properties that are usually ascribed to heat, with the effects which it produces, and with the sources whence it is derived, we shall be more competent to enter upon the investigation of its nature. This has been a subject of discussion from the earliest period of philosophical inquiry, and is yet far from being determined; for although the most generally received opinion is in favour of its being a substance, capable of a separate existence, and possessed of a material, although very subtile nature; yet there are, on the contrary, many eminent men who regard it as merely a property, necessarily attached to other matter, and arising from some peculiar modification or affection of it.

The illustrious Bacon adopted this latter hypothesis, and conceived that heat depended upon a vibration of the particles of matter; an hypothesis which he endeavoured to substantiate by shewing, that whatever excited temperature, tended to produce a motion in the particles of the heated body. His description of this peculiar action is, that "heat is an expansive motion, restrained and resisting in the minute parts;" a phrase which, if expressed in modern language, would probably signify a reaction between the expansive power of heat, and the attractive force of the particles of matter towards each other. The idea of Bacon, that heat depends upon a vibratory motion among the particles of matter, received the powerful sanction of Boyle and Newton. As, however, observations on the phenomena of nature were multiplied, and especially as chemical science advanced, the hypothesis which considered heat as merely consisting in motion of the particles of matter, appeared less easy to reconcile with the new discoveries, and consequently a different doctrine was advanced, in which the effects of heat were attributed to a species of subtile fluid, of a proper material nature, although differing, in many important particulars, from any other kind of matter. The first writer who distinctly maintained this doctrine, and applied it in a philosophical manner to the explanation of facts, was Boerhaave; and it was, for the most part, embraced by the French. The general impression that was produced by Dr Black's discovery, was much in favour of the materiality of heat; and indeed it seems very difficult to imagine, how a mere property can be so exactly measured, and can be transferred from one body to another, at one time rendered latent, and again coming into action, without its quantity being either increased or diminished. The successive discoveries of Crawford and Irvine, together with the whole fabric of the Lavoisierian chemistry, strongly favour the same opinion; so that, in the present day, it must be regarded as the hypothesis which is by far the most generally received. It has, however, been zealously opposed by Rumford; and the experiments on the heat excited by friction, of which we have given an account, were brought forward as an unanswerable objection against it. Our limits will not permit us to take a very full view of all the arguments that have been urged on both sides of the question; but we must endeavour to give a sketch of some of the principal points that have been adduced by the advocates of each of the opinions. It will scarcely be denied, that if we admit the existence of a subtile elastic fluid, the particles of which are endowed with a repulsive power, which tends to unite itself to all kinds of matter, to insinuate itself into their pores, to produce their expansion, and, if added in sufficient quantity, to impart to them its own elastic nature, we are in possession of an agent, which very conveniently explains a great variety of phenomena; for, excepting the experiments of Rumford on friction, and others of a similar nature, we do not know of any facts which are averse to the supposition, or which are not better explained on this than on any other that has been adduced. It must, however, be admitted, that it is merely an hypothesis; and as there is no direct experiment which proves the existence of this subtile elastic fluid, it must be abandoned, if there be any single phenomenon which is absolutely irreconcilable to it. But before we can allow this to be the case, in the present instance, it is necessary to shew, that our acquaintance with the phenomenon in question is complete; that we thoroughly understand all its relations, and are competent to decide upon the connexion which it has with all the other actions to which it may be referred. Now we believe that few persons will assert that this is the case; on the other hand, we conceive every one will admit, that any attempt to explain the intimate nature of the motion supposed to produce heat, and the manner in which vibrations can excite a sensation such as that which we refer to this principle, must be a most arduous task. Still more so will it be to explain, how it can be the immediate cause of liquidity and of elastic fluidity; how it can be transferred in definite quantities from one body to another; how this can be done even while it is lying dormant, or while we have no proof that the motion actually exists. In short, we shall find, that the hypothesis of vibrations is far from being unencumbered with difficulties; and that we have only removed one, to become involved in a much greater number. Besides, although we have admitted that there is no direct experiment to prove the independent existence of heat, or at least none against which some exception has not been taken; yet there are facts brought forward, perhaps as decisive on this side of the question, as those respecting friction are on the other. We refer to the transmission of heat through a vacuum. Pictet proved that this takes place in the vacuum of the air-pump; and Rumford, the great advocate for the immateriality of heat, has shewn that it is capable of passing even through the Torricellian vacuum. There seems no method of reconciling this fact with the hypothesis, except by taking for granted the existence of some kind of vapour or elastic fluid, along which it is propagated; a supposition equally gratuitous, and equally unsupported by direct and independent facts as that for which it is substituted. Indeed, the same remark may be applied to all the phenomena in which the radiation of heat is concerned; it seems extremely improbable, if not impossible, that these rays are carried along by the air, even when near the surface of the earth, and they must necessarily traverse an immense track totally devoid of air. If we, in this case, suppose the existence of a subtile medium, invented for the purpose of carrying them through space, we are here, as in the former instance, creating an agent at least as hypothetical as the matter of heat. Upon the whole, we are strongly inclined to the opinion which regards heat as an elastic fluid, of a proper immaterial nature, although of extreme subtilty, the particles of which are repulsive with respect to each other, but are attracted by other bodies, with different degrees of force, according to their respective nature.

Before we conclude this discussion concerning the immateriality of heat, it will be proper to notice the experiments which have been made, in order to ascertain whether it be actually possessed of gravity, or rather, whether its weight can be measured by a balance. The best contrived experiments of this description were those of Fordyce. He very carefully weighed a quantity of water, froze the water, and then again weighed it. Now he argued, that in this process, the water must have parted with the latent heat which maintains it in the liquid form; so that if heat be a ponderable substance, it might be expected that the ice would exhibit a diminution in its weight, equivalent to that of the caloric which had escaped. The result, however, did not correspond with this idea; and indeed, in some of the most accurate trials, it seemed as if the body that had parted with its heat had even acquired a slight addition of weight. It is, however, generally admitted, that no decisive conclusion can be drawn from such experiments; and that, from the conception that we have of the extreme tenuity of the particles of heat, it is not probable, that any portion which we can have it in our power to impart to a body, could be detected by the instruments that we employ in ascertaining the weight of bodies. Our preference, as we stated above, is certainly in favour of the hypothesis of the materiality of heat; because we think it explains the phenomena in general with greater facility, and is encumbered with less difficulties than the immaterial hypothesis. Yet we must remember, that it is not decisively proved by any direct and unexceptionable experiments; and it must also be acknowledged, that it has not received the sanction of some eminent philosophers, both at the revival of letters and in our own times. We have already mentioned the opinion of Rumford; and Professor Leslie, to whom science is so peculiarly indebted for his numerous experiments and discoveries on the subject of heat, also adopts the hypothesis, which ascribes its effects to a certain motion among the particles of bodies. He conceives that the propagation and transmission of heat, is very similar to that of sound, and that it in fact consists in certain aerial undulations. A hot body communicates a portion of its heat to the contiguous stratum of air; this immediately expands, and by this expansion, a vibration is excited in the adjoining stratum; this is propagated to the next, and so on until the equilibrium is produced. The passage of heat is therefore of the same velocity with the undulation of the air, or rather is identical with it; and according as the surfaces of bodies act upon the air in contact with them, so will they radiate heat with greater or less readiness. The facility of radiation is supposed to be principally owing to the approximation of the air to the surface; those bodies radiating the best, to which the air comes into the closest contact. This view of the subject explains why the best radiators should likewise be the best absorbers of heat; and it is also supposed to afford a reason for the effect of roughening the surface, or covering it with substances which destroy its polish. Professor Leslie seems to have advanced his hypothesis, merely as a convenient manner of accounting for some of his own experiments; he has not stated it in such a way as to apply to all the phenomena of heat, nor has he attempted to reconcile it with the experiments of Herschel, and others which appear decidedly adverse to it. Indeed, we much doubt whether it can be adapted even to some of his own experiments on the radiation and reflection of heat; for it must be supposed, that the undulations of the air are propelled from the surface of bodies, impinge upon others, and are again reflected, exactly as they radiate heat, with the same velocity, and in the same direction; a circumstance which we apprehend it would be extremely difficult to prove. It may be farther remarked, that although Professor Leslie's hypothesis supposes that the undulations of the air are the cause of heat, or that which produces the phenomena in question; yet there are many expressions which would seem to imply, that this heat is something distinct from the undulations themselves, and that the heat is transferred or transmitted from one wave to the other, not that the waves are themselves the actual cause of the effect. The farther consideration of this question would involve us in a discussion that would exceed the limits to which we are necessarily restricted.

In the former part of this article we alluded to the chemical properties of heat, but we proposed to defer the consideration of them until we had made ourselves more fully acquainted with its nature and its effects. On this subject there are two points to be determined: first, Does heat possess any properties, or any relation to other bodies, which can strictly be called chemical? And secondly, What are these relations? When we speak of a substance being possessed of chemical properties, we mean, that by its being separated from or added to another substance, the two substances, in the case of their decomposition, or in the other case, the compound of the two, manifest different chemical relations from those which they possessed before the operation. By some philosophers it has been supposed that this change takes place with respect to heat, that when it enters into combination with a body, as for example with oxygen, and forms oxygen gas, a compound is produced, possessed of new properties that are not merely mechanical, while at the same time the heat itself has entirely lost its former qualities by its union with the oxygen, and like other bodies, after a chemical composition, has imparted to the compound properties quite different from its own. If we again decompose the oxygen gas, as by uniting its base to carbon, the heat is precipitated, and resumes all its former properties, which had been entirely destroyed, or rendered latent, while it remained in the combined state. But although there may appear to be a considerable degree of plausibility in this method of reasoning, it has not been generally acquiesced in. The great objection which has been urged against the opinion, that heat unites chemically to bodies, is, that it may, in all cases, be separated from them, merely by a reduction of temperature, without the intervention of a more powerful affinity; a circumstance which is conceived to be essential to a proper chemical decomposition. With respect to the new properties which heat imparts to other substances, by its union with them, these have been said to be merely mechanical, or to be such as must necessarily result from these particles being placed at a greater distance from each other. As to the heat itself, there is undoubtedly something more analogous to chemical union, in the changes which it experiences; as by entering into combination with other bodies, its characteristic properties are all destroyed. Yet this involves a discussion rather about words than ideas, and in a great measure depends upon the meaning which we attach to certain modes of expression. The fact is, that heat seems to have electrive attractions for different bodies, independent of any of their relations to other substances; that it combines with them, and produces a change in their state, which perhaps may be regarded as merely mechanical; but that by these combinations its action is destroyed, and it no longer possesses the properties it previously exhibited. Upon the whole, we are inclined to the opinion, that the effects of heat are not referable to the usual laws of chemical affinity, but must be referred, partly to those of mechanical impulse, and partly to what we may denominate specific action, *i. e.* an action peculiar to itself, and essentially different from what we can observe in other natural objects. See our articles COLD and EXPANSION. (α)

## APPENDIX.

In the preceding article, we have given an account of the experiments of Dr Herschel, Sir H. Englefield, and M. Berard, from which it follows, that there exists beyond the red extremity of the spectrum a set of invisible rays, which affect the thermometer more powerfully than even the red light of the spectrum.

These experiments were repeated, under the most favourable circumstances, by our celebrated countryman Sir H. Davy, who favoured us with an account of them when we had the pleasure of seeing him at Geneva. Availing himself of the fine climate and the serene sky of Italy, he resolved to inquire into the cause of the difference between the results obtained by Dr Herschel and Berard; the former having placed the point of maximum intensity beyond the red rays, while the latter found the heat greatest within the extremity of the red space. It occurred to Sir Humphry, that thermometers with circular balls of the size used by Berard must necessarily shew the maximum of heat to be within the red space, as a cooling agency must always be exerted by that part of the bulb which is out of the limits of the calorific rays; and hence the diminution of temperature which this occasioned would compensate for the greater effect produced by the invisible rays. In order to remove this source of error, Sir H. Davy employed extremely slender thermometers, not more than $\frac{1}{12}$th of an inch in diameter, with very long bulbs filled with air confined by a coloured fluid; and in this way the bulb was affected only by the invisible rays. The general results of these experiments, which were repeated also at Geneva, confirmed those of Dr Herschel, and may be considered as removing the objection of Professor Leslie, that, in our climate particularly, there must always be a concentration of extraneous light beyond the red extremity of the spectrum.

We regard it, therefore, as a point established in physics, that there is a distinct effect produced upon the thermometer beyond the red extremity of the spectrum; but we cannot admit for a moment the conclusion which has been universally drawn from it, that it is produced by a separate set of heat-making rays, refracted by the prism, and having a greater refrangibility than red light. Dr Herschel has attempted to prove that invisible culinary heat is also susceptible of refraction like the invisible rays, and M. Prevost and M. Delaroche have likewise endeavoured to shew that this kind of heat is capable of permeating glass. We have no doubt that this opinion will be found to be erroneous, and we think it is demonstrated,* that invisible culinary heat is incapable of refraction, or of permeating glass like light, and hence we cannot suppose that the invisible rays of the sun are capable of being refracted by glass. If this shall be found to be the case, it will follow that the invisible heat of the sun is a substance possessing properties essentially different from those of invisible culinary heat. As radiant heat, therefore, possesses very different properties from light, we think it will be found, that light, like all other matter, whether gaseous, fluid, or solid, is capable of being heated, and that the solar rays are nothing more than *heated light*. Hence the least refrangible rays, having the greatest velocity, or momentum, will produce the most powerful calorific effect. We shall have occasion to resume this subject in another part of our work. See OPTICS. ED.

* See *Phil. Trans.* 1816, p. 105.

# INDEX.



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HEBREWS. See Jews.

HEBRIDES. See Argyleshire, Arran, Bute, Staffa, and Scotland.

HEBRIDES, New, a cluster of above twenty islands in the south Pacific Ocean, extending about 375 miles in a direction from N. W. to S. E. and situated from 14° 29′ to 20° 4′ S. Lat. and 166° 41″ to 170° 21′ E. Longitude.

The appellation which is now bestowed on this group, results from its complete recognition by Captain Cooke in 1774. So long ago as the year 1606, the Spanish navigator Quiros landed on the most northern island, which he seems to have considered as a continent, and called it *Tierra Austral del Espiritu Santo*, or the southern land of the Holy Ghost. Bougainville, in his voyage of discovery in 1768, found it an island; and after a partial examination of the group, named it the Archipelago of the Great Cyclades; but almost all geographers seem inclined to admit the nomenclature of Captain Cook, who was occupied 46 days in the survey; and considering these islands the most western of the Pacific, he named them Hebrides. Nevertheless, Fleurieu questions Captain Cook's right to change the appellation of Great Cyclades, bestowed by Bougainville, and expresses a hope that the name given by both will be superseded, by restoring that of Quiros.

These islands are of unequal dimensions, and separated from each other by channels of different breadth. But the following list, obtained from collating the narratives of successive navigators, will more briefly explain these peculiarities, making some allowances for the whole not being seen exactly under the same aspect.

Pic d'Etoile, 14° 29′ S. Lat. 168° 9′ E. Long.—Tierra Austral, 66 miles long, 36 broad. St Bartholomew.—Isle of Lepers, 54 to 60 miles in circuit, 15° 20′ S. Lat. 168° 31′ E. Long. Aurora Island, 36 miles long, 5 broad, 15° 6′ S. Lat. 168° 24′ E. Long. Whitsuntide Isle, 33 miles long, 8 broad, 15° 45′ S. Lat. 168° 28′ E. Long. Mallicolo, 54 miles long, 24 broad, 15° 50′ S. Lat. 169° 38′ E. Long. Ambrym, 60 miles in circuit, 16° 15′ S. Lat. 168° 20′ E. Long. Apee, 60 miles in circuit, 16° 42′ S. Lat. 168° 36′ E. Long. Paoom, 15 miles in circuit. Three Hills Island, 12 or 15 miles in circuit, 17° 4′ S. Lat. 168° 32′ E. Long. Shepherds Isles. Monument. Two Hills.—Montague Isle, 9 miles in circuit. Hinchinbrook Isle, 14 miles in circuit. Sandwich Island, 75 miles in circuit, 17° 40′ S. Lat. 168° 30′ E. Long. Erromango, 90 miles in circuit, 18° 48′ S. Lat. 169° 20′ E Long. Tanna, 72 miles in circuit, 19° 30′ S. Lat. 169° 38′ E. Long. Irronan.—Immer, 15 miles in circuit. Annatom, 30 to 36 miles in circuit, 20° 3′ S. Lat. 170° 5′ E. Long.

Some of these islands contain volcanoes, such as Ambrym and Tanna; that on the latter throws up prodigious columns of fire and smoke, attended with loud explosions at frequent intervals, and huge stones are sometimes seen in the air. Native sulphur is found on the island, and nephitic vapours arise from the ground. Quiros affirms that he and another Captain saw silver and gold on the Tierra Austral; but this has not been confirmed; nor are we particularly acquainted with the mineralogy of the New Hebrides, unless in their exhibiting volcanic products, red ochre, and chalk. Hot springs issue from the rocks of Tanna, raising the thermometer to 202°.

Vegetables grow throughout these islands in great profusion and variety. Quiros, who wrote a recommendatory memoir to his own court, regarding the island upon which he landed, describes it as of greater fertility than Spain; and later navigators have remarked, that the hills of other islands were covered with woods to the very top. Trees occur 150 feet high. Figs, nutmegs, and oranges, which Captain Cook found no where besides, grow here, as well as cocoa-nuts, bananas, the bread-fruit, and the sugar-cane.

Fish are numerous on the shores, but many are poisonous; and the crews of different ships have suffered severely, though not fatally, from having fed upon them.

Large and beautiful parroquets, of black, red, and yellow plumage, are seen on the islands; and, among other birds, that species of pigeon which feeds on the nutmeg, and is described by Rumphius as disseminating the real plant in the Spice Islands. Quiros speaks of goats; but the only quadrupeds observed by later visitors are hogs and rats. No dogs have been observed by strangers on any of the islands visited by them; nor have the natives any name for the animal, which shews that it is unknown.

The New Hebrides are evidently inhabited by different races of people, whose origin some navigators are inclined to derive from Papua or New Guinea. None possess that symmetry and stature seen in other parts of the Southern Pacific Ocean. Those of the Tierra del Espiritu Santo seem more robust and better formed than most of the rest. Bougainville describes the natives of Lepers Isle as small, ugly, and ill made, and the few women observed were altogether as disgusting as the men. The inhabitants of Tanna are of middle size, their limbs well made and rather slender; and some are tall, stout, and strong. Their features are large, the nose broad, eyes full, and in general with an agreeable expression. The hair is black; but, in several instances, with brown or yellow tips. Brown and reddish hair has appeared here and elsewhere; but it is frizzled and woolly for the most part. The women of the Mallicolese present the most disagreeable features of any seen in the South Seas; and the daubing of their whole bodies, or covering their heads with the orange powder of turmeric root, has a dirty appearance. All the inhabitants of the group are of a deep chesnut brown colour, and their skin is uncommonly soft and smooth to the touch. M. de Bougainville says, those of Lepers Isle are of a black or Mulatto colour, the hair of some being a yellow wool, which, it is not unlikely, might have been the consequence of disease, as he gave the island its name from the inhabitants being much afflicted with leprosy.

The language of the New Hebridians is different from that of all the other tribes of the South Sea; it abounds in consonants, and even in the united duplication or triplication of them. But they have a remarkable facility in understanding and imitating strangers, and have a very quick and ready apprehension. Their admiration is expressed by hissing like a goose. They are singularly honest, unlike all savages; and most of them have a manly, good natured, open aspect.

In general these people go nearly naked; boys and girls absolutely so. The greater part of the women have a short petticoat; many only a cord about the body, with a bunch of straw. A decided characteristic of the Hebridians consists in a rope tied round the middle, which, being put on at a very early age, makes a deep groove, dividing the belly as it were into two parts, so that the one almost overhangs the other. Captain Cook, in describing the Mallicolese as "the most ugly and ill-proportioned people I ever saw, and in every respect different from any we had met with in this sea," and specifying "their long heads, flat faces, and monkey countenances," continues, "but what most adds to their deformity, is a belt or cord which they wear round the waist, and tie so tight over the belly, that the shape of their bodies is not unlike that of an overgrown pismire." They are less acquainted with the art of tattooing than many other islanders, and they obtain a similar effect by incisions of the flesh, producing elevated scars, which resemble external objects. A number of personal ornaments are employed by them, more generally by the men than the women. The face and body are frequently painted black, brown, or red; and bracelets, ear-rings, or a bone through the nose, are worn among both sexes. The women and children are in general shy; the former are held in subserviency by the men, and condemned to the more laborious operations.

The disposition of the Hebridians seems to be courteous and liberal; they are not equally prone to revenge injuries, as many other savages, and are more willing to be satisfied. The English circumnavigators were treated with great hospitality, and it seems doubtful in any misunderstandings which was the aggressor. M. de Bougainville considered an attack on him at the isle of Lepers, followed by a flight of arrows, as the consequence of premeditation. They are evidently often at war, from the number and variety of their arms; and during the visits of strangers, they are always on the watch, keeping their bows constantly bent. These are very strong and elastic; made of the best club wood, and highly polished. The arrows are made of reeds nearly four feet long, and pointed with a piece of hard brittle black wood, twelve or fifteen inches in length. Some have three points for shooting birds, others are discharged at fish, and pointed with a bit of bone two or three inches long. They have also clubs, spears, and darts; the first of different sizes and shapes, from two feet and a half in length to six feet, and are slung from the right shoulder by a rope. Their arrows are shot with great force and precision to the distance of 8 or 10 yards, but are little to be dreaded at 25 or 30. Their darts also are thrown with much power and accuracy to a short distance. Some arrows exhibit a greenish gummy substance on the points, which the natives affirm is poison; but in experiments made with it by the English on animals it was not fatal.

The arts are in a very low state; navigation is little understood, and fishing seldom resorted to. No fishing tackle whatever was observed by the English in the largest islands; and their canoes consisted of several pieces of wood clumsily sewed together. Only 14 belonged to the whole island of Mallicolo. However, that of Immer is chiefly inhabited by fishermen, and the various canoes are from 20 to 30 feet long, but all of indifferent workmanship. The dwellings on shore are miserable huts of rude construction, or, properly speaking, large sheds about 35 feet long, open at both ends, and of which the roof, ridged at top, reaches to the very ground. Captain Cook compares them to a house without walls. They seem to contain no furniture except mats, palm leaves, and dry grass, which cover the floor. The quality of the climate is such that the inhabitants can almost dispense with artificial shelter, and all their pursuits concentrate in warfare and in procuring subsistence.

A large portion of the New Hebrides is well cultivated. Whole islands are covered by woods and divisions, indicating much industry, and a correct notion of property; and extensive grounds are laid out in regular plantations of the sugar-cane, bananas, and plantains, all kept in good order, and sometimes protected by stone fences two feet high.

It is not ascertained that the natives have any religion, or any form of government. They offer the branch of a tree as a sign of pacification, and pour water on their heads, as indicating a desire for conciliation, or in token of contrition. They dance round fires to the sound of drums; and these are heard in the woods on occasions of alarm. Their music is of a lively turn; they have pleasing airs embracing a considerable compass, and it is said they sing in parts,—a fact worthy of being ascertained, as the music of savages is so limited. An instrument consisting of eight reeds, like the syrinx or Pan's pipe, and extending throughout an octave, has been seen here.

It is singular, that in some of the islands, as Tanna, iron is of no value, while in others it bears the highest price. Looking-glasses prove the source of great amusement to the natives, and their complacent self-contemplations have induced their visitors to affirm that they are extremely conceited.

All those who have reached the New Hebrides bestow the warmest commendations on their soil, climate, and productions. The later navigators have thought that a settlement might be profitably made on Sandwich Island; and Quiros, two centuries ago, sought to interest the avaricious court of Spain, by pointing out the benefit which would result from one on the Tierra Austral del Espiritu Santo. "In a word," he says, "the union of so many advantages would produce such power and riches, that these territories would not only support themselves, but afford an overplus for the assistance of America, aggrandize your majesty's dominions in general, and very speedily elevate Spain to the highest degree of prosperity. All this I will undertake to answer for, if I shall be assisted and supported in my enterprise." The north side of the island is penetrated by a capacious bay, which he considers capable of being a harbour for 1000 vessels; and after acquainting his sovereign, that, amidst its numerous properties, "the dawn is ushered in by a most delightful concert of millions of birds from the forests wherewith the shores are shaded, and that every evening and morning the air is perfumed with the odours of all species of flowers intermixed with those of aromatic plants," he concludes with these words: "Finally, sire, I can with confidence assert, that this harbour, which is situated in 15° 20′ South Latitude, presents the greatest natural advantages for the establishment of a large city and a numerous colony."

None of these anticipations, however, have been realised, and the New Hebrides, yet unoccupied by Europeans, are only resorted to, as we learn, at rare intervals, for cargoes of wood from their forests.

Navigators have been so much mistaken regarding the population of the South Sea Islands, as to warn us against listening to conjectures. The inhabitants of Mallicollo were computed at 50,000 in 1773, and those of Tanna at 20,000; but we cannot forget, that while about the same time the population of Otaheite was supposed above 200,000, calculations of tolerable accuracy reduce it at this day to 5000; towards which, however, several causes, perhaps unknown to the New Hebridians, may have contributed. See *Torquemada Monarquia Indiana*, t. i. p. 738. De Brosse's *Navigations aux terres australes*, t. i. p. 306. t. ii. p. 243, 348. Bougainville's *Voyage*, p. 242. Dalrymple's *Historical Collection*. Cook's *Second Voyage*. Forster's *Voyage*, vol. ii. (*c*)

HECLA. See Iceland.

HEDGE. See Agriculture.

HEDJAS. See Arabia.

HEDWIG, John, a celebrated botanist, was born at Cronstadt in Transylvania, on the 8th of October 1730, and was the son of one of the magistrates of that town. His love of botanical pursuits shewed itself at an early period; and while his school-fellows were busy with their amusements, Hedwig was actively employed in collecting wild plants, and transplanting them to his father's garden. After studying four years at the public school of Cronstadt, he was enabled, notwithstanding the loss of his father in 1747, to go to the university of Presburg to continue his studies. He remained here two years following his medical pursuits, and then went to Zittau to attend the lectures of Gerlach. In 1752, he entered himself as a student at the university of Leipsic, and attended the lectures on medicine, philosophy, and mathematics. Here he gained the particular friendship of the celebrated Ludwig; and such was the opinion entertained of him by Bose, the professor of botany, that in 1756 he took him into his own house, gave him the charge of his garden, and allowed him, during three years, to attend for him at the hospital. Upon the completion of his studies, he was naturally anxious to settle as a physician in his native place; but upon applying for license to the magistrates, he was mortified to find that no physicians could practise in Transylvania, who had not been members of the university of Vienna. His friend Bose, however, having advised him to commence practice in some small town in Saxony, he presented his dissertation *sur l'emploi des emetiques dans les fievres aigues*, and was admitted doctor of medicine. Having a friend resident at Chemnitz, he fixed upon that town, where he settled, after marrying Miss Sophia Teller, a lady from Leipsic. Hedwig now devoted his mornings to the collection of plants, and his evenings to their examination, while the rest of the day was employed in his professional pursuits. The cryptogamic plants particularly attracted his attention; and having had occasion to write to the celebrated Schieber, who was then publishing the Flora of Leipsic, for the explanation of some difficulties, a correspondence immediately commenced between them, and Hedwig received from his friend several books, a single microscope, and afterwards a compound one made by Rienthaler the optician. By means of this instrument, on which he made some improvements, he was enabled to determine the male and female flowers of the mosses. See our article Botany, and Musci.

His wife, who had brought him nine children, died in 1776; and though he was oppressed with grief at such a loss, yet as he was unable to continue his pursuits, and attend to the education of his six surviving children, he yielded to the advice of his friends, and married, in 1777, Miss Salzberger of Leipsic. In 1779, he published at Leipsic, in a German periodical work, his great discovery, under the title of "Observations on the true parts of generation in Mosses, and on the Multiplication of Mosses by seed." At the urgent desire of his wife, who considered his talents as lost at Chemnitz, he removed to Leipsic in 1781, and in the following year he published his work, entitled *Fundamentum Historiæ naturalis Muscorum frondosorum*, illustrated with 20 coloured plates.

The Petersburg academy having offered a prize of 100 gold ducats, for a determination of the parts of fructification of the cryptogamic plants, Hedwig sent a large treatise on the subject, which gained the prize, and which was published at St Petersburg, in 1784, under the title of *Theoria generationis et fructificationis plantarum Cryptogamicarum Linnæi*. A new and enlarged edition of this work afterwards appeared in 1798.

Hitherto Hedwig had lived in a state of obscure poverty; but his talents were now about to receive their proper reward. In 1784, he was made inspector of the military hospital at Leipsic, and in 1786 he was appointed professor extraordinary to the faculty of medicine. In 1789, Frederick Augustus, elector of Saxony, nominated him professor of botany, and superintendant of the public garden, and at the same time gave him apartments at the academy.

Having been occupied more than 35 years in the study of nature, Hedwig published the results of his observations in the following treatises.

1. A Treatise on the origin of the parts of fructification, in which he shows that the stamens and pistils are not produced by the pith, as Linnæus believed, but by the same vessels as the other parts of the plant.
2. A Memoir on the Cotyledons.
3. A Dissertation on Bulbiferous Plants.
4. A Memoir on the Organs of Transpiration in Plants.
5. An Examination of the distinctive characters of Plants and Animals.
6. An Answer to certain Questions proposed by Dr Arthur Young, on the Irrigation of Meadows with spring water.
7. A Dissertation on the Origin of the Vegetable Fibre.
8. Observations on the use of the Leaves in Plants.
9. A Memoir, in which, after having described the sexual organs of several *Cucurbitacea* at the time of fecundation, he considers the manner in which the pollen impregnates the ovaries, and the changes which this phenomenon produces in plants.
10. Notes on the Aphorisms of Humboldt, in which he lays down several principles of vegetable physiology.
11. Lastly, Considerations on the present and future state of the Science of Botany, and on the best means to be pursued in the study of it.

Between the years 1787 and 1797, Hedwig published his great work, entitled *Descriptio et Adumbratio Microscopica analytica Muscorum frondosorum, nec non aliorum Vegetantium, classe Cryptogamica Linnæi novorum dubiisque nexatorum*, in 4 vols. folio, the first of which appeared in 1787, and the last in 1797. This work contains an analytical description of 148 species of mosses, and 50 other cryptogamic plants, all of which were examined with the microscope, and figured with great elegance and truth. Each volume is illustrated with 40 excellent coloured plates. He likewise prepared a general History of the Mosses; but this work, which he did not live to finish, was arranged and published by Frederick Schwægricher, one of his pupils. It contains notices of 360 species, of which 157 are figured. Out of six children by his second wife, five died at an early age, and one of his daughters, whose education he had superintended, was carried off by the small-pox in December 1797. This severe blow affected his health: and having neglected to take proper care of himself during the severe weather of 1798 when he was visiting his patients, he was attacked by a catarrhal fever, from which he had scarcely recovered, when he was carried off by a nervous fever, on the 7th of February 1799, in the 69th year of his age. Out of 15 children, only four survived him, two sons and two daughters. One of his sons, M. Romain Adolphus, professor of botany at Leipsic, published two fasciculi of a splendid work on ferns, with coloured plates; but he did not long survive his father.

Hedwig was distinguished by all the social virtues. He was neither elevated by the high reputation which he had acquired, nor depressed by the illiberal criticisms with which he was assailed. His enjoyments and his sufferings were of a higher class. They were the luxuries and the sorrows of domestic life. See Deleuze's *Account of the Life and Writings of Hedwig*, published in the *Annales du Museum d'Histoire Naturelle*, vol. ii. and in Brande's *Journal of Science and the Arts*, vol. i. p. 103.

HEGIRA, or Hejera, is an epoch to which the Arabs and Mahometans refer historical events. It comes from an Arabic word, which signifies *fled*, and the epoch is dated from the night between the 15th and 16th July A. D. 622, when Mahomet was forced to leave Mecca to avoid the persecutions of his enemies. The year of the Christian era, corresponding to any year of the Hegira, may be found by the following formula, H being the year of the Hegira, and C that of the Christian æra, $C = \frac{H \times 354}{365} + 622$, or $C = H \times .9692 + 622$. Thus if we wish to know what year of our æra corresponds with the year of the Hegira 1232, we have $C = 1232 \times .9692 + 622 = 1816$.

Tables shewing the correspondence between the years of the Hegira and those of the Christian æra have been given by Greaves in his *Epochæ Celebriores*; by Riccioli in his *Chronologia Reformata*, 1659; and by Beckius in his *Ephemerides*, 1695. A more correct table has been published by Mr Marsden, in his paper *On the Æra of the Mahometans called the Hejera*, printed in the *Philosophical Tansactions* for 1788, vol. lxxviii. p. 414, or in the abridgment, vol. xvi. p. 509.

HEIDELBERG, is a city of Germany, in the circle of the Lower Rhine, formerly the capital of the Palatinate, and recently forming a part of the grand duchy of Baden. It is a long and narrow town, and is situated at the foot of a mountain on the south side of the Neckar. This river is crossed by a fine bridge, which cost 170,000 florins, and from which there is a fine view upon the river. It is surrounded with walls, which have six gates. The citadel, called Fort l'Etoile, was long ago destroyed by the French. It contains three churches for Roman Catholics and Protestants, an university, an economical society, an anatomical theatre, a military hospital, a cabinet of mineral models and physical instruments, a botanical garden, and more than 20 fountains. The university was founded in 1386, and has been under the direction of 20 professors, 16 Catholic, and four Reformed. When the Bavarians took it in 1622, its library was transferred to the Vatican, by Robert Maximilian of Bavaria. The fine statue of the Elector, the church of St Esprit, the church of St Peter, with the sepulchral inscription of the celebrated Olympia Fulvia Morata, are worthy of being seen. The castle and the garden of Heidelberg, situated near the town, are now in ruins. The statues of the ancient Electors and Count Palatines are still to be seen on the front of the castle; the remains of the hall of the chevaliers are still visible; and the granite columns, which formerly supported a part of the imperial palace at Ingelheim near Mayence, are seen supporting the roof of the fountain of the castle. The subterraneous passage extends to the great square in the town. A Restaurateur is now established in the middle of these ruins. Heidelberg has been celebrated for its wines, called *vin du Necker*, obtained from grapes which grow on both sides of the mountain; and for its capacious tun, which originally contained 528 hogsheads, and 600 when it was rebuilt, and which is still shown to strangers. It has manufactures of camblets, silk stockings, and silk handkerchiefs, wax lights, soap, cotton, clothing, paper hangings. The population, which is principally Lutheran, amounts to 12,000.

HEIGHTS. Methods of measuring heights by the Barometer will be found in our article Pneumatics, and trigonometrically in our article Trigonometry.

HEILBROUN, or Hailbron, is a town of Germany in Suabia, which belonged to the King of Wirtemberg. It is situated in a very pleasant and fertile country on the banks of the Necker, which is crossed by a covered stone bridge. The town is strong and well built, and has some fortifications, three churches, two convents, and public baths. The principal objects of curiosity in this town are, the Gothic tower of the church of St Kilian, which is remarkable for its architecture, the public library, the house of correction, the great fountain, and the fine promenade before the gates of the town. In the archives of the town are preserved the letters of the two celebrated Chevaliers François de Sickengen and Goez de Berlichingen, the last of whom was imprisoned in a tower, which still remains, and was interred in the convent of Schoenthal near the town. The town carries on a great trade in tartar and all sorts of glass. It contains distilleries of brandy, paper manufactories, tanneries, oil mills, and wheels for tobacco. Population, 8000.

HELENA, St, generally ranked by geographers among the islands of Lower Guinea, is situated in 15° 55′ South Latitude, and 5° 49′ 45″ West Longitude from Greenwich. It is 600 miles from Ascension Island, the nearest land, 1200 from the coast of Africa, and nearly 2000 from that of America. In sailing from Europe, it is generally necessary, in order to make the island, to stretch along the Brazil coast quite out of the tropics, till it can be gained by the aid of the south-east trade winds; but of late years the inner or easternmost passage has frequently been followed, and has not uncommonly been made in 7 or 8 weeks from England. A bird, called the St Helena pigeon, which is seen only to the windward of the island, generally indicates its vicinity to the navigator, long before the land can be discerned by the telescope.

St Helena was discovered by the Portuguese commander John de Nova, on St Helen's day, May 21st 1501. It was then inhabited only by seals, sea-lions, sea-fowls, and turtles. The interior of the island was one entire forest, and even many of the rocky precipices on the coast were covered to the brink with the gum wood tree. Its first settlement and improvement are ascribed to the following interesting occurrence: Several Portuguese noblemen, who had deserted in India to the native princes, were punished by Albuquerque in the most cruel manner, by having their noses, ears, and right hands cut off; and in this mutilated condition, were put on board the ships returning to Europe. Fernandez Lopez, one of the sufferers, preferring a voluntary exile to a life of ignomy in his native country, was at his own request, landed on the island of St Helena in the year 1513, with a few negro slaves. Many of his countrymen, commiserating his sufferings, exerted themselves to contribute every comfort and convenience which his forlorn situation would admit. Hogs, goats, and poultry, were landed for his sustenance. Partridges, pheasants, guinea-fowls, peacocks and other wild fowl, were let loose in the woods. Figs, oranges, lemons, peach trees, and various vegetables, were planted in the infant soil. By his skill in botany and gardening, the fruit trees were brought to great perfection; and the live stock and feathered tribes increased so abundantly under his protection, that in a short time they entirely overspread the face of the country. After a residence of four years, Fernandez was removed from the island by orders from the court of Portugal; but the spots which he had cultivated continued to supply the ships of his country with seasonable and abundant refreshments in their Indian voyages.

The Portuguese succeeded in concealing the situation of St Helena from other European nations till the year 1588, when it was descried and visited by Captain Cavendish on his return from a voyage round the world. It soon became well known also to the Dutch and Spaniards; and the crews of the different nations are accused of having wantonly laid waste the plantations, and destroyed the live stock, as if grudging to succeeding visitors any participation of the benefits which themselves had enjoyed. After the Portuguese had acquired so many ports on the eastern shores of Africa, they removed entirely from St Helena, which remained for a long time in a desolate condition; but, according to other accounts, they were expelled from it by the Dutch, by whom it was again abandoned upon the establishment of their colony at the Cape of Good Hope in 1651. Upon their departure, the English East India Company immediately formed a settlement upon St Helena; and about ten years afterwards, obtained a charter for its possession from Charles II. Many settlers were induced, by the offer of lands, to emigrate thither from England; and slaves were imported from Madagascar to work in the plantations. In 1665, the Dutch succeeded in an attack upon the island, but in a few months were obliged to give place to the English; and after the destructive fire in London in 1666, numbers of the ruined families, who sought relief in distant countries, removed to the new settlement on St Helena. It was once more retaken by the Dutch in 1672, through the treachery of one of the planters, but was almost immediately recovered by an English squadron under Captain Munden, and again restored to the East India Company. The first fortification was erected by the English in 1665, and a few lines formed across the valleys, and batteries, slightly elevated above the level of the sea, were at different times constructed; but more than a century was suffered to elapse before its impregnable heights were employed as posts of defence.

Till the beginning of the 18th century, the history of the settlement contains little else than a succession of petty contentions, insurrections, and mutinies. A general spirit of insubordination appears to have infected all ranks on the island, planters, soldiers, and slaves; and though every attention was paid by the Company to support the interests of good order, morality, and religion, yet two causes chiefly seem to have defeated all the good effects of their regulations, viz. the injudicious conduct of the governors in failing to check the first symptoms of disaffection, and the profligate character of the persons who presided over the religious instruction of the inhabitants. An abundant distillation of spirits from potatoes was no inconsiderable auxiliary to the spirit of disorder; and this source of depravity became at length so great a nuisance, that, in the year 1700, all the stills were suppressed by an order from England. But, by the wise and vigorous measures of Governor Roberts, from 1708 to 1714, and by the pious exertions of Mr Tomlinson the chaplain, a degree of tranquillity hitherto unknown was established in the settlement, and a new æra commenced in the history of the island. The Company's lands were brought into a promising state of improvement; planting and inclosing encouraged among the settlers; the culture of vines and sugar canes introduced; lime quarries discovered and wrought; a manufactory of bricks and tiles set on foot; a code of the existing statutes arranged and published for the information of the inhabitants; and the exercise of martial law in a great measure abolished, except in times of alarm or attack.

From the year 1727 to 1731, great encouragement was given under Governor Byfield to the planting of furze fences, both with a view to afford protection to the lands, and to secure a supply of fuel. The increase of trees also was greatly favoured by a resolution to withhold the liberty of keeping sheep and goats, which were so injurious to the young plantations; and in place of the general privilege, grants were given to individuals of keeping goats on certain parts of the Company's waste lands, called goat-ranges. About the year 1749, the Scotch and spruce firs were introduced by Governor Hutchinson; and acorns were at the same time planted, from which oaks have grown to the size of 8 or 11 feet in circumference. The same gentleman succeeded, after repeated attempts, in introducing the coffee plant, which is now regularly cultivated. The importance of St Helena became daily more manifest, as the trade and prosperity of the East India Company increased; and, in the year 1759, many important regulations were introduced into both the civil and military establishments. Towards the close of the year 1783, the tranquillity of the island was seriously interrupted by an extensive mutiny among the soldiers, occasioned by a few trifling regulations respecting their punch horses, which appeared to them of an insulting and degrading tendency. After a slight skirmish, the insurgents were reduced, and the ringleaders executed. The mutinous disposition of the garrison was afterwards entirely suppressed, and the whole character of the troops highly improved, under the judicious management of Governor Brooke. The place became even a nursery of excellent recruits for the East Indies; and during his government, from 1788 to 1800, more than 12,000 soldiers were sent to India. The same gentleman made great additions to the defences on the heights, established a code of signals, built a new and safer wharf for the shipping, improved the regulations relative to the treatment of the slaves, gave encouragement to many useful suggestions for the improvement of agricultural operations, and, by his active enterprizes at the commencement of hostilities with the Dutch in 1795, rendered the little island of St Helena peculiarly serviceable to Great Britain. His successor Colonel Patton evinced a similar zeal and ability, in whatever concerned the welfare of the settlement. He particularly erected telegraphs, rendered the guns on the heights more efficacious for annoying an enemy, introduced the use of terra puzzolana in the formation of aqueducts, and applied his attention, by means of honorary rewards and religious instruction, to improve the character of the slaves. Many important agricultural improvements were introduced by Governor Beatson, and particularly the use of the plough in the tillage of the soil. In a volume of tracts relative to the island, he has minutely pointed out its various capabilities, and suggested divers plans for its better administration and culture. The greatest want under which the settlement labours is the scarcity of fuel, and coals have actually been carried thither from England. But the last mentioned writer maintains, that with ordinary care, the island might be made to produce in a few years a sufficiency of wood for its own consumption in fuel, and for all the other purposes of life.

The island of St Helena, when first seen at sea, presents the appearance of a naked and rugged rock, extremely abrupt at its northern extremity, but more shelving towards the south. Upon a nearer approach, the central eminences are perceived clothed with verdure, and towering to the clouds. Upon drawing still nearer, these are again shut out from the view, and nothing is beheld but a girdle of inaccessible precipices overhanging the ocean, some of them exhibiting the most fantastic shapes, and others rent down to their base, disclosing the most hideous chasms. These rocks are principally basaltic; and the strata are observed to lie in every possible variety of direction. The whole mass has every appearance of having been produced by a submarine volcano; or, what some consider more probable, being the summit of a great submarine mountain, which had formerly been a volcano. The sea around the coast is of an unfathomable depth, and vessels may pass within a cable's length of almost perpendicular cliffs 1600 feet in height. The only anchorage is in Chapel Valley bay on the north-west and leeward side of the island, where ships may lie in smooth water from 8 to 25 fathoms deep. The tide rises sometimes to the height of five feet; and the surf upon the shore, especially about the season of Christmas, is very tremendous. Many lives were lost in approaching and leaving the land in boats, till the new wharf was constructed by Governor Brooke in 1790; but there is only one instance of a shipwreck upon the island, which happened at the time of its discovery; and only one also of a vessel being windbound in the roads. The variation of the compass on the coast, in 1768, was 12° 47′ west; in 1777, 13° 15′; in 1796, 15° 47′ 30″; in 1802, 16° 30′. The principal inlets, by which the island can be approached, are James's Town, Rupert's Bay, Lemon Valley on the north-west side, and Sandy Bay on the south-east; all of them regularly and strongly fortified. There are likewise several ravines, where it may be possible, though with great difficulty, for individuals to effect an entrance; but even these are either protected by batteries, or easily defended by rolling stones from the heights. The island is 10½ miles at its greatest length, 6¾ in breadth, about 28 in circumference, and contains 30,000 acres on its surface. There are only two plains in the whole of this extent; the largest of which, at Longwood, comprises 1500 acres of fine land, sloping gently to the south-west.

St Helena is unequally divided by a lofty chain of hills, which runs in a curved direction nearly east and west, bending towards the south at each extremity; and from which alternate ridges and valleys branch off in various directions, but chiefly north and south. Towards the eastern termination of this chain is Diana's Peak, the highest point of land on the island rising nearly 2700 feet above the level of the sea. On the same ridge are Cuckold's Point, 2672 feet; and Halley's Mount, 2467. Nearer the coast, and overhanging the sea, are Flag-staff, 2272; and Barnscliff, 2015. In the centre of the island is the alarm house, 1960. High Knoll, to the southward of Ladder Hill, is 1903; and Longwood-house, the official country residence of the lieutenant-governor, is 1762 feet. On coming round to the north-west and leeward side of the island, James's Valley opens to the view. It is bounded by two rocky mountains, Rupert's on the east, and Ladder Hill on the west, which gradually recede from each other as they approach the coast, where they terminate abruptly in two stupendous and perpendicular cliffs. The space inclosed between these heights is of a triangular form, about a mile and a half in length, and 350 yards broad at its base, which faces the sea. In this confined spot is situated James's Town, which presents in its whole appearance, a peculiar combination of military strength and rural simplicity. A fortified line extends from cliff to cliff, fronting the anchorage, and covered with cannon, nearly level with the water's edge. After passing the draw-bridge, and advancing between a double row of Peepel trees, (a species of Indian banian,) you enter the town by an arched gate-way, under a rampart or terrace, which forms one side of a handsome parade, about 100 feet square. On the left side is the government-house, usually named the Castle, inclosed with a wall; and directly fronting the gate-way is the church, a plain but not inelegant structure. The principal street, containing about 28 houses, commences between the church and the Company's garden; and, in its progress, divides into two other streets, one on the east side leading into the country, and the other, which has a number of well furnished shops, proceeding towards the upper part of the valley, where the barracks, hospital, and new garden are situated. The houses, generally two stories high, are neatly built in the English style, and well white-washed. The town contains many little gardens, groves, and shaded walks, and extends the whole length of the valley, which gradually decreases in breadth, till at last there is room only for a single house. The view on each side, from the streets, is awfully sublime, and discovers enormous masses of rock impending over the valley, in a manner sufficiently alarming to the mind of a stranger. The roads which give access to the interior of the island, and which have been formed with incredible labour, by blowing up the rocks, are carried along the sides of Rupert's and Ladder Hill in a zig-zag direction; and the ascent to the summit is so easy, that oxen and carts pass along the apparently perpendicular precipice without difficulty or danger. For the space of two miles, nothing but naked sterility and a rocky wilderness meets the eye of the traveller; but the sight is soon gratified by the sudden prospect of woody heights, verdant lawns, cultivated plantations, and handsome little country seats. The summit of High Knoll, particularly, presents a beautiful series of such prospects, surrounded by a lofty ridge of hills and precipices, which completely close in the view, and finely contrast with the softer and richer scenes which they inclose. On the south side of the Knoll, about three miles from the town, is the governor's country residence, called Plantation House, a handsome and well-built edifice, erected in 1792. Its environs, by the combined efforts of nature and art, have been rendered the most beautiful spot in the island. Besides the indigenous productions of the place, the pine of the north, the mimosa of New South Wales, the coffee plant of Arabia, the banian and bamboo of India, the African aloe and prickly pear, the apple, peach and mulberry of Europe, with various other plants and trees, from the most opposite and distant climes, are to be found within the inclosures. Longwood, the country residence of the lieutenant-governor, on the opposite side of Ladder Hill, and also about three miles from the town, is situated on an elevated plain, or rather gently rising ground, on the summit of which is a flagstaff, from which the place takes its name. The adjoining space was once nearly covered with gum-wood trees, which, upon the opening of avenues among them, were gradually destroyed by the south-east wind; but young trees, which have been since planted, are thriving well, and the whole scenery bears a greater resemblance to that of England, than any other spot on the island. There are here about 1500 acres of good meadow land, of excellent soil, and capable, if supplied with water, of proving highly productive. From Sandy Bay, which is about an hour's ride from Plantation House, by a winding road along the declivities of little green hills, a still more romantic and beautiful scenery opens to the view, of which actual observers have given the most enraptured descriptions. "Though in general," says Mr Brooke, "a bird's eye view lies before the spectator, hills rise above him to an elevation much greater than the spot on which he stands. Those on the left, richly clothed with trees to the very summits, display a wonderful contrast to the wild and grotesque nakedness that triumphs on the right, where shelving cliffs, surmounted by huge perpendicular and spiral masses of rock, are multiplied under every shape and aspect. The downward view consists of a variety of ridges, eminences, and ravines, converging towards the sea into one common valley. Among this scenery are interspersed the dwellings of planters, the different forms of gardens and plantations, and the pasturing of cattle; the prospect closing with the distant sea, rushing in between two black craggy cliffs, which the surf whitens with its spray. The infinite diversity of tint that overspreads the whole of this extraordinary picture, the majesty of one part, the reposing beauty of another, and the horror of a third, cannot fail to delight and astonish every observer of nature." "One feels," says Mr Johnson, "as if transported into a new planet, where every object strikes by its novelty, and is altogether unlike any thing which he had ever before seen. All the surrounding hills, cliffs, rocks, and precipices, are strangely fashioned, and so fantastically mixed and blended, that they resemble more the aerial shapes which we see among the clouds, than any thing composed of denser materials." But it is from the summit of Diana's Peak, which is nearly in the centre of the island, that the most complete view of St Helena is brought under the eye. Nothing intercepts the horizon; and all the detached scenes and prospects are beheld at once, forming a picture inconceivably diversified, and full of the most interesting groups.

The climate of St Helena is remarkably temperate and salubrious, and peculiarly adapted to the constitution of Europeans. In James's town, the thermometer seldom rises above 80°; but, in calm weather, the heat reflected from the sides of the valley is frequently oppressive. In the country, the temperature is more mild and uniform; scarcely so hot, and never so cold, as in England. In some seasons, the highest point of the thermometer, during the summer, has been only 72° in the interior of the island; and the ordinary range of Fahrenheit's scale, during winter, is from 55° to 56°. The average temperature through the whole year is from 66° to 78° of Fahrenheit at James's Town; from 61° to 73° at the Plantation-house; and from 56° to 68° at Longwood. The rains also fall more equally through the whole year than in most tropical climates, but most abundantly in the month of February. In the vicinity of some of the higher points, especially of Diana's Peak, which, by being covered with trees, is supposed to attract the clouds, scarcely a day passes without a shower. Cloudy days are more numerous than those of clear scorching sunshine; a circumstance which has been remarked as propitious to the growth of trees and pasturage, but unfavourable to the ripening of European fruits. Thunder and lightning are scarcely ever experienced; and the atmosphere is generally so clear, that a ship may be descried at the distance of 60 miles.

The soil is of a clayey nature, and well suited both for European and Indian productions. It is in many places of considerable depth, and always most productive in spots which are most elevated and farthest removed from the sea. Even on the summits of the interior hills, the grass is often so luxuriant as to reach the knees of the oxen. Clear and wholesome springs issue from the sides of almost every height; but they form only very inconsiderable rills. A few of these, especially those at Fisher's Valley and the Briars, are not observably diminished in dry weather; but, in general, they are wholly dependant on the rains, or the clouds, which are almost perpetually in contact with the tops of the mountains.

Iron ore has been found in some parts of the island; but the scarcity of fuel prevents it from being brought to the furnace. Appearances of gold and copper have been observed, and some stones capable of taking a beautiful polish. Limestone is plentiful; and some of it, a concretion of sand and shells, is of an excellent quality; but the cement used in ordinary buildings is mud or earth, which is found to answer the purpose extremely well, perhaps from its containing a mixture of terra puzzolana. This last mentioned substance, which abounds on the island, forms, in conjunction with lime, a cement remarkably retentive of water, and acquiring, from the contact of that fluid, the solidity of rock: hence it is much used in the construction of aqueducts.

The summits and sides of the interior hills are covered with furze, of which the seed was brought from England, and with various indigenous trees and shrubs. Of these, the most abundant used to be the gum-wood, of which there are three kinds, all evergreens, the common, the bastard, and the dwarf gum-tree. The last is generally called *scrub-wood*, and seldom grows higher than three feet; but the common kind has a tolerably straight stem from 20 to 30 feet in height, and throws out its branches and leaves in the form of an umbrella. The bastard species has less of the gummy texture, and is farther distinguished by having a smooth leaf, and bearing its blossoms in small bunches. All the kinds contain a highly aromatic gum, which renders the wood extremely pleasant as fuel, for which purpose it is chiefly calculated, though not altogether unfit for building, if protected from the weather. From the trunks of the common and bastard species, a sweet-flavoured liquor, called by the natives *toddy*, issues spontaneously; and a bottle, so placed as to catch the natural exudation, may be filled in the course of a night. Of the other native trees may be mentioned, string-wood, dog-wood, red-wood, or ebony, and the cabbage-tree, of which the two last are very durable, and much valued in building. Oaks, cypress, and pinaster, have been introduced into the plantations, and thrive well. The first, particularly, grows up very quickly, but decays with equal rapidity, though the wood, when cut in a sound state, is said to be of a very close grain and firm texture. The ferns of St Helena are very numerous and beautiful; and one species, called the *tree-fern*, grows to the height of 14 or even 20 feet, with leaves five feet in length. The myrtle, to which the climate is peculiarly adapted, grows to the height of 30 feet, and the cotton plant thrives very readily. A shrub, which the natives call *samphire*, but supposed to be the barilla, grows spontaneously on the thin crust of soil generally found near the sea, and yields from its ashes a large quantity of the marine alkali for the manufactories of soap. The English vernal grass prevails in the higher parts; but, in the low grounds, the wire-grass, or droop, is more abundant. This last is sweet and nutritious, and suffers less than the other sorts from hot or dry weather; but, instead of it, a coarse herb, called *cow-grass*, originally from the Cape of Good Hope, has been introduced into many of the pastures. Lucerne has succeeded in some situations, and is considered as well calculated for general cultivation.

Fruits, in general, ripen best in the vallies near the coast; but almost on every farm are produced vines, figs, limes, oranges, lemons, citrons, guavas, bananas, peaches, quinces, pomegranates, tamarinds, mulberries, melons, water-melons, and pumpkins. Mangos, cocoa-nuts, sugar-cane, pine-apples, and strawberries, are also raised in the island, but only in small quantities. Apples have not succeeded generally; but one orchard, particularly, about three acres in extent, has been known, besides other fruits, to yield in one season 24,000 apples of a large size. Cherries have been tried, but without success. Gooseberry and currant bushes when planted, become evergreens, and yield no fruit; but the common blackberry, which was introduced in the year 1780, has found the soil and climate so congenial, that it has completely overspread large tracts of ground; and, as the only remedy against its encroachments, a public order was issued, and has uniformly been in force, for its entire extirpation. A species of yam, originally imported from Madagascar, is commonly cultivated in the vallies; but it requires almost continued moisture for fifteen months to bring it to perfection. During the last twenty years, however, the culture of the potatoe has more profitably occupied the attention of the farmer; and three successive crops of this valuable root are frequently produced in one season. Cabbage, peas, beans, and other garden vegetables, are raised every where in great abundance. Attempts have more than once been made to introduce the cultivation of wheat, barley, and oats; but probably from drought, or some unknown peculiarity in the soil or climate, the experiment did not succeed. It is more from this failure, than from the alleged voracity of the rats and mice, that grain is not raised. Indeed, as the principal value of the island consists in its being a place of rendezvous and refreshment for the homeward bound ships from India, the cultivation of grain has been deemed of less importance, and less anxiously encouraged, than the rearing of live stock, and the production of wholesome vegetables.

The breed of cattle and sheep on the island is originally English; but, in consequence of the large demands from the India ships, the stock is very scanty; and the inhabitants during the greater part of the year subsist upon rice and salt provisions, issued below prime cost from the Company's stores. Goats are numerous, and their flesh well tasted; but pork, except what is reared by the more opulent inhabitants, is of a very inferior quality, as the animals are chiefly fed with the heads and offals of the coarser kinds of fish. Rabbits abound in some spots. Rats and mice are amazingly numerous, and frequently very destructive. In 1756, they are said to have barked the trees at Longwood for food; and in 1700 actually devoured one another, so as almost to clear the island of the whole tribe. With a little ordinary care, however, Governor Beatson cleared his farms and gardens of vermin, as completely as could have been done in England.

The canary bird abounds in the island; and the Java sparrow is a great annoyance to the farmers. Red linnets are also numerous; and are observed to build two nests, in the uppermost of which the male bird takes his station, and serenades the female with his song during her incubation. Pheasants and partridges, in consequence of their having been protected by government, have become numerous; but the guinea-fowl, with which the island was formerly well stocked, are now seldom to be seen. The shores abound with sea-fowl, which deposit their eggs among the cliffs; and these, which are collected in the months of October and November, greatly resemble in flavour those of a plover. One species of these sea-birds make their nests in the more central and woody eminences, whither they are often seen flying across the country with fish in their bills.

More than seventy kinds of fish are found on the coast; but those which are commonly caught are, mackerel, albicore, cavalloes, jacks, congers, soldiers, old-wives, bull's-eyes, &c. The coal-fish, from two to three feet in length, are singularly delicate and high flavoured; but seldom more than eight or ten of them are taken in the course of a year. The flying-fish, when pursued by their various enemies, often drop upon the rocks; and some have been picked up, measuring more than two feet in length. Whales are frequently seen in the vicinity of the island; and have sometimes been killed in the roads by the south-sea whalers. Turtle frequent the coast in the months of December and March, and are often taken by the fishing boats. Shell-fish are not uncommon, especially one species resembling lobster; and rock oysters are found in some situations in a solid mass, which may be separated into distinct fish.

The whole superficial extent of St Helena is calculated at 30,000 acres, of which the greater part is a barren waste

About 8000 acres have been brought into cultivation; and much more might be improved as pasture-ground, if water were conveyed to it, which in many situations is perfectly practicable. Of the cultivated portions, about 1500 acres are in the occupation of the governor, the lieutenant governor, and the Company; 4000, besides goat-ranges, have at different times been let in leases at a low rent, seldom exceeding 16s. per acre; and about 2300 have become free by original grants to settlers. In no country is farming a more profitable employment than at St Helena, when droughts and other causes do not occasion a failure in the crops. The richest lands produce three crops of potatoes in the year, amounting in all to 400 bushels per acre, which will sell at 8s. per bushel. The price of labour, however, is high. The wages of a carpenter are 6s. or 7s. a day; of a mason, 4s. or 5s.; of a common labourer 2s. or 2s. 6d. A black servant may be hired from 10*l.* to 20*l.* per annum; but must in addition be supplied with clothing, maintenance, and medical attendance in case of sickness. The price of a slave of good character, and acquainted with husbandry work, is 150*l.*; but others of inferior qualifications may be procured for 30*l.* Even with all these expences of cultivation, the lands in general are estimated to yield a profit of seven or eight per cent.; and, if wisely improved, as supposed by Governor Beatson, to be capable of affording an inexhaustible supply of fresh provisions and vegetables for the trade of the southern and eastern world. The use of the plough, drawn by oxen, so recently introduced by this officer, may tend to diminish the expences of the farmer; but only 2000 acres are said to be capable of being tilled in this manner, of which not more than 68 have been brought under cultivation. As the roads are in general inaccessible to carts, particularly in the inland districts, the produce of the farms in the country is carried on men's heads, occasioning a great waste of labour. Asses, however, have lately become an object of attention, as suited for this service; and their price has risen from 5*l.* to 25*l.* They are well adapted to the island, as they prefer those vegetables which the other animals refuse to eat.

By repeated charters from the crown of Great Britain, the island of St Helena is assigned to the East India Company as perpetual proprietors, with all the powers of sovereignty and legislation. The supreme authority on the island is vested in the governor and a council. The council is composed of the lieutenant-governor, and senior civil servant, with the addition occasionally of a fourth and sometimes a fifth member, as the Court of Directors may judge proper. These represent the lords proprietors, superintend all the concerns of the island, act as justices of the peace, and exercise the ordinary jurisdiction of the ecclesiastical court. When the council is not assembled, the whole authority of the board centres in the governor, who may also exercise, as occasion requires, all the powers of Captain-General. The civil establishment consists of an accountant, pay-master, store-keeper, and the secretary to government, with their assistants, some of whom are at the head of inferior departments, and among whom promotion takes place according to seniority. The ordinary military force is composed of a corps of artillery, commanded by a lieutenant-colonel, a regiment of infantry, and five companies of white and black militia, who are at times rather on the footing of volunteers. There are also a head surgeon, an engineer, and a chaplain.

The whole island forms only one parish, but is divided into three districts, the East, West, and South or Sandy Bay divisions. There are two churches, one in the town, and the other in the country; and the ministers of religion in the settlement have, of late years, been as highly distinguished for the excellence of their character, as, in the earlier period of its history, they were noted for their incompetency and profligacy.

The civil and military establishments cost at an average 40.000*l.* per annum;* and there is generally an additional expenditure of 10,000*l.* on the head of contingencies. The only revenue of the Company is derived from the rents of their lands, which may amount to about 1100*l.* but gradually increasing as the old leases expire; and from the profits of a monopoly of arrack, which are estimated at 6000*l.* But they have a dead capital of 200,000*l.* sunk in public works, naval and military stores, &c.; and also warehouses for all kinds of articles useful to the natives or the shipping, which, though sold at a profit of ten per cent. do not cover the expences. But the best returns from the island must be sought in the accommodation which it affords to the Company's shipping, and the security which it provides for their commerce, against the hazards of the sea, and the attacks of an enemy. Its water,† climate, and vegetable productions, are so excellently adapted, particularly for scorbutic diseases, that many who have been sent to the hospital in the last stage of the scurvy, have, in the space of two weeks, been restored to perfect health. It is generally acknowledged, however, that the spirit of monopoly renders all the necessaries of life immoderately expensive, especially to strangers; and that a more abundant supply of fruits and vegetables might be provided for the vessels which arrive in the roads, if it were not that the persons who raise these articles for sale prefer a high price to a large disposable crop; and would rather, it is affirmed, allow them to rot, than sell them at a lower rate. Fresh beef, which, by a regulation of the government, is fixed at a certain rate, (of late years about 6d. or 6½d. per pound,) is the only kind of provisions which can be procured at a moderate price. Other articles of food, in the year 1805, were purchased at the following prices, which vary, however, considerably, according to the demand.

| | *l.* | *s.* | *d.* | | *l.* | *s.* | *d.* | |
|---|---|---|---|---|---|---|---|---|
| Turkeys, from . . | 1 | 10 | 0 | to | 2 | 0 | 0 | each. |
| Geese, from . . . | 1 | 5 | 0 | to | 1 | 10 | 0 | each. |
| Ducks, from . . . | 0 | 8 | 0 | to | 0 | 12 | 0 | each. |
| Grown fowls, from . | 0 | 9 | 0 | to | 0 | 12 | 0 | each. |
| Mutton, from . . . | 0 | 1 | 2 | to | 0 | 1 | 6 | per lib. |
| Pork, from . . . . | 0 | 1 | 6 | to | 0 | 1 | 8 | per lib. |
| Potatoes, from . . | 0 | 8 | 0 | to | 0 | 10 | 0 | per bushel. |
| Eggs, . . . . . . . . . . | | | | | 0 | 5 | 0 | per dozen. |
| Cabbages, . . . . . . . . . | | | | | 0 | 1 | 6 | each. |
| Pumpkins, . . . . . . . . . | | | | | 0 | 2 | 6 | each. |
| Milk, from . . . . | 0 | 0 | 4 | to | 0 | 0 | 6 | per quart. |
| Turtle and coal fish, . . . . . | | | | | 0 | 0 | 8 | per lib. |
| Fish of other kinds, from | 0 | 0 | 2 | to | 0 | 0 | 3 | per lib. |

Strangers residing in the town can be accommodated in private houses, at the rate of thirty shillings, or one guinea a day, with an excellent table, good wines, and comfortable lodgings.

By the registered returns for the year 1805, the population of St Helena, exclusive of the garrison and Company's civil establishment, amounted to 2064, of which number 504 were white inhabitants, and 1560 blacks: Of the latter,

* The late additions to the officers and garrison, in consequence of Bonaparte's residence on the island, are said to have raised the annual expences of the settlement to 300,000*l.*

† The water is excellent and abundant, and can now be conveyed so easily into the boats by pipes, that a fleet has been known to take on board 2000 tons in less than three days.

329 were free. In 1814, the whole population, including the garrison, which ought always to be about one thousand men, was estimated at 4000 souls. Upon an average of five years, from 1801 to 1805 inclusive, 165 ships touched annually at the island; and in time of war, when fleets are detained for convoy, the crews and passengers frequently equal the whole amount of the population. No strangers are permitted to settle on the island, without permission from the East India Company. It has been recommended to allow the soldiers, whose time of service may have expired, to remain as husbandmen; and to import Chinese labourers, who might be bound to serve the Company in the first instance, but permitted to hire themselves to others when not required to work for government. No importation of slaves has been allowed for a long time; and those who belong to the island, being generally treated with much kindness, are rather increasing in number. The inhabitants are in general a robust and healthy race, but rarely attain to a great age. The diseases to which they are subject, are principally of a catarrhal nature; and yet it has been observed that the driest seasons are frequently the most unhealthy. The inhabitants of the town retire to their farms and gardens during the greater part of the year; but, upon the arrival of the homeward bound India fleets, they flock with alacrity to the town, open their houses for the accommodation of the passengers, and entertain their guests with plays, dances, and concerts. They are a worthy, humane, and cheerful race, of people, superficially accomplished, and sufficiently fond of gaiety. The young women are described as very smart and agreeable in their manners. They are bold and expert riders, galloping up and down the most formidable precipices. Their complexions are fine, and they are said to be very successful in procuring hasty matches among those who touch at the island, on their return from India. Most of the settlers, more recently arrived from Europe, employ their capital rather in mercantile than in agricultural concerns; and considerable gains are made among them by the sale of European articles to the India fleets.

This extraordinary spot of ground, independent of its political and commercial advantages, may justly be regarded as a most interesting natural curiosity, and, notwithstanding all that has been written respecting it, there is still wanting a scientific survey, and accurate classification of its natural history. But it has recently become a peculiar object of curiosity to the nations of Europe, in consequence of its having been selected as the prison of Napoleon Bonaparte; and as there appears to be but one opinion as to the justice and policy of his detention, the principal point of enquiry generally relates to its adaptation for the security of his person. In addition to the almost inaccessible ramparts with which it has been provided by nature, its eminences are covered with telegraphs and watch towers, and its various fortifications defended by nearly 500 pieces of cannon, so that, with ordinary vigilance and a competent garrison, it may be pronounced impregnable by any external force. But though a rescue may be next to impossible, an escape is not accounted impracticable. There are various points on the coast, where one or two individuals, with a certain degree of naval assistance from without, (which the multitude of fishing boats and ordinarily favourable state of the weather must tend to facilitate,) may, without much difficulty, leave the island; and instances have occurred to prove, that, even in an open boat, a run might be accomplished, with little hazard, to the island of Ascension, or even to the coast of Brazil. See Lord Valentia's *Travels*, vol. i. Forbes's *Oriental Memoirs*. Campbell's *Travels in Africa*. Brooke's *History of the Island of St Helena*. Johnson's *Account of St Helena*. Beatson's *Tracts relative to the Island of St Helena*. (*q*)

HELIACAL, is a term derived from ἡλιος, *the sun*, and applied to the rising and setting of the heavenly bodies. A star is said to *rise heliacally*, when, after having been in conjunction with the sun, it gets to such a distance from that luminary as to become visible in the morning before sun-rise. A star is said to *set heliacally*, when it approaches so near to the sun that it can no longer be seen in the evening after sun-set.

HELICON, is the ancient name of a mountain in Bœotia, near the Gulf of Corinth, sacred to Apollo and the Muses, who thence received the name of Heliconides. Its modern name is *Sagara*, pronounced *Sacra*, an obvious corruption, as Dr Clarke has stated, of *Ascra*, a town upon Helicon, and the birth-place of Hesiod. Dr Clarke, who visited this mountain, has favoured the public with a very interesting description of it. Instead of proceeding to Lebadea, by the usual circuitous route along the level country, he ascended the mountain from Neocorio, passed by the monastery of St Nicholo to Sagara, and afterwards descended by the monastery of St George to Lebadea. He ascended in a north-west direction above the village of Neocorio, and passed a chapel in ruins. On his right hand, there was a rivulet flowing from Helicon towards the plain of Neocorio, or Thespia; and beyond this, on the opposite side of the dingle through which this rivulet fell, he saw from an eminence a village called Panaja. After travelling along the north-east side of the mountain, he reached in about an hour the little monastery of St Nicholo, situated within a sheltered recess of Helicon. The mountain surrounded it on all sides, a ruined tower belonging to Panaja appearing in front through a small opening. The aromatic plants filled the air with their spicy odours. A perennial fountain threw its limpid waters into the rivulet below; and the monastery was almost concealed amid trees, no less remarkable for their variety than for their beauty and luxuriance. The fountain was covered with moss and with creeping plants, forming a pendant foliage over all the fabric constructed around it. In a church near the monastery, Dr Clarke found a long inscription on the shaft of one of the pillars, distinctly mentioning that the ΜΟΥΣΕΙΑ, or games sacred to the Muses, according to Pausanias, were celebrated near a grove upon Mount Helicon. This inscription, and other evidence, convinced Dr Clarke that he had now discovered the fountain Aganippe, and the Grove of the Muses. Hence it followed, that the rivulet below was the Permessus, parent of Aganippe, called Termessus by Pausanias, and flowing, as he describes it, in a circuitous course from Mount Helicon.

A path winding through the grove, conducts from the monastery to the spot where, upon the left hand, the water gushes forth in a clear and continued stream. "The work about the fountain," says Dr Clarke, "was until lately very ancient, and not long ago there was an antique cistern in front of it; but the present monks, finding the work in a ruined state, undertook to repair it, and thus destroyed much of its original and venerable appearance. In its state of restoration, however, it is not without picturesque beauty; for they have merely erected an arcade of stone, whence the water issues, and this is already adorned by moss and creeping plants. The walks about the fountain, winding into the deep solitude of Helicon, are in the highest degree beautiful. All above is grand and striking, and every declivity of the mountain is covered with luxuriant shrubs, or tenanted by browzing flocks. Higher up the mountain, at the distance of two miles and a half from this grove and from the fountain Aganippe, was the fountain Hippocrene, fabled to have sprung from the earth when struck by the hoof of Pegasus."

From the Grove of the Muses, Dr Clarke descended to the Permessus, and crossing that rivulet, he ascended in a north-west direction towards the higher parts of Helicon. Wherever the surface was laid bare, he found the rocks to consist of primary limestone. By proceeding with difficulty along a craggy narrow path, he reached the heights of Sagara, where he observed part of the ancient paved causeway, which formerly led from Thespia to Ascra and to Lebadea. From this point, which was two hours journey from Neocorio, the whole of Bœotia was seen. The road now extended south-east and north-west, and another hour was necessary to descend into the deep valley in which Sagara is situated. This valley is entirely surrounded by high rocks, and by the towering summits of Helicon. A level plain is seen below, having its woods and cornfields almost buried in the deep bosom of the mountain. A steep and rugged descent now conducted Dr Clarke to the village of Zagara, which is divided into two parts by a river flowing across this valley, one part of the village being high above the other. The lower part stretches into the level plain; and above the upper part a small white edifice, the monastery of Panaja, appears embosomed among trees. Dr Clarke has shewn, we think very satisfactorily, that this village is the Ascra of the ancients, the place of Hesiod's nativity.

After passing Zagara, Dr Clarke advanced among the boldest rocks, and ascending by a narrow, steep, and stony path, he reached the highest part of this road over Helicon, "commanding a prospect," as he remarks, "which, in the grandeur of its objects, and in all the affecting circumstances of history thereby suggested, cannot be equalled in the whole world. The eye ranges over all the plains of Lebadea, Chæronea, and Orchomenus, looking down upon the numerous villages now occupying the sites of those and of other illustrious cities. From the spot where the spectator is placed, the most amazing undulations of mountain scenery descends in vast waves, like the swellings of an ocean, towards Parnassus, whose snowy bosom, dazzling by its brightness, was expanded before us with incomparable grandeur."

After passing another fountain, and travelling a quarter of a mile over an ancient paved way, Dr Clarke reached a magnificent terrace, elevated as it were above all Greece, and continuing to descend, the monastery of St George appeared in view, bearing north and by west. He then arrived at the village of Kotumala, about 1¾ hour from Zagara, and commanding the most sublime views. After passing the remains of an aqueduct, and the ruins of a city upon a hill, he reached Panori, two hours distant from Kotumala. He then passed two bridges, and came in sight of Lebadea, which will be described under that article.

We have thus given our readers a very brief account of Dr Clarke's most interesting examination of the antiquities of Mount Helicon. They will naturally turn to the original work for an ampler account of his journey. The classical reader will feel himself inspired at every step, and will share the fine sentiments which the sight of ancient Greece awakened in the first of modern poets.

> Where'er we tread, 'tis haunted holy ground;
> No earth of thine is lost in vulgar mould;
> But one vast realm of wonder spreads around,
> And all the muses' tales seem truly told,
> Till the sense aches with gazing to behold
> The scenes our earliest dreams have dwelt upon;
> Each hill and dale, each deepening glen and wold,
> Defies the power which crushed thy temples gone:
> Age shakes Athenia's power, but spares gray Marathon.
> Long to the remnants of thy splendour past,
> Shall pilgrims pensive but unwearied throng;
> Long shall the voyager, with the Ionian blast,
> Hail the bright clime of battle and of song;
> Long shall thine annals and immortal tongue
> Fill with thy fame the youth of many a shore;
> Boast of the aged! Lesson of the young!
> Which sages venerate, and bards adore,
> As Pallas and the Muse unveil their awful lore.
>
> Byron's *Childe Harold*, Canto II.

See Clarke's *Travels*, Part ii. Sect. iii. p. 92—118.

HELIGOLAND, or Helgoland, is a small group of islands belonging to Great Britain, and situated opposite the mouths of the Elbe and the Weser, and at the distance of nine German miles from each. The islands of Heligoland consist, 1st, of the island of Heligoland; 2d, the Sandy Island, called the Downs; and 3d, of several reefs and rocks, of which that called the Monk is the most remarkable. The island of Heligoland is divided into the High Land or the Cliff, and the Low Land. It is said to be in a state of rapid destruction from the encroachments of the sea; and it is reported among the inhabitants, that during the last century, it has been reduced from 11 miles in length to its present dimensions of 1 mile. The high land or cliff, according to the measures taken by Dr Heinemeyer, is 166 feet at its greatest, and 88 feet at its least height, and has a circumference of 4200 paces. It is ascended by a flight of 203 steps. The low land, which increases sensibly every year, is connected with the eastern part of the cliff by a rock about 500 paces long. The circumference of the low ground was 1400 paces in 1800. The circumference of the whole island, including the high and low ground, is 4600 paces. The Downs, or Sandy Island, is about two-fifths of the size of Heligoland; but its extent is constantly varying.

According to Dr Macculloch, Heligoland consists of strata of indurated clay alternating with beds of gray limestone, forming an angle of 30° with the horizon, and dipping to the north-east. The clay is of a strong red colour, and contains much oxide of iron, and some carbonate of lime. The limestone is in some parts formed of various marine remains, and in others it is uniformly granular. Through both these are dispersed in various places deposits of copper ore in small quantities. These consist of carbonate of copper diffused through the earthy matter, and of crystallized masses of the same substance; and more rarely there are found lumps of red oxide, mixed with particles of gray ore and native copper. The beach is covered with various siliceous pebbles, containing grains of the same substance imbedded in them, together with variously coloured porphyries and hornstones. On the shore are found belemnites, and other calcareous and flinty fossil remains; and considerable quantities of pyrites, and carbonized and pyritaceous wood, are contained in the clay strata.

This island is said to have suffered great physical revolutions in the years 800, 1300, and 1500. The Downs, or the Sandy Island, was not only connected with the low ground of Heligoland, but even a part of the reefs was covered with earth. Other revolutions took place in 1649 and 1720. Before the first of these epochs, the low land of Heligoland contained the isle called the Downs; and even before 1720, there existed between the two islands a narrow isthmus, which was seldom covered with water, except during very extraordinary tides. Since 1720, the two islands have been separated by a strait called Waal, which is from 18 to 20 feet deep.

The soil which covers the rock is from 3½ to 4 feet deep, and is rather fat than sandy. It produces annually about 300 tons of barley, and a little oats. The uplands afford good pasture for about 60 cows, and 400 or 500 sheep. In the north-west part of the island there are three ponds of rain water, called *safiskulen* by the inhabitants. The water of the two springs in the low ground is fit only for cattle, and is scarcely of use for washing. The principal revenue of the island is derived from the fish which are caught. About 120,000 Lubeck marc of fish, amounting to about 230,000 francs, are exported annually.

There are two good harbours in the island, which could be improved at a trifling expence. The northern harbour, where the larger vessels of the islanders lie, varies in depth from 7 to 42 feet at half-tide, and the southern harbour, which receives the chaloupes, has a depth of from 10 to 24 feet. To the east of the Downs is a road, which has 48 feet of water. The tides ordinarily rise 9 feet, but with a north-west wind they rise to a great height.

The island was defended in 1800 by four batteries, that of the south-east, that of the south, and the high and low battery on the north. The two first were directed to the landing place for large vessels, and the other two against the current between the islands. They mounted 19 cannon, and 4 howitzers, with 56 regular troops. The light-house serves to direct all vessels that wish to enter the Hever, the Eyder, the Elbe, the Weser, and the Jade.

There are no fewer than 342 houses on the high ground, and 78 on the low ground, making in all 420. The church, the magazine, and the public buildings, are erected on the high ground. Those on the low ground are merely the huts of the fishermen. A building has been erected on the sandy island, for the accommodation of those who may be shipwrecked upon it. The population was 2200 in the year 1800. In the same year there were 11 sniggs (small vessels) on the island, 97 chaloupes, and 80 yoles.

The natives of Heligoland are descended from the Frisians, and have preserved their language and their principal customs. They are chiefly employed in fishing and piloting vessels up the Elbe, the Weser, and the Eyder. They live in huts, and lie upon planks placed one above another, though some of the houses on the high ground are clean and well furnished. The women plough and sow the ground, thrash the grain, and grind it for food. They have neither carts nor horses. They obtain from Nordhovet in Eyderstedt, forage for their cattle in winter, and their fuel is got from the ports on the Elbe.

This island is supposed by Malthe Brun to be the Alokiai islands of Ptolemy. It appears also to have been the *Fosetisland*, *Fosteland*, or *Phosteland*, which appears in the history of the 7th, 8th, and 9th centuries to have been the seat of a peculiar worship paid to the idol *Fosetes*, who is supposed by some to be the Vesta, or Festa, of the Romans, and the Hertha of the Scandinavians. The altars of this deity were, however, overturned in A. D. 866, and his temple changed into a monastery. In 1403 and 1417, two famous pirates endeavoured to establish themselves on this island, in consequence of which it was put into a state of defence in 1539. The town of Hamburgh was afterwards anxious to obtain possession of it, but the Dukes of Holstein and Gottorp claimed with success this ancient dependency of Denmark, and it passed with the duchy of Sleswick into the possession of the Danes in 1714. The Danish government, however, neglected the great advantages of this position, and did not put it into a state of defence till the canal of Holstein was opened.

In September 1807, a small English squadron under Admiral Russel blockaded the island, which surrendered a few days afterwards, for the want of provisions. Thirty-two pieces of cannon, besides field-pieces and mortars, and a large stock of ammunition, were found on the island. By the arrangements in the treaties of Paris in 1814 and 1815, Heligoland has been transferred to Great Britain. East Long. of the light-house 7° 53′ 13″, North Lat. 54° 11′ 39″. See Malthe Brun's *Annales des Voyages*; Carr's *Northern Summer*; and the *Geological Transactions*, vol. i. p. 322.

HELIOCENTRIC. See Astronomy.

HELIOGABULUS. See Rome.

HELIOMETER from ηλιος the *sun*, and μετρειν to *measure*, is the name given by M. Bouguer, in 1747, to an instrument for measuring the diameters of the sun and moon. It differs in no respect from the divided object glass micrometer, which had been previously invented by Mr Savary, excepting that in the heliometer two whole object glasses were used instead of two semilenses. The object glasses are separated by a screw, as in Savary's instrument. See the *Memoirs of the Academy of Sciences* 1748, and our article Astronomy, vol. ii. part ii. A new heliometer, in which the semilenses are fixed at a certain distance, and the variation of the angle produced optically, is described in Brewster's *Treatise on New Philosophical Instruments*, p. 31. and 173. See also Micrometer.

HELIOPOLIS, from ηλιος, and πολις, *the city of the sun*, is one of the most ancient cities in the world of which any vestiges can now be traced. The most enlightened philosophers of Greece and Rome were attracted to this celebrated seat of learning. It was here that Herodotus became acquainted with the sciences and mysteries of Egypt. Plato was here taught philosophy, and about 30 years before Christ its ruins were visited and described by Strabo.

Strabo describes Heliopolis as built upon an artificial mount of earth, so as to be out of the reach of the inundation of the Nile; but owing to the accretion of soil from the annual inundations of that river, the place where it stood is now a perfect plane. In this city was erected a temple to the sun, where a particular part was appropriated for the feeding of the sacred ox, which was here worshipped under the name of Mnevis. There was also another splendid temple, with avenues of sphinxes and superb obelisks before the principal entrance. Out of the four obelisks which were erected here by Sochis, two were carried to Rome, one was destroyed by the Arabs, and the fourth still remains.

When Pococke visited Heliopolis, he observed the fragments of sphinxes still remaining in the ancient way leading to the eminence on which the temple of the sun stood. The sphinxes are, however, no longer visible. They are no doubt covered with the soil deposited by the Nile; and we agree with Dr Clarke in thinking, that not only the sphinxes, but even the pavement of the temple, might be disclosed by a very trifling excavation.

The obelisk or pillar of On, which is now the only piece of antiquity that marks the site of Heliopolis, is about 68 feet high, and 6½ feet wide on each side. According to Dr Clarke, who has given a very correct engraving of it, it is one entire mass of reddish granite. Each of its four sides exhibits the same characters, and in the same order. Those which face the south have been the least affected by the decomposition of the substance in which they are hewn; and it is from the southern side that Dr Clarke's engraving is taken. For a particular account of this obelisk, and the hieroglyphics which it contains, the reader is referred to Kircher *Syntagma* VIII. *Theat. Hieroglyph Oedipi Egyptiaci*, tom. iv. p. 330; Pococke's *Description of the East*, vol. i. p. 23; Shaw's *Travels*; Norden's *Travels*; but particularly Dr Clarke's *Travels*, part. ii. sect. ii. p 98.

HELIOSTATE, or Heliostata, from ηλιος the sun, and ιστημι I *stand*, is the name of a very ingenious and useful instrument, invented by Dr s'Gravesande, who was professor of mathematics at Leyden. The object of it is to give such a motion, by means of clockwork, to a polished mirror, that the beam of the sun which it reflects may be fixed, or remain in the same position during the diurnal motion of the earth. Hence it is of great use in all optical experiments, in which it is required to transmit the solar rays into a dark room.

The heliostate, which is represented in Plate CCXC. Fig. 1. consists of two principal parts; 1st, A plane metallic speculum, supported by a stand; and 2d, A clock for giving motion to the speculum. The speculum S, contained in a wooden frame, is placed in the brass case *a*, *a*, and is suspended by the handle AA, so as to have a free motion round an axis *a a*, which should pass along the surface of the speculum. The handle AA is joined to the cylinder C, whose axis is coincident with the middle part of the axis *a a* of the speculum. The axis of the tail DF, joined perpendicularly to the back of the speculum, is directed to the same point. This tail is made of a cylindrical brass wire, about the sixth part of an inch in diameter. The cylinder C is put upon the wooden stand P, the upper part of which is shewn separately in Fig. 2. The smooth iron cylinder *e* goes into a cavity in the copper cylinder C, so that, by the motion of the tail DE, the position of the speculum may be altered at pleasure. The wooden stand P is raised and depressed by the three brass screws B, B, B, turned with a key, and moving in a plate of brass.

The clock is represented at H, with an index which revolves once in 24 hours. The plane of the clock is inclined to the horizon, at an angle equal to the co-latitude of the place. The copper pillar FG, which supports the clock, consists of two parts, joined by the screws *d*, *d*, between which, as in a sheath, is moved an iron plate, in the middle of which there is a slit through which these screws pass. This plate is fixed to the lower plate of the clock itself, so that it can be raised and depressed, and fastened at any height by the screws *d*, *d*. The same effect may also be produced by the screws I, I, I, passing through the copper plates L, L, M. The extremities *b c*, *b' c'* must be in the same straight line, and a vertical plane passing through them must be perpendicular to the horizontal lines drawn on the plane of the clock, such as *fg*, *hi*.

When the plane of the clock is inclined at an angle equal to the co-latitude of the place, the plane LLM must be brought into a horizontal position by the plummet Q, the point of which is made to coincide with a point *o* marked on the foot M. But if it were required to use the instrument in another latitude, another point *o*, would require to be marked; and it would be necessary to incline the plane LLM to the horizon. The axis of the wheel which moves the index has a cylindrical perforation, but a little narrower below than above. The index, shewn separately at ON, in Fig. 3. is made of brass, and has a tail *pq* exactly filling the above mentioned perforation, into which it is thrust tight, so as to stick and be carried along by the wheel. The tail *p q* has also a cylindrical hole, through which passes the small brass wire *l k*, which remains in any position into which it is put. At the end *o* of the index there is a small cylinder *n* perforated cylindrically. The length of the index *n n'* was six inches in s'Gravesande's machine.

The iron tail *t* (Fig. 4.) of the piece T goes into the cavity *n*, Fig. 3. as shewn in Fig. 1. and moves in it freely, though not loosely. The small pipe R, Fig. 5. through which the tail DE of the speculum may be moved freely, may be suspended at different heights between the legs of the piece T (Fig. 4.) by the screw *r r* going into the parts *m m* of the pipe. The pipe can then turn freely round *mm* as an axis.

In order to fix the machine, another part, called the *placer*, must be used. The cylinder and the speculum being removed from the stand P, the brass pillar VX (Fig. 6.) is stuck tight upon *e*, Fig. 2. The ruler YZ moves round a centre at X, so as to remain in any position in which it is placed. The arm XZ has a peculiar construction and a certain length, but the length of XY is determined at pleasure. The end X*y* of the ruler, which does not extend beyond *y*, is included between other two, viz. *x* Z, and are on the opposite side. They are joined at Z, and are kept together by the screws *z*, *z*, which pass through a slit in the enclosed ruler X *y*. On this ruler is marked the small line *v s*, whose length is equal to $\frac{9}{100}$ parts of the length of the index. The arm XZ is equal to the length of the index, reckoning from the centre of motion at X to the end Z, when *x* coincides with *v*, where the divisions on *v s* commence. The line *v s*, which is unequally divided, serves to determine the length of the arm XZ for different times of the year, by bringing *x* to the division corresponding to the given day when the machine is used.

In order to mark the divisions, the arm is supposed to be divided into 1000 parts, hence *v s* will be 90 parts. The distances corresponding to the different times of the year are set down in the following table.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 21st March. | 1st March. | 21st Feb. | 11th Feb. | 1st Feb. | 21st Jan. | 11th Jan. | 21st Dec. |
| 21st Sept. | 11th Oct. | 21st Oct. | 1st Nov. | 11th Nov. | 21st Nov. | 1st Dec. | 21st Dec. |
| Parts. | Parts. | Parts. | Parts. | Parts. | Parts. | Parts. | Parts. |
| 0 | 8 | 17 | 32 | 47 | 64 | 77 | 90 |

On the opposite side of the ruler is drawn another line corresponding to *v s*, the divisions for which are given in the following Table.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 21st March. | 11th April. | 21st April. | 1st May. | 11th May. | 21st May. | 1st June. | 21st June. |
| 21st Sept. | 1st Sept. | 21st Aug. | 11t Aug. | 1st Aug. | 21st July. | 11th July. | 21st June. |
| Parts. | Parts. | Parts. | Parts. | Parts. | Parts. | Parts. | Parts. |
| 0 | 11 | 22 | 36 | 51 | 66 | 79 | 90 |

The instrument being thus constructed, is used in the following manner. Having adjusted the point $x$ of the placer to the division for the day of the month, place XV upon the stand P, (Plate CCXC. Fig. 1.) and put the ruler Y into the position and direction in which it is wished to fix the solar ray. The lines $bc$, $b'c'$ are placed in a meridian line drawn on the plane, and the point of the plummet Q is brought to $o$. The index NO is then turned till the sun's rays pass directly through the pipe R, which may be varied in its position till this is effected. The brass wire $lk$ is then raised or depressed, till the shadow of the end of it $l$ passes through the middle of the pipe R. This part of the machine is then moved to the *placer* as formerly adjusted; but the clock is moved and raised in such a manner that the end $l$ of the brass wire $lk$ may coincide with the end Z of the ruler YZ. The sun's rays, and the shadow of $l$ passing through R, and the point of the plummet corresponding with $o$; the pillar VX with its ruler is removed, and the cylinder C, carrying the speculum S, is substituted in its place, without altering the position of the stand P. The piece T is taken out of its place, that the tail DE of the speculum may be put through the pipe R; and when the piece T is replaced, the machine is then ready for use. The rays reflected from the speculum have the same position and direction as the ruler of the placer; and while the tail of the speculum moves with the clock, whose index follows the sun, its situation is altered with respect to the sun, but the ray reflected from the centre of the speculum remains fixed. By substituting the index K, Fig. 7. in place of NO, the machine becomes a common clock. For a demonstration of the truth of the preceding construction, the reader is referred to s'Gravesande's *Physices Elementa Mathematica*, tom ii. p. 714.

A very simple substitute for the heliostate, as proposed by Dr Thomas Young, is shewn in Fig. 8. A mirror C is fixed on the outside of a window facing the south, opposite the aperture D, through which it is required to transmit the solar rays. Another mirror is fixed by a joint to a rod AB, moveable about its axis, and parallel to the axis of the earth. The mirror A being placed in a position required for the day, so that the light which it reflects is received at such an angle upon C, that it may be transmitted through the aperture. In order to keep the ray in this position, nothing more is necesssry than to turn the axis BA round on its socket. See Young's *Nat. Phil.* vol. i. p. 426, 785. Analogous contrivances by Peyrard will be found in the *Phil. Magazine*, vol. xxxvii. p. 183, &c.

HELIOTROPIUM. See MINERALOGY.

HELIX. See CONCHOLOGY.

HELLESPONT. See TURKEY.

HELL GATE, this celebrated strait is near the W. end of Long Island Sound, opposite to Haerlem in York Island, and about 8 miles N. E. of New York city, and is remarkable for its whirlpools, which make a tremendous roaring at certain times of the tide. These whirlpools are occasioned by the narrowness and crookedness of the passage, and a bed of rocks which extend quite across it; the tides meet at Frog's Point, several miles above. A skilful pilot may conduct a ship of any burden, with safety, through this strait, at high water with the tide, or at low water with a fair wind. There is a tradition among the Indians, that in some distant period, in former times, their ancestors could step from rock to rock, and cross this arm of the sea on foot at Hell Gate.

HELMINTHOLOGY, is a term in zoology, derived from ελμινς, an *earth-worm*, and λογος, *a discourse.* Under this head are included those animals which Linnæus called *vermes.* For an account of the different orders of this class, see ANIMALCULE, CONCHOLOGY, INTESTINA, MOLLUSCA, RADIATA, and ZOOPHYTES.

HELOISE. See ABELARD.

HELSTON, a town of England in the county of Cornwall, is situated on the side of a hill, which slopes gently to the little river Cober. The town consists principally of four streets, which meet in a centre, and form a cross, and a channel of water runs through each of them. The market-house and town-hall stand near the middle of the principal street. The church, which was erected in 1762 on an eminence to the north, has a pinnacled tower 90 feet high, which forms a conspicuous sea mark. There was formerly a priory and a strong castle at Helston. Some vestiges of the castle were seen in the time of Leland. The priory of the knights of St John of Jerusalem was at St John's village, near the town. The remains of it were destroyed some years ago to make room for a methodist meeting-house. The town is governed by a mayor, five aldermen, a recorder, and sworn freemen, amounting to 36. Helston was one of the original stannary towns, but very little tin is now stamped here. Vessels take in their lading at a good harbour, a little below the town. Near Helston is a curious heap of stones, piled up in the form of a circle. It is called Earth Castle, and was formerly used as a fortification.

The population of the burgh and parish, in 1811, was,

| | |
|---|---|
| Number of inhabited houses | 328 |
| Number of families | 531 |
| Ditto employed in agriculture | 119 |
| Ditto in trade and manufactures | 166 |
| Males | 935 |
| Females | 1362 |
| Total population in 1811 | 2297 |

See the *Beauties of England and Wales*, vol. ii. p. 455.

HELVETIA. See SWITZERLAND.

HELVETIUS, CLAUDE ADRIAN, a celebrated metaphysician of the modern school, was born at Paris in January 1715. His ancestors, originally of the Palatinate, had been obliged, by their attachment to Protestant principles, to remove to Holland. His father, grandfather, and great grandfather belonged to the medical profession, and were all men of eminence. His grandfather in particular obtained celebrity by the introduction of ipecacuanha into the Materia Medica. M. Helvetius, the father of the subject of this article, was physician to the Queen of France, and held in great honour at court, was well known through Europe as a man of talents, and highly esteemed by all who knew him, for the probity of his character. He gave his son an excellent education, by placing him very early under the care of an intelligent tutor, M. Lambert. The young Helvetius was remarkably docile, and rapidly imbibed the spirit of the different authors whom he read; and from his exquisite sensibility to praise, he rendered himself an early proficient in literature, dancing, fencing, and the various other accomplishments which produce admiration. At college he became warmly attached to the philosophy of Locke. To trace all mental operations to sensation, appeared to him a happy explanation of these complicated phenomena; and he became animated with an ambitious desire to improve and extend the principles which he so much admired. At the age of twenty-three, he obtained the very lucrative situation of a farmer-general. He indulged the habits of a man of pleasure, but not without maintaining a degree of masterly prudence, which enabled him to manage his fortune without incurring inconvenience, and to give efficiency to the feelings of a noble humanity, by devoting a great part of his income to benevolent acts. He assiduously sought out and rewarded talent and merit, and always observed a delicacy of manner, which avoided the slightest wound to the pride of the most fastidious of those whom he served. Intent on the improvement of his own powers, he cultivated the society of Fontenelle, discussed along with him the doctrines of Locke and of Hobbes, and with his aid successfully cultivated the talent of expressing his ideas with perspicuity. He also became acquainted with Montesquieu and Voltaire, and profited in a similar manner by his intercourse with each of these eminent scholars. The earliest literary labour of Helvetius, was his poem on Happiness, in the composition of which Voltaire gave him great encouragement, and inculcated on him maxims which he himself had felt to be important, particularly on the indispensable necessity of truth of description, and regularity of language.

In the office of farmer-general, Helvetius was the uniform advocate of humanity, and exerted his influence to obviate the hardships to which individuals were so often liable, from the persons employed to collect the revenue. Here he had to contend with men long inured to an unfeeling system of procedure. In many of his remonstrances with the other farmers-general, his perseverance was rewarded with success: but his employment was on the whole accompanied with much disgust, and was further rendered unpleasant by the time which it occupied, and which he was desirous of devoting to philosophical studies. He therefore resigned its advantages, and with a sum of money which he had saved, he purchased an estate in the country, to which he retired. He married Mademoiselle Ligniville, after an acquaintance of 12 months, formed at the house of Madame Graffigni, the authoress of the *Peruvian Letters*. In compliance with the wishes of his father, he still passed a few months annually in the metropolis, attended court, and accepted of the situation of Maitre d' Hotel to the Queen. He took as inmates of his house two persons who had been his secretaries, chiefly from motives of benevolence. One of these, an unhappy cross-tempered and sarcastic character, of the name of Bandot, presuming on his knowledge of Helvetius in his infancy, habitually treated him as a harsh schoolmaster treats a child. This circumstance is worthy of mention, for the light which the indulgence given to him throws on the character of Helvetius. Bandot's great delight was to discuss with his master the whole conduct, talents, character, and works of the latter; and the discussions uniformly ended with satirical abuse. Helvetius, after retiring with his wife on such occasions, sometimes said, "is it possible that I am so deficient as this man represents me? I do not believe it, but I labour under these defects to a certain degree; and if I did not keep Bandot, I should have no one to point them out."

In his rural retreat, he composed his work *De l' Esprit*, or "An Essay on the Mind and its Faculties," which was published in 1758 In this work, he developed with much eloquence, and followed to some bold conclusions, the principles which he had imbibed from Locke, that all thought is a modification of physical sensation. He makes this the foundation of a system of public and private morals. This work had a powerful political effect. It was written under an impression, that the numerous evils of society are the offspring of corrupt institutions and strongly protected prejudices, and that the true source of them had been concealed by the want of analytical views of human nature and society. These fruits of his studies were presented to the world in a style and manner which were fitted to make a deep impression. His mode of representing the subject was favourable to that rage for pleasure, and that tendency to licentiousness in some points of morality, which had long prevailed in France. The author, however, in publishing it, gave a pledge of his sincerity, by risking all his honours, his property, and the whole peace of his life. His opinions were in some points wrong, and some of their tendencies were injurious; but we do not see, in his mode of stating them, marks of such haste or obstinacy as would have disinclined him to sacrifice any passion which he found really hurtful, or from renouncing the eclat of a philosophical reformer, if truth and consistency had been shown to lie on the opposite side. The points at issue between him and his adversaries were of equal importance to all, and the prohibition of his writings can only be attributed to the love of power on the part of others, and a senseless dread of the consequences of free inquiry.

He was first attacked in some of the popular journals, with criticisms, which contained some truth and plausibility mingled with marks of the lowest superstition and ignorance, and which were animated with the bitterest style of denunciation and invective. The doctors of the Sorbonne issued their censures against his heresies, which they enumerated in such concise propositions as the following: That physical sensibility produces our ideas; that pain and pleasure are the sources of thought and action; that the desire of happiness is sufficient to conduct men to virtue; that morality is, like physics, an experimental science; that vices and virtues proceed from different modifications of the desire of happiness; that virtuous actions are those which are useful to the public; that it is by good laws that mankind are rendered virtuous; and, that the chief cause of all existing vice is the ignorance of legislators, who set the interests of individuals in opposition to that of the public.

His first and most zealous enemies were the Jansenists, whose influence in the parliament of Paris procured from that body a condemnation of his work. Their rivals, the Jesuits, who had been spared by Helvetius, and with some of whom he had lived on friendly terms, made no public appearance against him till called upon by the general voice, and a regard for the character of their order. One of their number, a friend of Helvetius, conceived the plan of procuring from him a retractation of his errors. To gratify this friend, Helvetius subscribed a sort of apology, and afterwards another, which was ampler and more humiliating, with a view to save from persecution the public censor, who had suffered his work to pass the ordeal required by law. This, however, was not satisfactory: Helvetius was deprived of his situation at court; Tercier, the public censor, lost his office; and the interference of the council was necessary to save both of them from further severities, meditated by the Jansenists and the parliament of Paris.

The philosophical doctrines to which this author was attached comprehend a subject too extensive to be discussed in this article: (See METAPHYSICS.) But we find his opinions reprobated even by some liberal minds, along with those of some of his cotemporaries, as tending to degrade human nature, and destroy the dignity of moral truth. We do not apprehend, that such tendencies arose from any metaphysical opinions on the nature of matter and mind, subjects wholly unknown, and on which no opinion can be said to exist. The practical evils complained of seem to arise from a particular mode of employing words, tending to discourage all elevated conceptions, and thus generate in some individuals a degree of indignation, while its plausibility seduces others, and insensibly mars their love of moral order. An inordinate propensity to dwell on analytical views, sometimes withdraws the attention of the mind from the acknowledgment of magnificent objects. When the phenomena of mind are minutely dissected, and shown to consist of the same materials with others of a trivial nature, such as the puncture of a pin, or the titillation of a feather, all the pleasure arising from the novel exercise of acuteness, implied in the tracing of these general analogies, is of short duration, and the utmost circumspection is afterwards necessary, to resist an exclusive tendency to cherish detached sensibilities, and degenerate into a mean direction of sentiment and conduct. Persons thus influenced, consider all differences betwixt higher and meaner objects as depending on differences of arrangement, without duly acknowledging the importance of that principle of arrangement which deserves their veneration much more than minor insulated objects. The error of not acknowledging the importance of differences, merely because we are pleased with the generalization implied in the discernment of analogies, is also a radical fault in the use of the intellectual powers, tending to the same moral confusion. It is not the mere pointing out of such analogies that does harm, but the undue rank that is assigned to them. To say that virtuous and vicious actions are equally explicable on the principle of self-interest, has an apparent tendency to smooth over the difference between them. Our previous sense of their difference renders us averse to consider them as possessing any thing in common. But if any person should think it worthy of mention, that these two sets of phenomena agree in possessing the essential quality of activity, and are reducible to the varied motions of the human organs, no dangerous consequences could be apprehended, because such a position never could make a prominent figure in a moral treatise, so as to distract the mind from distinctions of essential importance.

Even a general test of morality is not sufficient to obviate the noxious effects of magnifying such analogies. The annunciation of this summary doctrine, that public utility, or the promotion of the greatest sum of pleasure, is the ultimate end of virtue, is even productive of some disadvantage. Although it may have been tacitly acknowledged, those who are averse to innovation feel in it something different from what they have considered as a definition of virtue; while those who are dazzled with it as an important discovery, satisfy themselves with vague appeals to this general ral test, in cases which require more minute discrimination, or perhaps the spirit of morality evaporates amidst the interminable disputes which those who trust in the all-sufficiency of that principle maintain about its particular applications. Some launch into an ocean of the wildest confusion, and merely because they associate their actions with the acknowledgment of this generalizing principle, imagine that they are men of superior virtue. This mode of thinking has proved a frequent source of imprudence, unhappiness, and misanthropy.

The works of Helvetius are probably less read now than formerly. This may be partly the effect of the influence of indiscriminate acrimonious censure; and, although their merit is not of the highest order, it may in a short time give way, among some readers, to an equally indiscriminate admiration. It is therefore useful to be aware of some of their tendencies, which must, on consideration, be allowed to be injurious by men of all varieties of theoretic opinion. One of the most untenable of the opinions of Helvetius was, that any differences in the original endowments of men are of no account in giving origin to the differences between mind and mind, which appear on the great theatre of the world.

The conflict which took place between the sentiments of this author and those of the age in which he lived, only afforded a specimen of a scene of hostility in moral literature which was much more extensive; and, when we consider the spirit of mutual defiance in which both parties indulged, we cannot wonder at the antipathies which it created, and the dismal political dissensions which flowed from it as soon as the restraints imposed by existing institutions were withdrawn.

The works of Helvetius were, through the influence of the French clergy, condemned by the Roman inquisition; but they were universally read and much admired in Italy and the whole of Europe. Even the dignitaries of the church, among whom was Cardinal Passionei, wrote complimentary letters, to thank the author for the fund of instruction and delight which he had afforded them.

The tide of popular sentiment, however, was so adverse to him in France, that he found it prudent to leave that country for a time. He visited England, and was much pleased with some favourable features in the state of English society as contrasted with that of France, particularly the happiness and contentment of the lower orders, the prevalent warmth of parental affection, and he even construed the want of free association among adults to their exemption from ennui, and from all dependence on frivolous amusements. He also visited Prussia, where he was received with great attention by the king, lodged in his palace, and freely admitted into his familiar parties.

When the storm raised against him in France had subsided, he returned home, and prosecuted his studies at his estate of Voré. He employed himself in extending the doctrines of his first work, in a " Treatise on Man, his Faculties and Education;" but had the prudence to give nothing more on the subject to the public. B ing attacked with the gout in his stomach, he died in December 1771.

The private character of Helvetius was distinguished by great humanity. He was a most indulgent landlord; and Madame Helvetius and he concurred in the execution of continual plans of beneficence. His lands being infested by poachers, he sometimes was provoked to punish them; but the slightest appearance of suffering produced instant reconciliation, and awakened all his benignity.

After his decease, his poem *De Bonheur*, on which he had long laboured, was given to the public. The object of this poem is to recommend literary improvement as the only source of true enjoyment. For this he has been blamed as restricting happiness to the possession of advantages which are confined to a small part of mankind. But, when we consider the life which he recommends as opposed to gross sensuality, vulgar ambition, and the pursuit of wealth, we shall find his poem to contain much valuable truth. It is equally true, that if we withdraw our attention from these limited contrasts, and leave out of view the interests of persons, who, in consequence of indulging in an inordinate passion for particular objects, have become the victims of chagrin and disappointment, we shall find happiness an object which is better secured by measures of a different kind, but which were condemned by Helvetius as haughty, stoical delusions.

His work on man was also published after his death. It is in some respects more profound than his former work; but it is written in a similar strain, and liable to the same objections. His disquisitions were conducted on a limited scale: he was betrayed by a love of simplicity into precipitate conclusions: and his pretensions were by far too gigantic, either for the extent of his talents or the success of his researches. (*H. D*)

HEMIDIAPENTE, in music, is an interval whose ratio is $\frac{45}{64}$, $= 311\Sigma + 6f + 27m$, or the *minor* FIFTH, which see.

HEMIDITONE, in music, is an interval whose ratio is $\frac{5}{6}$, $= 161\Sigma + 3f + 14m$, or the *minor* THIRD, which see.

HEMIOLIUS, in music, an interval, whose ratio is ses-qui-alterate, or 1 : $1\frac{1}{2}$; that is, $\frac{2}{3}$, = 358 Σ + 7 f + 31 m, or the *major* FIFTH, which see.

HEMIPTERA. See ENTOMOLOGY.

HEMITONES, in music, are a class of intervals of one degree of the scale, called also HALF-*tones*, HALF-*notes*, or SEMITONES, by different writers, (see these articles) all of which single degrees of the scale, although of such different magnitudes that the largest of them are more than three times as great as the smallest of them, and yet all regularly expressed by only one f, in our notation, viz.

HEMITONE of *Aristoxenus*, or ancient hemitone, is an interval whose ratio is $\frac{243}{256}$ = 46 Σ + f + 4 m, or the LIMMA, which see.

HEMITONE *artificial* of Holder, has the ratio $\frac{19}{20}$, = 45.270982 Σ + f + 4 m; see the SEMITONE of *Feytou*, &c.

HEMITONE *chromatic* of Holder and Tartini; its ratio $\frac{24}{25}$ = 36 Σ + f + 3 m, or the SEMITONE *minor*, which see.

HEMITONE *elementary* of Overend; its ratio is $\frac{15}{16}$, = 59 Σ + f + 5 m, the SEMITONE *major*, which see.

HEMITONE *greater*, of Euclid's genus Diatonum molle, $\frac{3}{10}$ths of a 4th = 76.27168552 Σ + f + 7 m; its common logarithm is .96251813,7912. = .1245114 in Euler's logs. (VIII) and 6.947433 in major comma logs. (c)

HEMITONE *greater*, of Ptolemy's genus Chromatic molle, has the ratio $\frac{14}{15}$ = 60.047096 Σ + f + 5 m; its log. = .9700367,7662, = .09953567 × VIII, = 5.553855 × c.

HEMITONE *greater* of Quintilian, has the ratio $\frac{16}{17}$, = 53.53181 Σ + f + 5 m; see the SEMITONE of *Malcolm*, &c.

HEMITONE *lesser*, of Euclid's genera Diatonum syntonum or intense, and his Diatonum molle and Toniæum chroma, $\frac{1}{5}$th of a 4th, = 50.80314496 Σ + f + 4 m; its log. = .9750122,5278 = .0830076 × VIII, = 4.631622 × c.

HEMITONE *lesser*, of Ptolemy's genera Diatonicum tonicum, and his chromatic molle, has the ratio $\frac{27}{28}$ = 32.052904 Σ + f + 3 m; its log. = .9842057,3282, = .05246742 × VIII. = 2.927559 × c. This is also the minor hemitone of Archytas; and in some experiments by Messrs Kirby and Merrick, on the sound of a pipe blown by a mixture of carbonic and hydrogen gases, and by atmospheric air, this interval resulted. See our article *Sounds of the* GASES.

HEMITONE *major*, of Archytas's chromatic genus, has the ratio $\frac{224}{243}$ = 71.947096 Σ + f + 6 m; its log. = .9646417,4474. = .1174576 × VIII, = 6.553858 × c.

HEMITONE *major* of Aristides and Feytou, has the ratio $\frac{16}{17}$, = 53.53181 Σ + f + 5 m. See the SEMITONE of *Malcolm*, &c.

HEMITONE *major* of Boethius and others, has the ratio $\frac{2048}{2187}$ = 58 Σ + f + 5 m, or the APOTOME. See that article.

HEMITONE *major* of Euler, Holder, Liston, Smith, &c. has the ratio $\frac{15}{16}$ = 57 Σ + f + 5 m, or the SEMITONE *major*, which see.

HEMITONE *major*, of Eutosthenes' chromatic genus, whose ratio is $\frac{18}{19}$, = 47.729018 Σ + f + 4 m. See the SEMITONE of *Feytou*.

HEMITONE *major*, of Ptolemy's genus Chromatic intensum, has the ratio $\frac{11}{12}$, = 76.897955 Σ + f + 7 m. See the HALF-*tone* of Brougham.

HEMITONE *maxima* of Webb, has the ratio $\frac{25}{27}$ = 68 Σ + f + 6 m, or the SEMITONE *maximum*, which see.

HEMITONE *maximum*, or greatest, of Holder, has the ratio $\frac{25}{27}$. See as above.

HEMITONE *medium* of Holder, has the ratio $\frac{128}{135}$, = 47 Σ + f + 4 m, or the SEMITONE *medius*, which see.

HEMITONE *minor* of Archytas' chromatic genus, has the ratio $\frac{27}{28}$, = 32.052904 Σ + f + 3 m. See HEMITONE *lesser* of Ptolemy.

HEMITONE *minor* of Aristides, Feytou, Quintilian, &c. has the ratio $\frac{17}{18}$, = 50.46819 Σ + f + 4 m. See SEMITONE of *Malcolm*, &c.

HEMITONE *minor* of Boethius, Sauveur, &c. has the ratio $\frac{243}{256}$, = 46 Σ + f + 4 m, or the LIMMA, which see.

HEMITONE *minor*, of Euclid's genera Chromatic toniæum, and his Diatonum molle, $\frac{1}{2}$ of T, whose ratio is 2 √ 2:3, = 52.0039312 Σ + f + 4 m; its log. = .9744237,3877, = .084962 × VIII, = 4.74070 × c. It is also the chromatic diesis of Hoyle.

HEMITONE *minor* of Euler, Holder, Sauveur, &c. has the ratio $\frac{24}{25}$, = 36 Σ + f + 4 m, the SEMITONE *minor*, which see.

HEMITONE *minor*, of Eutosthenes' chromatic genus, has the ratio $\frac{19}{20}$, = 45.270982 Σ + f + 4 m. See SEMITONE of *Feytou*, &c.

HEMITONE *minor* of Ptolemy's genus Chromatic intensum, has the ratio $\frac{21}{22}$, = 41.198802 Σ + f + 3 m; its log. = .9797966,1391, = .06711422 × VIII, = 3.744815 × c.

HEMITONE *minimum* of Holder, improperly so called, because it belongs to the class of commas (wanting f,) rather than to that of semitones; its ratio is $\frac{625}{648}$ = 32 Σ + 3 m, or 31.8582014 Σ + f + 2 m, the SEMITONE *minimum* of Overend, which see.

HEMITONE *Pythagorean*, or ancient, has the ratio $\frac{243}{256}$, = 46 Σ + f + 4 m, the LIMMA, which see.

HEMITONE *subminimis* of Holder, has the ratio $\frac{243}{250}$, = 25 Σ + f + 2 m, the SEMITONE *subminimis*, which see. (g)

HEMLOCK, a lake in New-York state, twelve miles long, and one broad, in the Genessee country.

HEMORRHAGE. See SURGERY.

HEMP. See AGRICULTURE.

HEN. See ORNITHOLOGY.

HENFLING'S *Temperament* of the musical scale. In the year 1711, M. Henfling communicated to the Parisian Academy a commensurate system of 50 equal intervals within the octave; of which parts, 29 make the fifth, which therefore, for imperfect instruments, will stand as follows, viz.

11 Fifths, viz. on C, G, D, A, E, B, ♯F, and ♯C, and on F, ♭B and ♭E, each equal to } 354.951969 Σ + 7 f + 31 m, = 3904.471659 Σ + 77 f + 341 m.
And the wolf fifth ♯D ♭E . . . . . . . . . . . . . . . . . . = 379.528341 Σ + 7 f + 30 m

Make 7 octaves each, 358 Σ + f + 53 m. . . . . . . . . . . . . . = 4284.000000 Σ + 84 f + 371 m.

And whence all its other intervals may easily be calculated, by help of the theorems, *in Phil. Mag.* vol. xxxvi. p. 41, or the corollaries at p. 374; see also p. 50, of the same volume. Dr Robert Smith, in Prop. xvii. of his "Harmonics," has calculated the temperaments of this system, and shewn, that it approaches extremely near to his system of EQUAL *Harmony* in three octaves. See that article.

HENGIST. See ENGLAND.

HENLEY UPON THAMES, a town of England, in the county of Oxford, is situated on the left bank of the river Thames, which is crossed by a fine bridge of five arches, with a handsome ballustrade instead of a parapet. The keystones in the centre arch contain two heads of the Thames and Isis, which were sculptured by the Honourable Mrs Damer. The town consists of two principal streets at right angles to each other, and some smaller ones.

The street which extends from the bridge to the cross is not very long, but is spacious, and contains some good houses. The street which extends from the cross along the Oxford road has a serpentine direction. It is longer than the other, and contains many excellent houses. At the junction of these streets is a simple stone obelisk, pointing out the direction of the roads, and the distances from London. The church, which is a very ugly building, is situated near the bridge, on the west side of the street. It has a tower with semi-octagonal buttresses at each angle, and embattled at the top. It is built of flints and stones. The tower is said to have been built at the expence of Cardinal Wolsey. The other establishments in Henly are a Royal Grammar School, founded by King James V. for educating 25 boys in the classics; a blue coat school, founded by Dame Elizabeth Perians, for educating and clothing 20 poor boys; a green coat school, and an alms house. Henly carries on a considerable trade with London by means of the Thames, in malt, flour, and beechwood. Above 30,000 quarters of flour are annually made here.

The following is the population of the town and parish in 1811.

| | |
|---|---|
| Number of inhabited houses | 522 |
| Do. of families | 543 |
| Do. employed in agriculture | 93 |
| Do. in trade and manufactures | 235 |
| Males | 1347 |
| Females | 1770 |
| Total population in 1811 | 3117 |

HENLEY HOUSE, a station of the Hudson Bay Company, on the north bank of Albany river, in New South Wales, 150 miles S. W. of Albany Fort, and 110 N. W. by W. of Brunswick House. N. Lat. 51, 14, 27, W. Lon. 85, 5, 54.

HENLOPEN, Cape, forms the S. W. side of the entrance of Delaware Bay, and Cape May, the N. E. side, 28 miles apart. Cape Henlopen lies in N. lat. 38° 50′, and in W. lon. 75° 26′. There is a light house here, a few miles below the town of Lewis, of an octagon form, handsomely built of stone, 115 feet high, and its foundation is nearly as much above the level of the sea. The lantern is between 7 and 8 feet square, lighted with 8 lamps, and may be seen, in the night, ten leagues off at sea. Its annual expence is about 650*l*. There is a strong iron net work, in order to prevent birds from breaking the glass at night. Yet so attractive is the light to the winged tribe, that shortly after its erection, 110 birds of different kinds were found dead one morning, and a duck in particular, flew against it with such force, as to penetrate through both the wire and the glass, and was found dead in the lantern. Since this birds have become more wary. Vessels off Delaware, upon displaying a jack at the foretopmast head, will be immediately furnished with a pilot. None, however, are to be depended upon, unless they are furnished with branches, and with a certificate from the board of wardens of Philadelphia.

HENRIQUELLE, a remarkable salt pond in the Spanish part of the island of St Domingo, about 22 leagues in circuit. It is inhabited by lizards and alligators, and land tortoises, all of a large size. The water is deep, clear, bitter, and salt, and has a disagreeable smell. Near the middle of this pond is an island about two leagues long, and a league wide, in which is a spring of fresh water, well stocked with *cabritoes*, and thence called *Cabrito Island.* This pond is about 11 leagues east of Port au Prince.

HENRY, Cape, the north-eastern extremity of Princess Ann county in Virginia, 12 miles S. by W. of Cape Charles in Northampton county. These capes form the entrance of Chesapeake Bay. Cape Henry lies in N. lat. 37, W. lon. 76 16.

HENRY I.—VIII. of England. See England.

HENRY I.—IV. of France. See France.

HENRY, Patrick, late governor of Virginia, was born about the year 1740 From all that has been recorded of him, what was precisely the condition of his parentage does not clearly appear. The chronicles of the provincial governments in North America, of the revolutionary war, and of the governments of Virginia and the United States since the year 1776, afford less satisfactory information of Mr Henry, and his specific services, than of any other man, at all distinguished in those several eras. He was born at a time, and among a people, when, and with whom, family legends were not very fashionable; unless they could be gilded by the lustre of office, or by the more imposing, though stupid pageantry of opulence. In the colonial era, the agents of the crown, and those advantageously connected with the public offices, were most generally from the mother country. The public archives, therefore, contain few traces of persons not in the confidence or employment of the provincial governments.

From the accounts most to be relied on, Mr Henry was of an obscure family. His education was limited; and poorly calculated to form an ordinary genius for eminence. His elevation, fame, and influence, resulted from unlettered, unadorned, but strong intuitive faculties. His gigantic mind bounded over all juvenile preparation for the active scenes of life. He was formed by nature a prophet among the most wise and most learned. He was therefore excused from the tardy, and sometimes discouraging, process of scholastic ratiocination; and, at the age when others yield blossoms of hope, often blighted by towardness or adversity, he was covered with delicious and matured fruit. He was a man of genius, eloquence, and virtue. He stepped on the stage of life without previous notification; and selected and acted his own character without the ceremony of rehearsal. His appearance commanded applause; his performance was followed by universal eclat; and his exit left his country in tears. In every situation of life he manifested an accurate perception and love of truth, which he always courted as the charm of his affections; and clearly demonstrated, by all his calculations and conclusions, that judgment taught him what experience alone could teach his cotemporaries.

At the age of twenty-five, Mr Henry was elected a member of the general assembly of Virginia. During the session of 1765, he introduced, for the consideration of the legislature, certain resolutions, fraught with the spirit of popular liberty, and pointedly protesting against the tyranny of the British government, which had then begun to be displayed with iron features in all the colonies, more especially in Virginia. The resolutions were approved by a majority of the assembly, and were the first adopted by any of the colonial legislatures against the famous stamp act. They not only declared what was tyranny and usurpation on the part of the mother country, and in contravention of chartered rights; but also defined the privileges and immunities of the colonists. These resolutions were the commencement of that opposition, which, though varied from time to time, ultimately resulted in the establishment of the independence of the United States. The debate on them was turbulent and proscriptive on the one side; zealous, determined, and vehement, on the other. The apologists of British tyranny raised the cry of "*treason!*" against the advocates of liberty and the rights of the colonists. In the midst of the storm, Mr Henry, until then unknown, burst forth with the thunder of his native eloquence; seared the visages of his haughty antagonists by his consuming scowl; and dealt out threatened vengeance on all, who should dare to array themselves against a people determined to assert their freedom. Encouraged by the undismayed front of their champion leader, his associates joined his standard, and marched boldly with him to the point of decision. It is recorded, in the reports of that celebrated parliamentary rencounter, that though the British authority remained yet unbroken, the old system of sergeantry still continued of force in the country, and the very hall, in which the assembly of Virginia convened, was thronged by his majesty's officers and procurers, Mr Henry, stimulated by the insolent and menacing denunciations of himself by his royal antagonists, exclaimed: "Cæsar had his Brutus, Charles the First a Cromwell, and George the Third——" here he was called to order by the presiding officer.

Mr Henry was not destined by his parents, or qualified by education, for any public profession. He grew up in the wonted occupations of a husbandman. Although accustomed to read, at leisure seasons, for his improvement and the gratification of an early taste for books, he had not adjusted himself to the design of becoming a public speaker. He always manifested a singular disinclination to court popularity. He inherited from nature splendid qualifications to become the theme of popular applause, and the deity of democratic idolatry; notwithstanding, from the commencement of his blazing career, he shrunk from the contact of vulgar associates; nor did he ever in his life swerve from the majesty of his spirit, the elevation of his sentiments, or the dignity of his deportment, from the consciousness of his ascendency over the taste and passions of the multitude, attracted by the benevolence of his enthusiastic heart, the ardency of his devotion to liberty, and the spell of his rapturous eloquence.

Virginia is indebted to one of those singular providences, which sometimes exhibit prodigies in the natural and moral world, for the ultimate and more accomplished developement of the intellectual powers of Mr Henry. Some time after his debut in the Virginia assembly, he was appointed an executor by the will of a deceased neighbour, whose estate happened to be involved in considerable litigation. In the execution of the task committed to him, he was obliged frequently to be in court; and to his counsel discovered a wonderful aptitude in business. His wariness, industry, correct apprehension of the testimony necessary to gain his ends, his method in preparing his cases for trial, and unerring anticipation of his antagonists, left nothing to be done by his counsel. Thus he developed the qualities essential to success in a lawyer or advocate. Those who witnessed the display of his talents, in the capacity of client, had the generosity to encourage their cultivation. They persuaded Mr Henry to prepare himself for the practice of the law. Though now considerably forward in years, and past the time most suitable to lay the foundation of eminence in any profession, he yielded to their persuasion, and actually commenced the study. In a short time he underwent examination, was found duly qualified, and enrolled one of that very honourable and useful fraternity, to which the people of the United States are much indebted for the great and inestimable blessings they enjoy. It is but justice to the memory of Mr Henry, to state, that he contributed much to enhance the respectability of the profession he selected and pursued; and, more perhaps than any other individual, to remove from the public mind an unreasonable prejudice against lawyers. He embarked in the practice immediately after his admission, and, contrary to his own expectation, for he was a man of little vanity, and of great humility in the estimation of himself, advanced suddenly to the first eminence. He became particularly famous as a criminal pleader. He was employed in every important case in his usual circuit, and generally on his own terms. Indeed so imposing was his fame, that he was frequently engaged in distant circuits; and no litigant conceived his cause safe when opposed by the peculiar talents of Mr Henry.

In 1774, he was appointed one of the deputies from Virginia in the first congress of the confederated colonies; and was a member of the committee of that body who drew and reported the petition to the king, which was afterwards voted. In May of the following year, Lord Dunmore, governor of Virginia, caused to be conveyed on board of a transport vessel a quantity of powder from the public magazine at Williamsburgh, to secure it from seizure by the citizens. Mr Henry assembled several volunteer militia companies, of Hanover and Prince William counties, and marched to Williamsburgh, with the avowed determination to compel a restitution of the powder to the magazine, or to enforce payment for it upon a fair valuation. His purpose was completely effected. To avoid the more serious alternative, the receiver general gave a bill for the amount, and the powder, from prudential motives, was retained by the governor. The spirit and decision of Mr Henry on this occasion left no room for hesitation. He submitted a choice of alternatives, which were, *restore*, *pay for*, or *fight for the powder*.

Lord Dunmore, foreseeing an approaching crisis, fortified his residence, and issued a proclamation against those concerned in the late enterprise, charging them with rebellious practices. The governor's proclamation only produced a counter-declaration. The people immediately thereupon assembled in county meetings, testified their approbation of Mr Henry, declared his conduct patriotic, and exchanged pledges to protect him against the vengeance of the governor. Lord Dunmore having departed for England in 1776, Mr Henry was chosen governor of the commonwealth. In this office he continued several years, using all means in his power to promote the freedom and independence of his country.

In the year 1778, the aspect of the revolution became exceedingly gloomy. Several dangerous intrigues were instituted to pull down the popularity of general Washington, and supplant him in the command of the army. One of the most serious occurrences of this sort was a cabal of general officers, members of congress, and some influential citizens. Their scheme against the amiable chief was to be effected by the circulation of anonymous letters to distinguished and influential gentlemen in various sections of the country, suggesting objections against the military conduct and character of the commander in chief. One was addressed to governor Henry, a man universally reputed a patriot of the first energy and influence. With his wonted shrewdness, he instantly discerned, through the anonymous disguise, the real motives of the authors. He concluded at once that the letter covered sinister, ambitious, and traitorous designs against his friend, in whom he continued to repose immutable confidence. With the magnanimity that belonged to his noble heart, a promptitude inspired by his devotion to the cause of liberty, and an indignation at the manner in which his own integrity had been assailed, he decided against the calumniators of Washington; and, to apprize him of the danger that surrounded him, communicated the anonymous libel to him, with such remarks as the occasion required. The correspondence between the two friends on this occasion was equally honourable to the candour, prudence, and intelligence of both.

Mr Henry retired from the government of Virginia, and sought some repose from the labours of public life, in the bosom of his family, and in the society of his neighbours; but his heart continued earnestly importunate for the success of the revolution. While in retirement, his conversation at home, and his correspondence with public functionaries at a distance, imparted instruction, and inculcated zeal and perseverance in the great cause of national liberty.

In 1788, Mr Henry was a member of the convention in Virginia, which so ably and eloquently discussed the constitution of the United States, and the expediency of its adoption. The part he took in the convention is familiar with the public. He employed his masterly eloquence, day after day, in opposition to the proposed constitution. His hostility to it proceeded entirely from an apprehension that the federal government would swallow the sovereignty of the states; and that ultimately the liberty of the people would be destroyed or crushed by an overgrown, ponderous consolidation of political power. Mr Henry would cordially have delegated to the government of the United States, a few specific powers, to preserve reciprocal interests, and constant alliance among the several states; and to regulate the relations of the whole with foreign nations. This in a few words was the government he wished to see adopted. Every feature in his opposition to the constitution cannot here be traced. It is enough to affirm, that he opposed it from pure and patriotic motives, a fixed hatred of despotism, jealousy of political power, and a constitutional enthusiasm in behalf of liberty. That such were the motives of his conduct, his future deportment amply testified. The constitution having been adopted, the government organized, and Washington elected president, his repugnance was measurably abated. The chapter of amendments considerably neutralized his objections: but nevertheless it is believed, that his acquiescence resulted more from the consideration of the citizen's duty, confidence in the chief magistrate, and a hopeful reliance on the wisdom and virtue of the people, rather than from any material change in his opinions. It is worthy of remark, that, in relation to the federal government, Mr Henry and Mr Hamilton, two of the most eminent men who have ever lived in the United States, entertained opposite fears. The first dreaded its energy; the latter its imbecility. Many will suppose that experience has already shewn, that the jealousy of the powers delegated to the general government was morbid and fantastical: but it may be remarked, that a few years, characterised by fortuitous circumstances, is not an alchemy to analyze the properties of any form of government. The experience of the United States has shewn, in the period of twenty-eight years, that their government is energetic or feeble, according to the heads and hearts of their chief magistrates. This is probably true of every government.

In August 1795, Mr Henry was nominated by president Washington, secretary of state, in the room of Mr Edmund Randolph, resigned; but considerations, wholly of a private nature, induced him to decline the honour. In the course of the succeeding year, he was again elected governor of Virginia. He entered on the duties of the office: but in a few months retired to his domestic circle. Early in the year 1799, Mr Henry was selected by president Adams joint envoy with Messrs Ellsworth and Vans Murray to France. His advanced age, increasing debility, and a severe indisposition, with which he was at the time afflicted, obliged him to decline the appointment. In the spring afterwards, at the special solicitation of general Washington, he became a candidate, in the district composed of the counties of Halifax, Charlotte and Prince Edward, for a seat in the senate of Virginia. Events preliminary to the election are memorable. At the same election Mr John Randolph, for the first time, declared himself a candidate, in the congressional district of Buckingham, Cumberland, Prince Edward, and Charlotte, for a seat in the house of representatives of the United States, in competition with Mr Clement Carrington, a federalist, and Mr Powhatan Bolling, a democrat. In canvassing before the election, Mr Randolph encountered Mr Henry, and his competitors for the honour of a seat in congress. It is a custom in Virginia for candidates to harangue the people in support of their personal pretensions and political principles. Mr Henry and Mr Randolph, on this occasion, conformed to this custom, and were publicly exhibited as political combatants, before the voters of Charlotte county. They met at the court-house, and supported a long and animated discussion of various topics. Mr Henry, in opening, maintained his long established reputation as a declaimer. On finishing his harangue, he literally descended into the arms of the obstreperous throng, and was borne about with triumphing exultation. His opponent might well have been deterred from ascending the stage: but his courage decided otherwise. Mr Randolph rose in the face of the success of his predecessor. His singular person and peculiar aspect; his novel, shrill, vibratory intonations; his solemn, slow-marching, and swelling periods; his caustic crimination of the prevailing political party; his cutting satire; the *tout ensemble* of his public *debut*, soon calmed the tumultuous crowd; and inclined all to listen to the strange orator, while he replied at length to the sentiments of the old favourite. When he had concluded, loud huzzas rang through the welkin. This was a new event to Mr Henry. He had not been accustomed to a rival; and little expected one in a beardless boy; for such was the aspect of the champion, who now appeared to contend with him for the palm which he was wont to appropriate to himself. He returned to the stage and commenced a second address, in which he soared above his usual vehemence and majesty. Such is usually the fruit of emulation and rivalship. It has been admitted, that Mr Henry displayed his greatest splendour on this occasion. He frequently adverted to his youthful competitor with parental tenderness; complimented his rare talents with the liberality of profusion; and, while regretting what he deprecated as the political errors of youthful zeal, actually wrought himself and his audience into an enthusiasm of sympathy and benevolence that issued in an ocean of tears. The gesture, intonations, and pathos of Mr Henry, operated like an epidemic on the transported assembly. The contagion was universal. An histerical phrenzy pervaded the whole audience to such degree, that they were at the same moment literally weeping and laughing. At this juncture the speaker descended from the stage. Shouts of applause rent the air, and were echoed from the skies. The whole spectacle, as it really was, would not only mock every attempt at description, but would almost challenge the imagination of any one who had not witnessed it. With a recollection of the event, Mr Randolph, eighteen years afterwards, in his place in the house of representatives of the United States, speaking of the general ticket law, which was carried by the democratic party by a majority of five votes only, in the popular branch of the Virginia assembly, said: "Had Patrick Henry lived, and taken his seat in the assembly, that law would never have passed. In that case the electoral vote of Virginia would have been divided, and Mr Jefferson lost the election. Five votes! Mr Chairman!

Patrick Henry was good for five times five votes." In the contest above mentioned, Mr Henry was elected to a seat in the senate of Virginia, and Mr Randolph a representative in congress. Mr Henry, however, did not live to take his seat. He died at Red Hill, in Charlotte county, on the 6th of June, 1799, aged sixty-seven years.

In private life Mr Henry was as amiable and virtuous, as he was brilliant in his public career. He was an exemplary christian; and his illustrious life was greatly ornamented by the religion he professed. His memory will be dear to every believer in the sacred Scriptures, for the steady and fearless example he exhibited in the observance of religious duty. In every situation he was studiously respectful of religious characters. He was accustomed to speak of the providence of God, which was munificent to him, in the most grateful and submissive terms. His conversation, private letters, and public speeches, evinced a constant and reverential regard of the Deity; and, many years before his death, he spent much of his time in religious reading and reflection. The Bible commanded his cordial accredence; and he was accustomed to say to his friends, and especially to his sons, that its rejection was certain evidence of a depraved understanding and corrupt heart, frequently the presage of infamy in this world, and always the harbinger of adversity in that which is to come. He was benevolent and hospitable to ministers of the gospel, whom he regarded as the heralds of peace and good will among men. He considered them not only necessary to the prosperity of the church, but greatly beneficial to civil society. In the temperament of his heart he was ardent, and, on all subjects which interested his feelings, his sentiments were expressed with energy and pathos. In his rhapsodies on freedom and religion, he would say, that, without the Bible and ministers, liberty would become licentiousness, and man more savage than the roaming tigers. In short, he was decided in the sentiments, that there was no liberty without religion; that christianity was the source of every human blessing; that without it there was no morality, nor restraint on the passions of the heart; that there never was, nor could be, a free and happy people, who did not assume the christian religion and its precepts as the basis of civil authority; and that the banners of the cross were the only standard under which men could be directed to a happy destiny. In consonance with these sentiments, he also declared that the infidel is a rebel against God and a traitor to mankind; that licentiousness, anarchy, and despotism, are the consequences of sin, and the offspring of hell; and that ruin would ever be the end of every empire, whose government is founded alone on the blind philosophy of free thinkers, and on the light of human reason.

Mr Henry abhorred human slavery in every shape. In a letter to a friend he expressed his feelings and sentiments on the condition of Africans in the following manner: "Is it not amazing, that, at a time when the rights of humanity are defined and understood with precision; that, in a country, whose inhabitants, more than those of any other, fondly cherish a love of liberty; that, in such an age, and in such a country, we should find men. professing a religion the most humane, mild, gentle, and generous, adopting a principle as repugnant to humanity as it is inconsistent with the Bible, and acquiescing in a practice wholly destructive to liberty? Would any one believe, that I am master of slaves—slaves of my own purchase? I am drawn along by the general inconvenience of being here without them. I will not, cannot justify it. I believe, I hope a time will come, when an opportunity will offer to abolish the lamentable evil. Every thing we can do is to improve it, if it happen in our day; if not, let us transmit to our posterity, together with our slaves, a pity for their unhappy lot, and an abhorrence of slavery."

Mr Henry, like Washington, was never out of the United States. He had no attachment to office; but uniformly preferred private life to public stations. He could only be diverted from his preference by imperious duty to his country, and the generous desire of benefitting mankind. Hence it will be found that he occupied comparatively few public stations, either in the state or general government. It is not more wonderful than true, that he never accepted of any office under the government of the United States, though frequently solicited, and more than once appointed. He accumulated a great estate by the practice of the law, and a judicious application of his time, genius, and industry. As his ambition never ran on offices and salaries, he never imbibed those morbid, baneful party feelings, which have too frequently engrossed the motives of public men, and seriously prejudiced the prosperity of the United States. In a letter to a friend, written a few months before his death, he used the following terms: "I deprecate the violence of parties in Virginia; and lament French infidelity, manners, and politics. I am too old and infirm to undertake public concerns. I live much retired, amidst a multitude of blessings from the gracious Ruler of all things, to whom I owe unceasing acknowledgments for his unremitted goodness to me: but if I were permitted to ask that one more might be added to the catalogue, it should be, the pleasure of seeing my countrymen learn wisdom in this their day, and know the things that pertain to their peace."

E. H. Cummins, A. M.

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HENZUAN or HINZUAN. See Johanna.

HEPATICÆ. See Fuci and Lichen.

HEPATITES. See Medicine.

HEPTACHORD *major*, in music, an interval, whose ratio is $\frac{8}{15}$, = 555 Σ + 11 f + 48 m, or the *Major* Seventh, which see.

Heptachord *minor*, has the ratio $\frac{5}{9}$, = 519 Σ + 10 f + 45 m, or the *Comma redundant minor Seventh*, which see.

Heptachord *minor* of Galileo, has the ratio $\frac{9}{16}$, = 508 Σ + 10 f + 44 m, or the *Minor* Seventh, which see.

HEPTAGYNIA. See Botany.

HEPTAMERIS, or Eptameris. In the new musical notation of M. Sauveur, which he had laid before the Academy of Sciences at Paris in 1701; he assumed, that the reciprocal logarithm of the octave may, without sensible error, be taken to be .301, instead of .3010299,9566; and which number of his being divisible by 7, he called each of these seventh parts of the octave a Meride, (see that article,) whose recip. log. = .043; and each of these 43d parts of the meride, or 301st part of the octave, he called a Heptameris. This interval is therefore = 2.04057055Σ; its common log. = 9989999,0035, which M. Sauveur assumed to be .9990000 0000, or 2.0403712Σ: it is equal .00332226 × VIII, = .185374 × c: he again divided his heptameris into ten equal parts, and called each of these a Decameride. See that article.

HEPTANDRIA. See Botany, vol. iv. p. 79, 81, 191.

HEPTARCHY. See England.

HERACLEA. See Greece.

HERACLIDES. See Greece.

HERALD. In the histories of the heroic ages, we find important functions ascribed to those officers whom the

Greeks call κηρυκεσ, and the Romans *feciales*. Their character is represented as sacred and inviolable; and in Homer, their common epithet is "*the divine*." Their duties were not less numerous than important. They could enter without difficulty into cities that were besieged, and mingle without danger among contending armies. They summoned the chiefs to the council; they commanded silence, that the discourses of the kings might be heard; and presented to each of them the sceptre before he commenced his harangue. The herald was charged with the most delicate missions, and accompanied his prince on the most difficult occasions. Agamemnon sent only Talthybius and Eurybates to bring Briseis from the tent of Achylles; and when Priam went to beg the body of his son, he took no one with him but his herald. The herald was distinguished by a long rod or sceptre, which he carried in his hand; and from this circumstance it was, that the Romans gave him the name of *caduceator*. Eckhel has published a beautiful medal of Crotona, from which we may judge of the dress of a κηρυξ, at a time much later than the age of Homer. He is arrayed in a long tunic like that of a priest, and holds in his hands a *patera* and a *caduceus*. The *patera* denotes a libation or offering to the gods, a function with which the heralds were frequently charged. According to Eckhel, this herald is in the act of demanding peace, and the coin was most probably struck at the time when the people of Crotona, humbled by a severe defeat, were obliged to send envoys to beg peace of the Locrians. The attitude of stretching out the right hand seems to have been considered as consecrated to the use of heralds; and it is on this account, that, on the imperial medals, the emperor is commonly represented in the same position, when he announces peace and security to his people.

The use of heralds was very long preserved among the Greeks. There were heralds whose office it was to proclaim the laws observed at the olympic games, the names of the combatants and the victors, and, in general, every thing which was commanded by the judges of the games. The best account of the κηρυξ of the Greeks, and the FECIALIS of the Romans, is to be found in the works of Grævius and Pitiscus: or, if ancient authors be preferred, in Homer throughout: in Livy, i. 32; Cicero *De Legibus*, ii. 9; and Dionysius Halicarnass. lib. 2.

In the middle ages, also, the heralds perform a part of considerable importance. The origin of their name seems to be entirely uncertain, and it is difficult to say which of the sixteen theories mentioned by Edmonstone is the most ridiculous. The date of their institution in the form of a college, in most of the European kingdoms, is equally obscure. The first king of arms of whom mention is made in the French chronicles, is Robert Dauphin, who was alive A. D. 1031. But the conjecture seems by no means unlikely, that the French borrowed the idea of a regular body of men charged with the care of armories, processions, and ceremonies, from the *veterani* of the empire. See *Bertrand Caprioli*, under the word MILITIA, as cited by Upton *De Militari Officio*, lib. i. cap. 8. In England it does not appear that any such officer as the herald was ever employed on missions by William the Conqueror, or either of his sons. Yet there can be no doubt that the office was familiar to Robert Curthose and Richard Cœur de Lion, both of which princes were so renowned in the wars of the cross, and had so many opportunities of mingling with foreign kings, in whose countries the heralds were already openly protected by the law. Very shortly, at all events, after this period, we find the heralds in full possession of all the privileges to which they ever attained, either in this island, or on the continent. They were allowed free entrance into the courts of all princes and great lords; they had power to reprove the faults of nobles, knights, and esquires; and if these did not amend, to exclude them from all tournaments and martial exercises. It belonged to the heralds to advertise knights and military commanders of the day of battle, to attend their sovereign's great standard in their best ornaments. They were, during the battle, to retire to an eminence, to witness what was done on either side, and report to the king or general those who behaved most valiantly, and commit the same to writing. When the battle was over, it was their province to number the dead, to ransom the prisoners, to summon cities, and, in case of composition, to march before the captain or governor, for security of his person. At justs and tournaments, it was the office of the heralds to carry all challenges, to lay out the lists, and assign places to the combatants. Such as wronged them, and refused to give full satisfaction, were declared guilty of high treason, and punished accordingly. An instance of which occurred in Scotland, A. D. 1515, when the Lord Drummond was solemnly forfeited in parliament, *Eo quod Leonem armorum regem pugno violasset cum eum de ineptiis suis admonet;* and it was upon that lords's humble submission, and at the earnest intreaty of the Lyon himself, that he was restored.

The society of heralds in England, consists of four kings of arms, who are called *Garter King at arms*, *Clarencieux*, *Norroy*, and *Bath*, whereof the first and last derive their names from the two orders of knighthood to which they owe their establishment; and the other two are provincial kings of arms, Clarencieux having power over all the east, west, and south provinces, as far as the river Trent; and Norroy, in like manner, over all parts of England north of the Trent; six heralds, viz. Somerset, Chester, Windsor, Richmond, Lancaster, and York; four *pursuivants*, who may be considered as the apprentices of heraldry, viz. Ronge-dragon, Portcullis, Blue-mantle, Rouge-croix. All these persons, (kings, heralds, and pursuivants) are by the King himself, or Earl Marshall, "crowned with crowns, graced with colours, attired with coats, named by names of addition, and with other ceremonies created."

In Scotland there is one king at arms, who derives his name of *Lyon* from the bearing of our kings. Under him are six heralds distinguished by local names, viz. *Snawdon*, *Albany*, *Rosse*, *Rothesay*, *Marchmont*, and *Ilay;* and five pursuivants, viz. *Unicorn*, *Carrick*, *Kintyre*, *Ormond*, and *Bute*. Besides these, the great nobility in England and Scotland had formerly heralds and pursuivants attached to their own service: as *Blanche Lyon*, the herald to the Duke of Norfolk; *Lion d'or* to the Dudleys; *Percy herald* to the Earls of Northumberland, &c. Le Laboureur is of opinion, that counts and high barons, who are not princes, may have heralds and pursuivants; and that knights bannerets may have pursuivants only, unless they be invested with some high dignity, as marshal or general of the army: (See *Origine des Armoiries*, p. 121.) The king of arms in France, was always known by the name of *Mont-joye St Denis*. His heralds, to a considerable number, derived their names from the different provinces of France; and his pursuivants were called, *Plain chemin*, *Voir disant*, *Haut-le-pied*, *La verdure*, *Gaillard-bois*, &c.

See Æneas Sylvius *De Officio Heraldorum*. *De l'Office des Rois d'Armes*, &c. par Marc de Vulson de la Colombiere, Paris, 1645; and particularly the *Traité du Roi René*, which is there printed; *Le Theatre d'Honneur*, par André Favin; and Edmonstone's *Heraldry*, vol. i.

# HERALDRY.

1. The art of the herald, known also by the names of "the art of blazon," "the art armorial," and "the art noble," consists, strictly speaking, in the knowledge of armories, and their due application, as ensigns of honour, and tokens of descent. The meaning of the term, however, is often extended, so as to include the knowledge of the ceremonial to be observed in all public assemblies of those who bear arms; such as cavalcades, processions, and the like.

*On the Origin of Armories.*

2. No subject has given rise to greater diversity of opinion among antiquarians, than the origin of armorial ensigns. The writers of the 16th and 17th centuries, who still continue to be the chief authorities on this subject, seem in general to have been infected with the desire of adding new consideration to their favourite pursuit, by maintaining that the art of blazon, so far from being the production of the middle ages, had been framed by the first masters of science among mankind, and practised in a manner little different from that of their own times, by the most polished nations of antiquity. The disquisitions of several great French and English heralds, indeed, and particularly those of Father Menestrier, had gradually brought into contempt the dreams of their more enthusiastic predecessors; and it appeared, that such fanciful opinions were wholly exploded among men of sound understanding, till of late years some of the most ridiculous of them have been revived in all their original extent, and defended with a show of learning more imposing than had ever before been called into their service, by a French writer of eminence, M. Court de Gebelin, in the 8th volume of his *Monde Primitif*. This ingenious author does not, indeed, after the example of Mr Sylvanus Morgan, commence his treatise with a description of the armorial bearings of the first parents of our race. He does not affirm, that "Abel quartered with his paternal escutcheon, *argent an apple vert*, for his mother Eve, who was an inheritrix;" nor mention Joseph, as receiving "an honourable augmentation to his coat, in consequence of his being invested with the family order of Pharaoh king of Egypt." But he is seduced, by his fondness for a very untenable theory, into absurdities scarcely less glaring than these, when he talks seriously of the word *ingenuus*, as equivalent to "a person who has a right to armorial bearings;" and refuses to perceive any difference between the personal or political emblems of the Greeks and Romans, and the systematic heraldry of the modern nations of Europe.

3. Since, however, the subject has so lately been agitated by a writer of such learning and reputation, it may not be amiss to examine somewhat more at large into the merits of the case, by investigating not his opinion alone, but the more probable of all those theories which have been supported by the most eminent of the heraldic authors. According to many of these writers, the use of armorial bearings was the invention of the ancient Egyptians; and in support of this opinion two passages from Diodorus Siculus are alleged; in the first of which it is said, that "Anubis and Macedon, the sons of Osiris, were the first who carried in war marks of distinction, taken from certain animals, symbolic of their valour," (*Bib. Hist.* lib. i.); and in the second, that "the Egyptians, observing that their troops were liable to be scattered in battle, invented certain signs, by which they might be able to recognize each other. And that making use of the figures of animals for this purpose, such a veneration was by degrees conceived for these images, that the animals themselves came to be considered as sacred and inviolable beings."

A second set of writers assert that this art took its rise among the Hebrews; and the Rabbins of later times have been at pains to lend all their learning to the defence of this opinion, by blazoning, in the most scientific manner, the coats-of-arms of all the principal personages mentioned in holy writ.* The only passage of Scripture which they seem to quote with confidence in support of their theory, is Numbers ii. 2. "Every man of the children of Israel shall encamp by his own standard, with the *ensign* of his father's house." But the weakness of any argument derived from this text will be sufficiently manifest in the sequel.

The third opinion is that of those who ascribe the first practice of heraldry to the ancient Greeks. And the defenders of this doctrine never fail to cite with great exultation those verses of the ΕΠΤΑ ΕΠΙ ΘΗΒΑΙΣ, in which Æschylus describes the bucklers of the seven Captains of the assailing army.

The fourth opinion is, that the practice of using armorial bearings was never reduced to any regular system till Augustus instituted legionary marks of distinction, and caused these symbols to be engraved and painted on the shields of his soldiers.

Fifthly, It is by no means an uncommon theory, that Charlemagne was the first patron of the heraldic art, in as much as after regulating the dignities and offices of the imperial palace, and establishing the order of peers, he instituted certain marks of honourable distinction, by which the great personages of his court might every where be recognised. It is true that the history of St Louis, by Joinville, speaks of armorial bearings conferred by Charlemagne on the Viscounts of Conserans, of the house of Comminges, and that the romances are full of those of Orlando, and the other heroes of that age. But it is fair to mention, that these authorities are equally conclusive respecting the coat-armour of Arthur, and the knights of the round table; so that the claims of Charlemagne to the honour of this institution are somewhat dubious, even by the admission of his most strenuous admirers.

A sixth party ascribe the origin of these insignia to the wars which the Franks carried on in the East against the infidel possessors of the Holy Land; and derive many arguments in support of their opinion from the ancient charters for the foundation and endowment of monasteries.

Seventhly, The Italians are unanimous in fixing the origin of the art in the times of the Emperor Frederic, when their country was torn in pieces by the rival factions of the Guelphs and Gibbelines. The Germans, in the last place, are equally zealous in carrying it back to the days of Henry

* To such a degree had these follies prevailed, that Father Menestrier complains very feelingly of the interruption which the meditations of pious readers must have received from the perpetual blazoning of the arms of St Gregory, St Augustine, &c. on the margin of prayer books, "Comme si l'on ne pouvoit pas assez pieusement lire une priere dans ces heures sans voir le blazon du Saint pere qui en avoit fait usage le premier."

the Fowler; and think they have sufficient evidence of the justice of their opinion, in the accounts which have come down to us of the ancient tournaments of Germany. The truth is, that it is by no means an easy matter accurately to ascertain the origin, or trace the progress of things which derive their authority from chance and the insensible influence of custom, rather than from reason and the positive institutions of legislators.

4. It is quite evident, that painted shields and military ensigns of some sort, are coeval with the art of war itself. Jews, Egyptians, Greeks, Romans, and Barbarians, must all have made use of some tokens, by which the warriors of the same nation might distinguish each other in battle. But there seems to be little reason for doubting that these people were familiar with the use of simple devices alone, or fanciful figures, which were not intended either to distinguish one family from another, or to mark the nobility of those who bore them. So little, indeed, is their nature ascertained, that the same things have been taken indifferently for devices, for emblems, for hieroglyphics, for symbols, and for armorial bearings, as may easily be seen in the treatises of Pierius, of Minos, of Ruscelli, of Bargagli, of Vulson de la Columbiere, and of Father Caussin, who all contrive to twist the same facts into evident testimonies of the truth of the most inconsistent theories. The dove of the Assyrians is, according to all the interpreters of the Scriptures, a figure of Semiramis. Yet this same dove is with Pierius a hieroglyphic, with Alciatus an emblem, with Bargagli a device, with Caussin a symbol, and with M. de la Colombiere a coat of arms. The error of all those who maintain the high antiquity of heraldic bearings seems to have arisen from the circumstance, that a few instances have been preserved by the poets and historians, in which these personal devices had, from some extraordinary causes, become hereditary and transmissible.

5. Aventinus, descended from Hercules, carried a hydra on his buckler; and one of the Corvini is mentioned by Silius Italicus as having the raven of his ancestors for his crest. In Ovid, Egeus recognizes his son Theseus by the marks of his family on the pommel of his sword. Hypolitus carried, in the same manner, the marks of his birth; and the children of Jason and Hypsipilus bore as their device the ship of the Argonauts. See *Æneid*, 7.

> ——Victores ostentat equos satus Hercule pulcro
> Pulcher Aventinus, clypeoque insigne paternum
> Centum angues, cinctamque gerit serpentibus Hydram.

See also *Sil. Ital.* l. 5.

> Corvinus phæbæa sedet cui casside fulva
> Ostentans *ales* proavitæ insignia pugnæ.

Ovid *Metam.* 7.

> Cum pater in capulo gladii cognovit eburno
> Signa sui generis.

Seneca in *Hypolito.*

> Regale parvis asperum signis ebur
> Capulo refulget gentis Actææ decus.

6. In like manner, we meet with marks of *dignity* among the ancient writers, the "χξυσεος επι της πελτης αετος," was the well-known cognisance of the Median and Persian kings. (Xenophon's *Hellenics*, l. 1.) All these authorities shew that there were figures on the bucklers of the ancients, on the guards of their swords, on their helmets, their standards, and their cuirasses; but they by no means prove that these figures were armorial bearings in the technical sense of the word. The hereditary nature of some of their bearings, merely shews the anxiety of superstitious men to trace themselves to the lineage of the gods; as for instance Coraxes, who made his soldiers bear a thunderbolt on their shields, because he believed himself descended from Jupiter. The verses of the poets whom we have cited, prove nothing more than that certain warriors adorned their shields, and the pommels of their swords, with certain images representing the great actions of their ancestors.

A gentleman who should preserve the cavalry-horn which had been carried by his father in some celebrated war, might call it *insigne paternum*; or if it had belonged to his great-grandfather, he might call it *pro-avitæ insignia pugnæ*, and yet all this might have nothing in common with the family arms. Chryxus carried on his shield a representation of the siege of the Capitol, and the Gauls weighing the gold of the Romans, to shew that he was sprung from Brennus.

> Ipse tumens atavi Brenni se stirpe ferebat
> Chryxus et in titulos capitolia capta tenebat
> Tarpeioque jugo demens et vertice sacro
> Pensantes aurum Celtas umbone ferebat.
> *Sil. It.* 4.

Yet who would think of asserting that the Capitol, and Gauls weighing gold, were the armorial bearings of Chryxus? Whoever maintains this, must admit that all the images and figures of ancient casques, cuirasses, and shields, were armorial bearings in the same manner as these, and he will find not a few who bore the whole history of a country, or a few dozens of the metamorphoses, for their blazon. It seems evident then, that all these authorities prove nothing concerning the origin of heraldic bearings, more than they do concerning that of emblems or of devices; because the signs of which they make mention do not appear either to have been fixed in their forms, or of any determined colour, or universally hereditary. The far greater part appear to be the mere fictions and ornaments of poetry; such as the chimera on the casque of Turnus; Io changed into a cow; Argus who watched her; and Inachus with his urn, from which a stream descended on his buckler. *Æn.* 7.*

7. The pretended arms of the tribes of Israel are entirely the reveries of the Rabbins of the later times, who have amused themselves with imagining these figures, on the authority of certain allegorical expressions of which Jacob made use, to predict to his children the fortunes of their descendants. They assign to the tribe of Judah a lion, because he said to one of his sons, "Judah is a lion's whelp; from the prey my son thou art gone up," &c. *Gen.* xlix. 9. And to that of Zabulon an anchor, on account of this prophecy, "Zabulon shall dwell at the haven of the sea." *Gen.* xlix. 13. And as they have not been able to find any thing very appropriate for Reuben in the malediction of his father, they blazon for him the mandrakes which he presented to his mother Leah.

To say nothing of the evident absurdity of all this, the authors in whose writings these bearings are mentioned are

> * At levem clypeum sublatis cornibus Io
> Auro insignibat, jam setis obsita, jam bos
> Argumentumq. ingens, et custos virginis Argus
> Cælataque amnem fundens pater Inachus urnâ.

very far from being consistent among themselves. Some give to Dan an eagle, others a serpent, and some an eagle choking a serpent. Barnabas Moreno de Vargas, indeed, blazons all the tribes of Israel in a manner different from what has been mentioned above; as, "Los de tribu de Reuben porque su padre lo comparo al aqua posieron por armas unas ondas de aqua: Los de Zabulon pusieron una nave," &c. *Discurs.* 18. *De la Noblez.*

8. Neither does there appear any greater certainty among the Greek writers. Ulysses, in Lycophron, carries a dolphin on his buckler, and is accordingly styled δελφινοσημος; but Homer assigns to him the figure of the giant Typheus. Agamemnon, in the Iliad, carries the gorgon's head, but, in Pausanias, the head of a lion; and elsewhere we find him described with one dragon on his helmet and three on his shield. As for the celebrated shields of the seven chiefs against Thebes, it is rather amusing to find, that, after all the many arguments which have been founded on the accurate account of them in Æschylus, that great poet does not coincide, in any one particular, with the equally minute and laborious description of Euripides.

Even when the authors are perfectly consistent, the utmost that can be made out of their report is, that these warriors bore certain emblems, which may perhaps have had some mystical meaning; but can never be proved to have been marks of noble birth, as our armorial bearings are, even though some of them may have passed from father to son; otherwise we must believe, on the credit of Suetonius, that the Domitian family carried a *beard or* for their arms; because the historian, in order to mark that a red beard was a common feature in that family, says—"Quod *insigne* mansit et in posteris ejus, et magna pars rutila barba fuerunt." (Sueton. *in Nerone*, c. 1.) And yet nothing can be more certain, than that passages in ancient authors, of a complexion exactly similar to this, are the only authorities for half the *armorial bearings* of the Greeks and Romans. Because Seleucus had a mark on his thigh which resembled an anchor, he and all his descendants are said to have borne an anchor for their arms. It is wonderful that Augustus is not alleged to have blazoned on his shield the Ursa Major, since it is well known that he had on his back as many moles as there are stars in that constellation, and arranged in the same manner: (Sueton. *in Aug.*) The figures on the legionary shields of the time of Augustus were exactly of the same nature with those of the Greeks of the heroic ages, or of the Egyptians, Anubis and Macedo. And, upon the whole, if we lay aside the dreams of enthusiastic heralds, and scholars equally enthusiastic, who will not condescend to allow to the moderns the honour of inventing even the arts which they themselves despise, we believe we shall find that to be the most rational theory which maintains, that armorial bearings were invented in the 10th century, perfected in the 11th, and have accordingly been for about seven hundred years only, in any part of the world, the distinguishing marks of families, and of noble birth.

9. In many parts of Europe, there remain tombs of princes, lords, and gentlemen of every degree, more ancient than the year 1000; and yet in no one of these can the smallest trace of armorial bearings be discovered. The most indefatigable antiquaries have explored Italy, Germany, Flanders, and the various provinces of France and England, without the least success; and have been obliged to confess, that neither in manuscripts, nor upon the gateways, and vaults of castles, nor upon the altars of the most ancient cathedrals, have they been able to find any thing more early than the well known arms of Varmond, Count of Vasserburg, on his tomb in the church of St Emeran at Ratisbon. He is represented as lying on his back upon his tomb, with a lance in his left hand, and on his right his shield without ornaments—"Coupé of argent and sable, and over all a lion, with this epitaph on the border of it: Anno D'ni MX. in die S. Leonis PP Dnus Varmundus nobilis comes de Vasserburgh qui huic monasterio dedit Hofmarchiam in Vogterrerent hic sepultus." There is even some reason for suspecting, that this tomb has been rebuilt by the religious of the abbey. All the tombs of the 7th, 8th, and 9th centuries, have simple inscriptions with the image of the deceased. The greater part of those of the 10th and 11th centuries also are without arms; and the practice of representing them on tombs does not appear to have universally prevailed till the 12th century. The first Pope who can be proved to have borne arms is Boniface VIII. of the house of Cajetano, whose escutcheon is in the church of St John Lateran, and in the vaults under St Peter's at Rome. The bearings of all the Popes before him are now ascertained to have been the inventions of Ciaconius, Antonio Cicarello, and Gian Baptista Cavalieri. Coins before the year 1200 have no arms. The seals of princes and kings before that time bear nothing more than their effigies, and those of bishops and chapters representations of the tutelary saints of their churches; as, for instance, those of the Popes, which bear commonly on the one side the heads of St Peter and St Paul, and on the reverse the name of the pontiff.

10. If, before these times, the figures on bucklers had been hereditary and fixed in so many families, why happens it that the sons of so many heroes never carried the devices of their fathers, and the glorious marks of their illustrious achievements? Whence comes it, that when notice is taken of Helenor being introduced in the 9th Æneid without any ensign on his shield, a sufficient answer is supposed to be given, by saying, that young men, who had as yet done nothing illustrious, carried shields without ornament? Could they not then, as at present, carry their father's bearings? The truth is, these marks were altogether personal, or else common to all the individuals of a military corps.

> Cuncta phalanx insigne Jovis, cælataque gestat
> Tegmina, dispersos trifidis ardoribus ignes.
> *Valer. Argon.* 6.

And it was on account of this latter character that they received from the Greeks the appellation of δείγματα.

It may however be alleged, (and M. Court de Gebelin has laid much stress on the circumstance,) that there are many cities, the armorial bearings of which are to be found on monuments of very high antiquity; as, for instance, those of Rome, which we every day see represented on so many basso relievos, or those of Nismes, which are so common on the reverse of medals. To this it may be answered, that these cities have, within the last seven or eight hundred years, framed for themselves armorial ensigns out of their ancient devices, and that, before that time, no examples can be found of these marks being placed on escutcheons. S. P. Q. R. was the device of the Romans; but not, as in the present day, disposed *secundum artem* on a band falling down between two fillets. The crocodile attached to a palm-tree was the ensign of Egypt conquered, which the people of Nismes put anciently on their coins, with these words abridged, *Col. Nem.*; and, accordingly, the modern city blazons the same on its public edifices. We by no means assert, that no kingdoms or republics had fixed devices before the use of armorial ensigns: on the contrary, the eagle was a common device of the Romans, and composed part of their military standards; but they had also the dragon, the minotaur, the wolf, and the swine. The lion and the eagle have in every age been the symbols of royalty; because the one is the chief of beasts, and the other of birds.*

11. It is necessary to be at all times on our guard against the monuments of heraldry which are produced by our old writers as of a date prior to the 12th century. They are in general the inventions of silly monks, who had little else to do but to gratify their own vanity, and that of their benefactors, by these harmless fictions. Much contempt, indeed, has been thrown on the whole study, by the detection of the gross absurdities which they contain, and by none more than those of the celebrated Chronicle of the Priory of Ely, long preserved in the college of the English Benedictines at Douay. In this MS. we are presented with the history of some chiefs of King Harold's army, who, after the defeat at Hastings, defended themselves for seven years in the isle of Ely. The conqueror, however, at length prevailed, and lodged 40 of his soldiers with the religious persons who had afforded an asylum to these obstinate warriors. Each soldier lodged with a monk; and the story is, that, on their departure, the brethren painted in their refectory the arms of their warlike companions, which are accordingly blazoned with great exactness on the margin of the MS. But, in spite of the zeal of Mathew Paris, the style of the writing, and also of the illuminations, is such, that the authenticity of this record has long been given up.

12. The art of heraldry, in truth, like every thing else of nature or of art, did not all at once spring up to perfection. Its beginning long preceded its universal practice, and its scientific arrangement. The ancient figures on shields, and military ensigns, were the first dawnings of the art. It may be said to have made its first regular appearance in the world at the times of the tournaments; and in all likelihood attained its utmost perfection in the period immediately following these military exercises. The name of Blazon which has always been given to this art, the form of the oldest escutcheons, the metals, the principal figures and divisions of the shield, the crests, the wreaths, the mantles, and the mottos of heraldry, all conspire to prove the general position, that the first practice of the art took place on occasion of the tournaments of chivalry. †*Blasen* is a German word, signifiying to *blow the horn;* and the reason why this name has been given to the description of armorial ensigns is, that anciently those who presented themselves at the lists of the tournament were announced by the sounding of the horn. The heralds, after having ascertained the nobility of those who offered themselves, blew the trumpet, in order to warn the marshals and their assistants, and then *blazoned* the arms of the aspirants; that is to say, that, after sounding the trumpet, they proclaimed with a loud voice the bearings of their shields. The *Rimes du tournay de Chavency*, (which took place in the year 1285.) written by Jacques Bretex, furnish an example of this usage.

Les trompeurs si trompoient
Et les Bachelers amenoient
D'armes si empapillonez
Que depuis l'heure que je fu nez
Ne vi a mongré, tel mervoilles
Un chevalier d'armes vermoilles
A cinq annets d'or in ecu.
Vi devant tous qui sans ecu
Vient a voir la premiere jouste
Comment qu'il soit ne coi qu'il couste
Si quier as autres qu'on luy doigne
Lors öi ecrier Chardoigne
Et puis Vianne a ces heraux,
Garcons glatir, huier ribaux
Chevaux hannir—tambour sonnir, &c.

In all the descriptions of jousts which Olivier de la Marche gives us, and in all those of the old romances, it is always expressly mentioned, that " les trompettes cornerent et furent faits les cris accoutumez." In describing the " Joustes de l'arbre d'or," he says, " si tost que Mondit Seigneur le Duc fut sur les rangs fut apporté le Blazon de M. le Prince d'Orange neveu de M. le Comte d'Armignac, et apres fut allé querre par le geant et par le Nain; fut par le geant presente, aux dames *et le Nain* sonna sa trompe." When the tournament was at an end, it was a common thing for the knights to hang up their arms and these horns in some church; and many still remain (or at least did within a century) attached to the great altars in the churches of Wirtsberg, Ratisbonne, Mayence, and Cologne, as Menestrier informs us, who saw them himself, and says that they were shewn by ignorant people, who understood nothing of their true nature, and contented themselves with asserting that they had belonged to Orlando, or some of the other heroes of the court of Charlemagne.

When any combatant had once made his appearance at these tournaments, which seem to have been originally held every three or four years in Germany, it was no longer necessary for him to make any proof of his nobility, this having been already sufficiently recognised, and *blazoned;* that is to say, announced by sound of trumpet by the heralds of the lists. The persons who had attained this distniction commonly carried two trumpets by way of crest, in order to mark that they were *gentlemen*, recognised and *blazoned;* and thus when the bearings of shields began to be more fixed than before, many families retained these crests of trumpets. Helmets adorned in this manner are called by Dlugossius and Simon Askolski *Galeæ Hastiludiales*, that is, helmets of tournament. (See Plate CCXCI. Fig. 1.) Many authors, indeed, explain these trumpet figures to be the trunks of elephants. But if there could remain any doubt on the subject, it would be removed by observing that those who still retain these crests, are the very families whose names occur in the ancient tournaments, as those of Bavaria, Saxony, Brandenburgh, Lutzelstein, Mecklenburgh, Swartzenberg, Die Lobl, Noppen, Talheim, Romersheim, &c.

To blazon, by a gradual transition, came among the French who had borrowed it from Germany, to signify every sort of description. Thus Jacques de Fouilloux, in his book on hunting, which he presented to Charles IX. makes in four lines what he calls the " Blason du lievre."

Lievre je suis de petite stature, &c.

Favin uses it as synonymous with "to praise," page 439. " Les habitans disent pour blasonner leur ville, &c." But we elsewhere meet with it taken *in malam partem*, as in the Chronicle of Louis the first Duke of Bourbon, where he is said, in conferring the order of the crown on his knights, to have ordered them to honour the ladies, and not to permit any one to speak ill of them—" *blasonner et mesdire.*"

* Pausanias describes the shield of Agamemnon as bearing a lion's head, with the motto, " ουτος μεν φοβος εστι βροτων ὁ δ' εχων Αγαμεμνων." *A lion crowned* is in like manner ascribed to Dieterick and the other heroes of the Sagas.

† It is proper to mention, that many are of opinion that the word *blazon* is of Oriental origin; and in the Arabic Dictionary of Gieuharis, we certainly find the word *Bladzon* with two significations, 1st, " Gens, famille, maison;" 2d, " Insignia, armoiries, symles d'une maison."—But we cannot help looking on this as merely a casual coincidence, and imagine few will deny that the German root offers so very natural a derivation, that it is ridiculous to look farther.

The word has the same significations among the Spaniards, who make it signify still farther glory itself; as in Rodrigo Mendez Sylva *Poblacion*, page 7. "Sivra sobre todo de Blazon, aver procreado al memorable cavallero Quinonez." Nothing can be more simple than the analogy by which all these meanings are derived from the primitive *blasen*. Nor is it at all to be wondered at, that the French should have borrowed this term of art from Germany, since it was in that country that the first regular tournaments were held by order of Henry the Fowler, who was either the original institutor, or at least the restorer, of these and many other exercises for the young nobility of his empire.

13. The form of the ancient escutcheons is a second proof of this origin of armorial ensigns; for they are always represented as lying on the one side, and tied up by small strings, exactly as the shields of the jousters were attached to the lists, or to the neighbouring houses, which they called "faire fenestre." They are so represented in the celebrated "Tournay de la Garthuse," in the National Library at Paris. They are also hollowed out on the right side for the reception of the lance, as may be seen in all the old monuments of the churches in Germany and Italy. From the tournaments, in like manner, is derived the custom of joining the shield and the helmet, to compose the complete armorial bearings; because they were so arranged in some cloister or public place a few days before the jousts, that the ladies might have an opportunity of seeing them. All these observations are verified by the curious treatise of René of Anjou, King of Sicily, which is printed in the Miroir de la Noblesse, by M. Vulson de la Colombiere. "All you princes, lords, barons, knights, and esquires, who intend to tilt at this tournament, ye are ordained to lodge yourselves in the city four days before the tournament, to make display of your armories, on pain of not being received at the said tournament; and your arms shall be thus. The crest shall be placed on a plate of copper large enough to contain the whole summit of the helmet, and the said plate shall be covered with a mantle, whereon shall be blazoned the arms of him who shall bear it; and on the said mantle, at the top thereof, shall the crest be placed, and around it shall be a wreath of colours, whatsoever it shall please him." "Moreover, when all the helmets are set in order after this fashion, then shall all the ladies come, and the damsels, and the lords, knights, and esquires, who shall visit them in their order, from the beginning to the end. And the judges who shall be there shall lead the ladies three or four turns, to see them well, and to examine the crests; and the herald shall set forth unto the ladies to whom this ensign pertaineth, and to whom that; and if there be any one which belongeth to any reviler of the ladies, the ladies shall touch his crest, and on the morrow it shall be sent away, and he shall have no tilting at this tournament. *Traité de la forme et manier des tournois a plaisance*, &c. *Miroir*, p. 56.

14. The colours which enter into the composition of armorial bearings are, by many authors, said to be no other than those of the ancient games of the Roman circus, which passed into the tournaments of the Gothic nations. The different factions of the hippodrome were distinguished by their colours of white, red, blue, and green. To these Domitian added yellow; and the only remaining tincture, viz. black, might be easily introduced by those chevaliers who were in use to frequent tournaments in habits of mourning, on occasions of particular distress. Thus King René of Anjou, after the unfortunate war of Naples, went to the tournament of "La gueule du Dragon," in the year 1446, clothed in complete suit of black armour, "his shield sable, semee de larmes, and a black lance in his hand."

The partitions of the shield are in like manner supposed to be deduced from the habits of tournaments, which were frequently of different colours, sometimes the one side of the garment differing from the other, sometimes the top part from the bottom, &c.; a relic of which custom may still be observed in the dresses of many provincial magistrates on the continent. From the barriers and lists, and their various parts, are taken the forms of the pale, the chevron, and the saltier. The ring or annulet is derived from the common reward of the victorious cavalier. The bend and the fess from the scarfs which the combatants wore, and which were often the gift of their ladies, as we read in the romances, the wreath and other ornaments of the helmet, are all connected with the same custom. The lady herself took care to adjust these parts of her knight's equipment, which were generally of *her colour*; and are accordingly known in the romances by the names of "faveurs des dames," "atours de dame," &c.

15. With tournaments, it is probable that the art of blazonry passed very soon into France. Many of the figures, indeed, were never introduced into the heraldry of that or of any other country, and remain at this day peculiar to Germany alone. If armorial bearings, however, were first used in Germany, it must be confessed that the French were the first to reduce the method of using them to rules. Accordingly, the only other nations which have made any progress in the art, viz. the English and the Scotch, make use of French terms. The Italians and Spaniards know nothing of the matter; and the attainments of the Germans themselves, are frankly admitted by Spenerus to be altogether contemptible. Sir Henry Spelman says expressly, that the gentry of England had no coat-armour till the time of the Norman conquest; and treats with the utmost derision the fables and reveries of those, who assign arms to the Danes, Saxons, Britons, and the pretended knights of the Round Table. The princes of Anjou, in all probability, introduced the custom into the kingdoms of Naples and Sicily, as may be seen in the treatises of Scipione Ammirato and Philibert Campanili. But although the practice of using armorial bearings may have been considerably extensive before the period of the Crusades, there can be no doubt, that these celebrated expeditions must have been at once the means of rendering their use universal among all the European nations, and at the same time of making the figures more fixed, and consequently the blazonry more scientific. Arms, it is probable, completed their hereditary character from the piety of children, which must have led them to adopt, with religious respect, any temporary devices borne by their fathers in these holy wars. The cross soon became the most common of all bearings, and its form was varied beyond every conception by the ingenuity of the heralds.

16. The heraldic writers who approach most nearly to each other, in their opinions respecting the origin of armories in general, are yet much at variance concerning the precise time of their introduction into England. It is needless to refute the statements of such writers as Stow, who can tell us gravely, that "Brute, after a long and wery journey with his Trojans, passing thorow France, building the citie of Toures, arrived in this isle, the which was then called Albion, at a place called Totness, in Devonshire, *bearing gules, two lions golde rampants a contrarie, also a bannar of Vert, a Diane of gold fichele crouned and entronised.*" Edmonstone is of opinion, that armories were probably first used in England by King Edward the Confessor, and afterwards more plentifully practised by William the Norman and his nobles. Camden, however, is inclined to think them of yet later date with us, and says, "that shortly after the Conquest, the estimation of arms began in the

expeditions of the Holy Land, when it was accounted an especial honour to retain those arms which had been displayed in the Holy Land, in that holy service against the professed enemies of Christianity, and that we received at that time the hereditary use of them; but the same was not fully established until the reign of King Henry III.; for that in the instances of the last Earls of Chester, the two D Quinceys Earls of Winchester, and the two Laceys Earls of Lincoln, the arms of the father still varied from those of the son." Sir Henry Spelman is of opinion, that arms are of a yet more modern growth in England, and says, "there is little reason to be confident in matters of pedigree and arms much beyond four hundred years," adding, "that he has his doubts as to their being entitled even to that antiquity. *Nescio an ea prorsus antiquitate.*" The period of their introduction into Scotland, must of course have been nearly the same with that of their first practice in England.

17. The custom being once fairly introduced, it is by no means difficult to see from what causes the great variety of the figures of heraldry must have arisen. Great events, or illustrious actions; the peculiarities of local situation; the partialities for particular employments, offices, dignities, and the spirit of devotion; the nature of fiefs, and the vestiges of ancient devices, factions, pilgrimages, and tournaments, must all have suggested to individuals the bearings which they adopted. Nothing, however, appears to have given occasion to more armorial ensigns, than the names of persons or of families. In every nation of Europe the effects of this practice are still abundantly apparent; yet we have no doubt the evidence would have been infinitely more striking, but for the many changes which have taken place in the names of families since the fixing of their arms. Many authors, it is true, treat with ridicule arms of this sort; but it is sufficient to observe, that Spelman, Menestrier, and Gebelin, are of a different opinion. The last indeed expressly says, that he has no doubt the armes parlantes are the most ancient of all. The original bearers of these arms, it is probable, thought their names so illustrious, that they could adopt no better means of making themselves known than devices, which would suggest these names to the beholder. Accustomed as they were to shout their names in combat, and hear them proclaimed at the tournament, it was a very natural thing to paint them on their surtouts, their shields, and the caparisons of their horses. There are very few families, whose names retain any meaning, which have not framed to themselves arms in some respect alluding to that signification. The instances of arms of this kind in our books of heraldry are innumerable. The Bollens, in allusion to the first syllable of their name, carry *argent* a chevron gules *between 3 bulls heads sable*. Pope Adrian IV. (whose proper name was Nicolas Breakspeare,) bore gules a lance broken argent. The illustrious family of the Lamberts bear 3 lambs argent; and the practice is equally evident in the bearings of the Lovets, the Bores, the Swineys, the Swintons, the Swallows, the Grifins, the Metcalfs, and the Starkeys; of Bowes, Cockayne, Dove, Askew, Arondel, Ravenscroft, Buikley, Heron, Beeston, Bird, Horsey, Cheval, Colt, Capraville, Quatremains, Borlase, Troutbec, and Godolphin. In France, the names of Ailly, Mailly, Crequy, Rubempré, Castelnau, Chabot, Gougeux, Hautefort, De la Tour, De Pontevez, De Porcelet, and De Retel, are among the most distinguished of the kingdom. Nor are their bearings a whit more significant than those of the great Italian families of Colonna, Ursini, Frangipani, Anguillara, Sanctacruce, Spinola, Cicala, Barbarigo, Negroni, &c. or of the Spanish houses of Luna, Solis, Zapata, Acuna, Quixada, Torres, and Cardona.

There are several ways in which arms may bear a relation to names. 1st, By the simple cypher or initial letter of the name; as is the case in the arms of many towns on the continent, and of the families of Montenegro in Spain, who bear an M crowned, and Awensberg in Germany, who bear an A, &c. 2d, By the representation of objects, either natural or artificial, which express the sound of the name: as the ancient sovereigns of Dauphiny and Auvergne bore a dolphin on their shield; the city of Lyons a lion; that of Berne a bear, &c. 3d, By things which have some likeness to the name: as the Chevriers, who bear a cheveron; the Gouviers, who carry a wolf's head, &c. 4th, By things which have some relation to the signification of the name: as Archer, who carries three arrows; Falconer, falcons: Diane, a crescent; Riddell, ears of rye. The family of Law in Scotland have a cock in their arms, in allusion to the common method of expressing the cry of that bird among the Scotch, "*Cocky-leery*-Law." 5th, There are arms which express the name by way of *rebus*: as *Richarmes*, three casques crested with crescents *or*; Gantelmi at Naples, a glove and a helmet, &c.

Many of these allusions are very far-fetched and absurd; perhaps none more exquisitely so than that of the Paravasini in the country of the Grisons, who bear a goose, because, says Menestrier, that bird has "some resemblance to a swan *par avis Cycno*." It is worthy of remark, that long before the science of heraldry existed, the ancients, in their marks and devices, affected this sort of resemblance of figures to names. Thus the reverse of a medal of L. Aquilius Florus bears a flower; the Rhodians had a rose on their coins; and the Delphians a dolphin. On the medals of Voconius Vitulus we see a calf; on those of L. Thorius Balbus a bull; and a man's foot on those of L. Turius Crassipes.

18. To commemorate any events of a marvellous and unexpected nature, is another very common object of armorial bearings. There is no point, however, connected with heraldic pursuits, in the investigation of which we must advance with greater caution than here. The absurd vanity of particular families has been the foundation of so many idle inventions, that it is difficult to avoid classing with these matters of a very different nature. As an instance of the species of arms to which I now allude, it is sufficient to mention the *three birds* of Lorraine, which are said to take their rise from the circumstance of Godfrey de Bouillon's stringing three birds on one arrow. Important discoveries and illustrious actions have been in all times celebrated in the same manner. Thus, after Columbus had returned to Spain from the discovery of the new world, he was allowed by Ferdinand and Isabella to bear under a chappé of the arms of Castille and Leon, in a sea of *Argent* and *Azure* five isles *or* with the motto, "A Castilla y a Leon, Mundo nuevo dio Colon;" which bearings still remain with his descendants of the houses of Veragua and Xamayca.

The Maid of Orleans, when she took arms against the English, carried on her banner a sword surmounted by a crown. This, with the addition of a fleur-de-lys, the king of France afterwards assigned as arms to her brothers, who were ennobled, by letters patent, in the year 1429, and took the name of du Lys. The house of Colonna, in Italy, have around their shield the 14 standards taken from the Turks in the famous battle of Lepanto by Marco Antonio Colonna, General of the forces of the Pope. The Douglasses of Scotland bear a bloody heart crowned with a royal crown, in memory of the good Sir James Douglas, who died on his way to the Holy Land, whither he was conveying the heart of King Robert the Bruce. A badge of the same species was assumed by the Earl of Surry, in the year 1515. "A silver lion (the old cognisance of his family) tearing in pieces a lion prostrate gules.

> "If Scotland's coat no mark of fame can lend,
> That Lion placed in our bright silver bend—
> Which as a trophy beautifies our shield
> Since Scottish blood discoloured Flodden-field,
> When the dark Cheviot our proud ensign bare,
> As a rich Jewel in a lady's hair, &c."
>
> *Drayton.*

Nicolas Upton mentions an English gentleman who assumed Argent, three ox heads sable, "pro eo quod ipse erat in bello Vernolii cum lancia per membra genitalia totaliter transfixus, sic quod amplius generare non potuit." (*De Milit Officio*, p. 154.)*

The influence of the spirit of faction has also given rise to innumerable bearings. In Italy, during the contests of the Guelphs and Gibelins, things came to such a pass that almost every family was obliged to adopt some method of expressing by their arms to which party they adhered. The Guelphs carried Coupé, the Gibelins party. The Guelphs bore the lily of Florence gules on argent; the Gibelins argent on gules. The fleur-de-lys-in-chief (after the Guelph party had embraced the cause of Charles of Anjou), became a Guelph mark,—and three stars in chief denoted a Gibelin. In France, in like manner, when the kingdom was split into two factions from the year 1409 till 1449, those who espoused the cause of Orleans and Berry, carried a white bend, and were called "bendes," while the adherents of the Duke of Burgundy were known by the cross of St Andrew.

19. Offices of dignity are marked in the same way. Thus the great officers of the empire were all accustomed to bear the tokens of their dignity. The Counts of Oldenburgh, as architects of the empire, gules *two fesses or*, which are supposed to represent two beams. The house of Wirtemberg bore three stag-horns. That of Wernigerode a fish; and the Electors of Hanover the imperial crown, as archtreasurers of the empire. When any great family had once assumed a particular bearing, it was very natural for their vassals to bear it, either in whole or in part, as a token of their dependence. Indeed, the grants of feudal tenure were commonly made with some such condition. Thus in Brittany almost every family bore Ermine in honour of the ancient sovereigns of that country; and a great many mascles, and billets, in token of their connection with the houses of Rohan and Beau Manoir. In Cheshire sheaves of wheat are very common, and these were the bearings of the old Earls of Chester. A striking instance of this custom is to be met with so late as the time of Edward III. in the case of the four esquires of Lord Audley, who all adopted the bearing of that nobleman, with some little variation. (Vide Spelman's *Aspilogia*, p. 49.) And there is preserved in the notes on the same treatise, a charter, by which Sir Gervase de Clifton makes a similar grant of a helmet to his well-beloved friend Richard de Bevercotes, dated in the third year of Richard II. In Scotland many old families bear stars in those parts of the country where the Douglasses were most powerful. And a large proportion of the families of Renfrewshire bear their figures chequered, in honour of the house of Stuart.

The ancient signiory of the castle of Tunbridge, in Kent, belonged to the Clares, Earls of Gloucester, who bare for their arms *or, three chevrons gules*; and therefore the family of Hardress bare *gules, a lion rampant ermine debruised by a chevron or*, to denote that they held their manor of Hardress by knight's service of the said castle of Tunbridge.

20. Soon after arms had acquired the reputation of being the avowed and established marks of gentility, they came to be looked upon as inheritances alienable. So that although no man could legally assume at his own pleasure the coat-armour which had been granted *per expressum* to another person by the king, yet it was generally supposed that the original grantee or proprietor had, as it were, an absolute freehold in his *arms*, as well as in his lands, and might with equal right transfer the property of either to another person. And accordingly instances are not wanting of the proprietors of coat-armour conveying and assigning by formal grants, and that with a covenant of warrantry, the original paternal ensigns of their own family, as well as the coat-armour of other families which had descended to them by intermarriages, to persons nowise connected with them by blood, *to the exclusion of their own heirs*. Although no doubt could have been entertained as to the truth of these facts, yet the legality of such concessions having been often called in question, it is proper to state that the matter was fully discussed in the court of the Earl Marshall of England, in the case which depended between Sir Thomas Cowgan and Sir John de Norwich, and in that between John Lord Lovell and Thomas Lord Morley.†

Latterly, however, it has been invariably held as indispensable, that arms should be either given or authorised by the prince. The concession of arms by the sovereign may be in the common way, viz. wherein the royal consent is given to the use of such and such arms, whether they have been formerly borne by the grantee or not, as it is expressed in the common words of letters of nobility on the continent of Europe. "In omnibus et singulis honestis expeditionibus, et actibus tam serio quam jocis nobilium, militarium armigerorum modo in tourneamentis hastiludiis," &c.; or the concession may be of a particular kind, by which the sovereign permits his subject to assume some honourable augmentation, often part of his own royal atchievement, in token of his peculiar favour. Thus the double tressure has been granted to several families in Scotland, as the Randolphs Earls of Murray, the Seatons of that ilk, &c.; and the lion, as to the Duke of Lauderdale by way of supporter. When Henry Duke of Brunswick came to England to visit his ally Henry II. who then bore five leopards *or*, King Henry gave two of them to be carried by the Duke, which are still retained by his descendants, and are marshalled with other figures in the fourth quarter of his present Majesty George III. Edmonstone gives at full length the deed by which Queen Elizabeth allowed the Duchess of Suffolk to "assume the arms of England and France quarterly within a border gobony gold and azure," "to be an apparent sign of her consanguinity." Arms granted in this manner are stated by Menestrier to be very common in every kingdom of Europe, and are in a proper sense distinguished by the name of *arms of concession*. We shall have occasion to take more particular notice of some of these bearings in the sequel. In the meantime, we proceed to consider in their order the signs of honour.

* "Ob hujusmodo causas insignia concedi satis magno est argumento scutum Coleonum gentilitium quod *icone trium testium* insignitur. Multi enim ex hâc familia tres testes habuisse perhibentur. Vide Aldrovandum de Monstrorum historia, Bauhinum de Hermaphroditis Kornmannum de Miraculis Viventium. Coleonum insignia ex vita Bartholomæi Coleonis huc transtulimus. Deditum fuisse amoribus Auctor satis ingenue confitetur. Et fidem rei fecerit illud evangelicorum ministrorum decretum quod triorchi cuidam apud Germanos principi permisit concubinam Uxori superinducere de quo videas Thuanum." *Note in Upton*, p. 57.

† See Anstis's *Register of the Garter*, vol. ii. p. 260.

*Of the Shield, Surcoat, and Ensign.*

21. These are called by heralds the three principal signs of honour, in as much as *arms* have been commonly placed on them. The *shield*, being always deemed to be a necessary instrument in the defence of the body, and an honourable badge, was judged by all nations the most convenient tabula to contain marks of valour and honour, and therefore it is considered as the most proper and principal of all the heraldic signs of honour. Historians furnish us with various forms of shields used by the ancients; but at the time when *armorial bearings* were first instituted in the way already described, and came to be considered all over Europe as *tesseræ gentilitiæ*, and hereditary marks of honour, shields, for the most part, were triangular, as may be seen on the most antique monuments, seals, &c.;* accordingly, the shield so shaped is called by the French the *ancien ecu*. From this triangular form came the custom in heraldry of putting the greater number of figures above, and the less below, as three, two, one. In subsequent times, a form of shield became more prevalent; square, rounded, and pointed at the end: these are most common in this island, and in France. The Germans make most use of the shield *chancre*, with bulgings and notches, derived from their tournaments. The Italians have mostly the oval shield. See Plate CCXCI. Figs. 1, 2, 3, 4, 5, 6.

The *surcoat* is a loose thin taffety gown, used formerly over armour, upon which the arms of the bearer were commonly painted or embroidered, that they might be distinguished in time of battle; a memorable instance of the use of which we have preserved in the history of the Chevalier Bayard. These surcoats were much like those now worn by heralds.

The third is the Ensign, under which general name are comprehended the varieties of Standard, Banner, Pennon, Gideon, and Gonfanon.

The first two are of a square form, bearing the whole achievement of such as have a right to them; which none hath under the degree of a *knight banneret*.

The *pennon* and *gideon* are of an oblong form, with a sharp point, and carry a part only of the owner's arms; as his device, crest, and motto.

The *gonfanon* is a banner of the church, square, but having three labels, or *fanons*, and the bearer thereof is called the *gonfaloniere*.

Arms have also been represented anciently on the furniture of horses, as in the seals of Alexander II. of Scotland, Edward I. of England, the two De Quinceys, Earls of Winchester, in Spelman, &c. See Plate CCXCI. Fig. 2.

Women place their arms on a lozenge, (See Fig. 7.) which is a square figure with one of its angles uppermost; or on a fusil, which is a figure of the same nature, but longer than it is broad. The old writers, particularly Sylvanus Morgan, in his *Nobility native, or Adam's coat*, are pleased to derive the common form of the man's escutcheon from the spade of Adam, and of the woman's lozenge from Eve's spindle; but, as Nisbet observes, "these things are mere fancies." Neither is he more pleased with the sentiments of Sylvester De Petro Sancto, who deriveth the lozenge from the cushion used in sewing, &c. *pulvillum in quo exercent mulieres linearia opificia.*

*Of the Blazoning of Arms.*

22. Blazon, or the art of blazoning of arms, consists in the knowledge of those colours, or metals, which are used in the art of heraldry, and of the several lines of partition, ordinaries, and changes, whereof the coat is composed.

*Of Tinctures.*

23. The colours and metals thus used are most commonly blazoned by tinctures, which have their proper and fixed terms taken from the French; which tongue has indeed, in consequence of the great excellence of the French heraldic writers, become, in some sort, the common language of heraldry among all the nations of Europe. The terms of these tinctures are these:

| | |
|---|---|
| *Or*, . . . . . that is . . . | Yellow. |
| *Argent*, . . . . . . . . . | White. |
| *Azure*, . . . . . . . . . | Blue. |
| *Gules*, . . . . . . . . . | Red. |
| *Sable*, . . . . . . . . . | Black. |
| *Vert* or *Sinople*, . . . . . | Green. |
| *Purpur*, . . . . . . . . . | Purple. |

1. *Or*. This metal is allowed to be the most honourable of all the tinctures. In Latin blazonry it is called, *aureus color*, *aurum*, *luteum*, *croceum*, *Galbinum*. It is known in engravings by small points or ticks. Fig. 8.

2. *Argent*. In Latin, *argenteus color*, *albus*, and *argentum*. To mark this colour in engraving the field is left blank. Fig. 9.

3. *Azure*. This is derived from the oriental *lazurd*, which signifies the heaven, or its colour. The Latins say, *cæruleus*, *cæsium*, *glaucum*, *cyaneus*. It is represented by horizontal lines. Fig. 10.

4. *Gules*, evidently derived from the eastern *gul*, or *ghul*, which signifies a rose, red, &c. In Latin, *color roseus*, *rubor*, *rubeus*, *sanguineus*, *coccineus*; marked in tallyduce by perpendicular lines. Fig. 11.

5. *Sable*, comes also from the oriental word which expresses the same idea, *zibel zebel*, still retained in the French, as *maitre zebeline*, *maitre noire*; marked by cross hatches, perpendicular and horizontal. Fig. 12.

6. *Vert*, the common French word for green. The French themselves commonly use *sinople*, a term, the origin of which has occasioned no small difficulty. Some think it is derived from the city of Sinope, in Asia, as if the earth there were green; others esteem it derived from the Greek πρασινα οπλα, green arms. This also seems to us to be of Oriental origin, *tsin*, herb, verdure; *bla*, blade: the young blade of grass, which is always of the most beautiful green. Indeed, our own word *green* expresses no other idea but that of *growing*. The latin writers say, *viridis* or *prasinus*. It is marked by diagonal lines from right to left. (Fig. 13.)

7. *Purpur*, is marked by diagonal lines from left to right. This colour is, by the best writers, little approved. Spelman talks of it as of new introduction in his time; and in Scotland it is entirely unknown, except among the *new gentry*, as Nisbet says. (Fig. 14.)

Besides these, the English heralds mention two other colours. 1st, *Tenny*, or orange; known, in engraving, by diagonal hatches from right to left, and *e contra* from left to right. 2d, *Sanguine*, or dusky red, marked by diagonal lines from right to left, and horizontal ones. These two colours are, by the English writers, appropriated to *abatements of honour*, and so are called dishonourable stained colours.

When any object is represented not in any of these heraldic colours, but as it is in nature, as, for instance, grapes, peacocks, &c. it is then blazoned *proper*.

* Spencer gives the Red-cross knight a shield of this form, *Fairy Queen*, 1. 6. 41. "And catching up in haste his three-square shield."

Some fanciful heralds, particularly in England, give out a rule, that gentleman's arms alone should be blazoned in the manner above mentioned, those of noblemen by precious stones, and those of sovereign princes by planets; thus,

| Tinctures. | Precious Stones. | Planets. |
|---|---|---|
| Or. | Topaz. | Soal. |
| Argent. | Pearl. | Luna. |
| Blue. | Sapphire. | Jupiter. |
| Red. | Ruby. | Mars. |
| Green. | Emerald. | Venus. |
| Sable. | Diamond. | Saturn. |
| Purpur. | Amethyst. | Mercury,&c. |

But these niceties seem to be entirely of a piece with the imaginations of another herald, who insisted on blazoning by *flowers*; as rose, jonquil, &c. or with the accurate definitions of virtues, &c. signified by particular tinctures, at one period so much in vogue: as *or*, faith; *argent*, innocency; *blue*, loyalty, &c. It is sufficient to observe, that not only is all blazoning of arms of different degrees in different manners unknown to the heralds of France, Italy, and Germany; but that the practice would tend to confound colours with charges, and the things borne with the colours. Moreover, it would render useless the great rule of not putting *colour on colour*, or *metal on metal*;* for this could not hold, were metals and colours no longer employed or named in certain armories.

### *Of Furs. Ermine. Vair.*

23. The use of furs in armories is in all likelihood derived from the habits and garments of military men and civil magistrates, according to the opinion of Sylvester De Petro Sancto, Nisbet, and others, though a different account of the matter is given by Sir George Mackenzie, The antiquity of their use is proved by the circumstance, that when Innocent III. commanded Conrad Bishop of Wurtzburgh, by way of penance, to go and fight against the Saracens, he particularly forbade him to appear in ermine, vair, or any colour employed in tournaments.

These furs, Ermine and Vair, are the principal furs employed in the heraldry of any country, and the only ones known in France or Scotland. Ermine is supposed to take its name from an animal of the same name, the skin of which has long been considered as a royal and noble ornament. In Great Britain, the different degrees of nobility are distinguished by the number of rows of ermine with which the mantle of the peer is trimmed; and Menestrier informs us, that at the coronation of Henry II. of France, for want of true ermines to line his robes, use was made of cloth of silver, spotted with patches of black velvet. This fur is represented in blazoning by a white field powdered with black spots, which spots have the point upward tipped with three ticks of black. (Fig. 15.) *Contre ermine* is that in which the field is sable, and the spots argent. (Fig. 16.) As for the English furs, *erminois* field *or* spots *sable*; *pean* field *sable* spots *or*; and *erminites* field *argent*, spots *sable*, *with a single hair gules at each side of the spot*, these are unknown in any other country.

Ermine and its kinds have two tinctures. The spots are in place of figures; and it may therefore form a complete *armory* of itself, as is the case with the arms of the Duchy of Burgundy. But ermine may also form a field, whereon every charge, either of metal or colour, may be placed; or it may form itself the charges, and be placed without impropriety upon any shield.

The spots of ermine are of an indefinite number, irregularly disposed on the shield; but any certain number of these under ten may be borne after the position of any of the heraldic charges. In this case, they are not to be blazoned *ermine*. The spots being in truth charges, are called by us *ermine spots*; by the French *mushetours*; and in the blazon their number and disposition must be expressed. The Latins call them *maculæ* muris *armeniæ*.

Vair is the other principal fur in heraldry. From what its name is derived seems perfectly uncertain. The Latins certainly blazon it, "Arma variata," &c. Its pieces are always *argent* and *azure*, disposed in the manner of rows of little figures, resembling shields or bells, so placed that the point of the bells in the second row is between the base of those of the first. (See Fig. 17.) The *grand-vair* of the French is that wherein the rows of these figures are only three in number. In *menu vair* the rows are above four, and this is the common *vair* of our heraldry. For *countre vair*, see Fig. 18.

The species of fur represented in Fig. 19. which consists of pieces alternately arranged of azure and argent resembling cups, goblets, &c. is variously named *meirre*, *vairy cuppy*, *vairy tassy*, or *potent contre potent azure et argent*. Potent is derived from *potence*, a *gallows*, the top of which these figures are supposed to resemble. These furs may all be used in the same manner as the ermines.

### *Of the Points of the Shield.*

24. For the convenience of blazoning, the different parts of the shield have received particular names, taken from the parts of the human body; of these a scheme is given in Fig. 20. ABC represents the highest part of the shield, which the French called *chef*, and we *the chief*. D is called *the collar* or *honour point*, because badges of honour are worn on the breast, as those of the garter, thistle, &c. E is called *the cœur point*, as also the *centre* or *fess point*. F, *the nombril*, or *navel point*. GH, by the French, the *flanque points*, by the English, the *base points*. I, the base point. A is the *dexter chief point*, or *canton*. B, the *middle chief point*. C, the *sinister chief point*. G, the *right base point*. H, the *sinister base point*.

When arms are blazoned without relation to, or expression of, the point wherein the figures are placed, they are then supposed to occupy the centre of the shield. When figures are ranged as ABC, they are said to be *in chief*. When ranged so as to reach from the dexter chief point to the sinister base point, to be *in bend*; from the sinister base point to the dexter chief point, *in bend sinister*; when placed between the base points, they are said to be *in base* or *in point*.

* The rule alluded to is thus traced to its origin by Feron, in that part of his work wherein he treats of the armorial bearings of Adam. "Telle couleur de rouge est attribuée à notre bon pere Adam, qui porta pour armes de gueulles seulement auquel commenca noblesse, et qui en langue ebraique signifie rouge. Aussi fut il formé de terre au champ de Damascene. Les quelles armes il ne porta longuemente, transgressant le commandement de Dieu; et lors furent chargées d'une pomme de sable, demonstrant le vilain peché par lui commis contre la puissance divine en trangressant son commandement. Qui est le motif que nos predecesseurs ont tenu pour maxime cester eigle generale, que *armoiries sont faulses ou couleu domine autre couleur*, qui à este observée jusques a present."

Vide *Not. in Uptonum*, p. 39.

*Of the Lines of Partition.*

24. The field or surface of the escutcheon is divided into parts by various lines.

1. A plain horizontal line.
2. An angle.
3. A Bevile.
4. Escartele.
5. Nowy.
6. Arched, or enarched.
7. Double arched.
8. Wavey, or undé.
9. Invecked.
10. Ingrailed.
11. Battled, embattled, or crenellé.
12. Battled, embattled.
13. Nebule.
14. Potent.
15. Indented.
16. Dancetté.
17. Patte, or dovetailed.
18. Urdé.
19. Rayed, radiant, rayonné, ráyonated.
20. Raguly.

It must be observed, that indented and dancetté are lines of the same form, differing, however, in the size and number of the cuts or indents; those of the former being more numerous and smaller than those of the latter. For example, a Fess *dancetté* should be composed of three indentations and no more, whereas the Fess *indented* may have double that number. These lines are all engraved in Plate CCXCI. from Fig. 21—Fig. 40.

When a shield is by a horizontal line divided into two equal parts, it is said to be *coupe*, or *parted per fess*. See Fig. 41.

When a shield is by a perpendicular line divided into two equal parts, it is said to be *party*, or *party per pale*. See Fig. 42.

When a shield is divided into two equal parts by a diagonal line drawn from the dexter point chief to the sinister point base, it is said to be *tranché*, or *party per bend dexter*. See. Fig. 43.

When it is so divided by a diagonal line from the sinister point chief to the dexter point base, it is said to be *taillé*, or *party per bend sinister*. See Fig. 44.

When the partition line is straight, as in Fig. 21. above mentioned, it has then no additional denomination in the blazon. But if it has any of the other twenty forms, then the term of that form must be added in the blazon, and is of frequent use for the distinction of cadets.

When the first two lines, *parted per pale*, and *parted per fess*, (in French *coupé* and *parti*,) meet in a field, they divide it into two equal parts, or quarters, which are of different tinctures, the first as the fourth, and the second as the third. Thus we say, *quarterly gules and argent*: the French, *ecartile de gueules et d'argent*; Gerard Leigh and his followers, *parted per cross*. See Fig. 45.

When tranché and taillé meet in a field, they divide it into four areas, which is blazoned *parted per saltier argent and azure*. The French would say *d'argent flanque d'azure*, or *L'ecartile en sautoir*. See Fig. 46.

When coupé, tranché, and taillé meet in a field, they make six triangular areas-blazoned *girony of six*. Fig. 47.

When the whole four lines, coupé, party, tranché, and taillé, meet in one field, they divide it into eight conal parts blazoned *girony of eight*.

When two half diagonal lines, rising from the dexter and sinister points base, meet in the collar points, it is *party per chevron*. See Fig. 48.

When a shield is divided into three equal parts, it is said to be *tierce*. See Fig. 49.

| | |
|---|---|
| If by perpendicular lines, | *tierce per pale*. See Fig 49. |
| If by horizontal lines, . . . | *tierce per fess*. See Fig. 50. |
| If by diagonal lines from right to left, . . . . . . . . . | *tierce per bend dexter*. See Fig. 51. |
| If by diagonal lines from left to right, . . . . . . . . | *tierce per bend sinister*, or *tierce en bar*. See Fig. 52. |

Repartition lines, are those by which the shield is divided into unequal parts, as *coupé my-partée*, and *party-my-coupée*. See Figs. 53 and 54.

*Of the Figures of Heraldry.*

25. These are either peculiar to heraldry, and derive their names from it, and therefore called *ordinaries*; or they are things natural or artificial, used in armories, but retaining their own proper names; these are *charges*, properly so called.

I. *Of Ordinaries.*

All ordinaries are composed of some one or other of the above-mentioned lines. and are in number 19, according to the English heralds, viz.

1. The Chief, which is formed by one line only drawn, horizontally across the face of the shield, so as to separate the third part of the escutcheon from the rest. See Plate CCXCII. Fig. 1.

2. The Pale, which is composed of two parallel lines drawn perpendicular from the chief to the base of the escutcheon, and should contain one third part of the breadth of the shield. See Fig. 2.

*N. B.* The *pale* admits of two subdivisions, or diminutions, as to its breadth. The half of the *pale* is called a *pallet*; and the half of the *pallet* is called an *endorse* or *verget*. According to the strict rules of heraldry, neither *endorse* nor *pallet* can be charged.

3. The Bend, which is formed by two equidistant lines drawn diagonally from the dexter chief to the sinister base of the escutcheon, according to a rule laid down by Leigh, Holme, Guillim, &c. should, if charged, be in breadth one-third; if not charged, one-fifth of the shield. Others make no such distinction, but tell us, that the *bend* possesseth always the third part of the escutcheon from the right chief angle to the left base angle.

When there are more than *one bend* in a coat, they are called *bendlets*; but when the field is equally divided by 4, 5, 6, 8, or 10 lines, or any even number *bendways*, then it is termed *bendy* of so many pieces.

The *bend*, or as it may be called for distinction sake, the *bend dexter*, has more subdivisions or diminutives than any of the other ordinaries: 1*st*, The *bendlet*, which should contain one-sixth of the shield; 2*dly*, A *garter*; 3*dly*, A *cottise*; 4*thly*, A *ribbon*, none of which can be with propriety charged. See Fig. 3.

4. The *bend sinister*, which passes diagonally from the sinister chief point to the dexter point in base, has not the same diminutives as those of the *bend dexter*; but, according to some heraldic writers, is subdivided into a *scarp* or *scarf*, which has just half the breadth of the *bend sinister*, and a *batton* or *fissure* containing half the breadth of the scarf. See Fig. 4.

Many, however, will by no means admit of the *batton* being said to be a diminutive of the *bend sinister*, or any part of any of the ordinaries. According to many years practice, the *batton* does not touch the extremities of the shield, nor the extremities of the quarter where the paternal arms are placed, as all the ordinaries do, but is, on the contrary, *couped* or cut short, and so borne as a mark of illegitimacy, (as may be seen in the arms of the Dukes of St Albans, Grafton, and Buccleuch, all descended from bastards of King Charles the Second,) and not as an ordinary or charge, or any part of the coat. For although some instances are to be met with of ancient arms, where the *batton sinister* is passed from the sinister chief to the dexter base over all, and others where it passes from corner to corner over the paternal arms, and not over the other quarterings; yet in every one of these it is used as a mark of illegitimacy, and not as either an ordinary or a charge. This mark or batton may, in the arms of royal bastards, be of metal or fur, or both; but in the escutcheons of those of the humbler sort, of colours only. When both a *bend dexter* and a *bend sinister* occur in the same coat, that is first mentioned which lies nearest the shield; thus *argent*, a bend azure surmounted by a bend sinister.

5. The Fess is formed by two lines drawn horizontally across the shield, and is understood to comprehend in breadth the third part of the shield, though less room is often assigned to it. This ordinary cannot be divided or diminished like the *bend*, but may be *voided*, a form to which all the ordinaries are liable. *Voided* is said of an ordinary when its middle is cut away, so that no more of it remains visible than the two outside lines; as *azure* a *fess voided argent*, by the name of *Bleckall*.

6. The Bar is formed by two equidistant lines drawn horizontally across the middle or centre of the escutcheon, after the manner of the *fess*, but containing one-fifth part only of the field. The *bar* hath two diminutives, viz. a *closet*, which is in breadth one-half, and a *barrulet*, which is in breadth one-fourth of the *bar*. When the field is dividep into 4, 6, 8, 10, or 12 equal parts, it is then blazoned *barry*; and when the diminutives of the bar are placed in pairs on the shield, they are called *bars gemelles*, from the Latin *gemelli*, twins.

7.· The Escutcheon itself is deemed an ordinary, and is composed of three lines. It may be carried singly, or with others, as in the coat of Hay, argent, three escutcheons, gules. See Fig. 7.

N. B. Inescutcheon signifies the same thing.

8. The Border hath, by several writers, been refused admittance into the number of ordinaries; they alleging, that it is not a principal figure, but a difference only. Nisbet, however, very properly observes, that this is quite unjust, inasmuch as many coats consist of other charges than the *border* alone. In blazon, borders always give way to the chief, the quarter, and the canton; so that, in coats charged with one of these ordinaries, the border goes round the field until it touches it, and there finishes; but, in respect to all other ordinaries, it passes over them. When a border is of two colours, and divided into squares, it is called a *border compony* or *compony*; if it hath two rows of squares, it is called *counter compony*; if three, it is called *cheque*.

A border *purflewed* is shaped exactly like *vair*: when it is of one row, it is called *purflewed*; when it is of two rows, it is *counter purflewed*; when of three, *vair*. The border *enalcron* is a border charged with birds; the border *entoiré* is charged with *besants*; the border *verdoye* is charged with vegetables; the border *enurney* with lions, &c. But these terms ought all to be discarded as useless.

9. The Orle is an inner border of the same shape as the escutcheon, and doth not touch the exterior of the shield, the shield being seen within and around it on all sides, so that it appears like an escutcheon *voided*. The edges of the *orle* may be ingrailed, indented, invecked, &c. When any bearings, as martlets, mascles, &c. are placed round an escutcheon on a field, they are said to be *in orle*; and it is needless to mention the number of them, for figures so placed are always supposed to be eight in number. See Fig. 9.

The Tressure is a diminutive of the orle, formed by a small line or trace passing along the field, and encompassing the inner part of the escutcheon in the same form as that of the shield. In some coats, the tressure is formed of two lines or traces, *flory counter-flory*, as in the arms of Scotland. Indeed, unless it be of this sort, it may as well be called an orle as a tressure, as Edmonstone has well observed.

10. "The Flasque consists of an arched line drawn somewhat distant from the corner of the chief, and swelling by degrees till you come towards the centre of the escutcheon, and then decreasing again with a like descent unto the sinister point base." See Fig. 10.

"The Flanch is formed of an arched line, taking its beginning from the corner of the chief, and from thence compassing orderly with a swelling embossment, until it come near the nombril of the escutcheon, and thence proportionably declining to the sinister base point." So says Guillim; but Gibbon and Edmonstone are both of opinion, that these two ordinaries are one and the same. The *voider* is certainly a mere diminution of the flanch, and, by reason of its smallness, cannot be charged.

11. The Saltier, or *Sautoir*, is an ordinary, consisting of a fourfold line, two whereof are drawn from the dexter chief towards the sinister base corner; and the other two from the sinister chief to the dexter base point. If not charged, it containeth one-fifth of the field; if charged, one-third. See Fig. 11.

12. The Cross, after the expeditions to the Holy Land, came to be an ordinary of most frequent use. It is composed of a fourfold line, whereof two are perpendicular and two horizontal; so that it seems to be formed of the *pale* and the *fess*, not lying on one another, but corporally united in the centre. The great variety of crosses used in heraldry is such, that in all considerable systems several pages are filled with engravings of them, Fig. 12. The most considerable are, the cross *patée*, Fig. 13; the cross *potence*, Fig. 14; the cross *avellane*, Fig. 15; the cross *furche*, Fig. 16; the cross *crosslet*, Fig. 17; the cross *botone*, Fig. 18; the cross *flory*, Fig. 19; the cross *patée fitched*, Fig. 20; the cross *pierced*, Fig. 21; the cross *moline*, Fig. 22. The proportions of the cross are exactly the same as those of the saltier.

13. The Cheveron is an ordinary, formed of twofold lines placed pyramidically, and is resembled to a pair of barge-couples or rafters, such as carpenters use to support the roof of a house. Its diminutives are the *chevronel*, which is half the chevron; and the *couple close*, which is half the chevronel. See Fig. 23.

14. The Fret is formed of six pieces, two of which compose a saltier, and the other four a mascle, over which the saltier pieces must be interlaced. When the fret is composed of 8 or 10 pieces, we say, *or fretty azure*, &c. See Fig. 24.

15. The Pile is an ordinary, composed of a twofold line, which forms a long wedge, broad at the top, and terminating at the base in an acute angle. See Fig. 25.

16. The Giron is an ordinary of a triangular or conical form, composed of two lines drawn from diverse parts of the escutcheon, and meeting in an acute angle in the *fess point*. This may be borne singly, or in couples, to the number of 4, 6, 8, 10, or 12. When there is only one gyron in a coat, it is blazoned thus, *argent a gyron sable*, without mentioning the point from which it issues, that always being supposed to be the dexter chief point; but if it stand elsewhere, it must be expressed. If there be six gyrons

in a coat, it is blazoned, *gyrony of six, or and sable*, and so of any greater number. See Fig. 26.

17. The Quarter is an ordinary, composed of two straight lines, containing one-fourth part of the shield. See Fig. 27.

18. The Canton is of a square figure less than the quarter, containing one-third of the chief. See Fig. 28.

19. The File or Label, though used as a distinction of houses, is very properly placed among the ordinaries by Holme, by reason that it is variously borne and charged.

*Of Charges or Figures not peculiar to Heraldry.*

26. Anciently arms were simple and plain, consisting of at most a few figures distinctly set forth on the shield; the heralds of those days being universally of opinion, that the plainer a coat is the more honourable it should be esteemed. The arms of the house of France, were simply three fleur-de-lys *or* in an azure field. The royal arms of England, at most three lions *or* on a field *gules*. The arms of Waldgrave, simply *per pale argent and gules*. Those of Burgundy *ermine* alone, without any charge whatever. As coats of arms increased in number, a deviation from this original simplicity soon became unavoidable; a conspicuous variation from each other was absolutely requisite; and this necessity was never more felt than in camps and tournaments. This at first was effected either by a repetition on the same escutcheon, of some one or other of those particular figures, which had heretofore been used as charges; or by placing in the field two or more distinct bearings. It was not long, however, before this mode proved inadequate to the purpose for which it was intended. The continual multiplication of arms had exhausted all the variations of which armories were, as they then stood, susceptible, and called for additional marks of distinction. Wherefore such a multitude of new charges have been from time to time introduced, that it may be truly said, there is scarce any thing either natural or artificial that is not, or has not been, represented in a coat armour.

The embarrassments which, from the multiplicity of coats of arms, and the infinity of charges former heralds lay under, in the contriving new armories, so as not to have them clash with others already in use, led them, as might well have been expected, into many absurdities; but to their praise it must be said, that they not only avoided, with great caution, all improper or indistinct figures, but blazoned what they did select with so much fulness and nicety, that none could be at a loss to draw them with accuracy and exactness. Modern heralds, however, have not always followed their good example in this respect; on the contrary, they have stuffed the newly purchased coats with such a multitude and variety of charges, and introduced such a medley of novel and extraordinary bearings, that these escutcheons are for the most part crowded, confused, and unseemly, and of consequence altogether inadequate to the original purposes of coat armour.

Possibly they are desirous of giving good pennyworths, and think that as purchasers now pay much dearer for their arms than they used to do, they are entitled to a greater number of bearings on that account. The arms granted to one Edward Chambers, of the island of Jamaica, afford a notable instance: "*Argent a negro cutting with a bill a sugar cane, all proper: on a chief azure two pine-apples* or, *leaved of the last*. But the escutcheon of an officer lately returned from the East Indies, viz. lieutenant John Nathan Hitchins, presented still greater absurdities: "*Quarterly 1st and 4th vert an elephant and tiger rampant combatant, an officer of the honourable East India Company's dragoons standing by with a musket in his dexter hand, and a dead horse couchant in the sinister point base, all proper. 2d and 3d gules between three pieces of ordnance* or *on a chevron argent two oriental tiaras contre embattled proper.*" The motto, "*Auroram et Gangem pauci dignoscere possunt.*" Another grant runs thus: "*Sable on a chevron between 2 pistols in chief* or, *a silver medal with the French king's bust, inscribed 'Louis XV. par la grace du Dieu Roi de France et Navarre,' tied at the top with a ribbon gules. A laurel chaplet in the centre, a scalp on a staff on the dexter, and a tomahawk on the sinister, all proper*. For the crest: *On a wreath a rock; over the top a battery in perspective; thereon the French flag hoisted, an officer of the Queen's Royal American Rangers climbing the said rock sword in hand, all proper!*"

The arms of one Templar are thus blazoned in the grant: "*Quarterly azure and gules, the perspective of an antique temple; on the pinnacle and exterior battlements a cross moline* or. *In the first quarter, an eagle displayed. In the second, a flag trippant, regardant of the last.*" The arms of Mr William Stitlington, teacher of philosophy in Wapping, are thus: "*Azure on the ecliptic circle* or, *the sign* Libra; *in chief, a terrestrial globe on a stand, all proper; and in the base, on a mount vert,* a male child *extended in bend sinister proper*. Crest, *On a wreath, a holy lamb regardant ermine accolled with a laurel branch vert, holding a banner proper*. Motto, *Have mercy on us, good Lord.*" On the ridiculous parts of these armories, and the incomprehensible jargon in which they are set forth in the grants, it would be absurd to enlarge. The arms are such as no ancient herald, rightly embued with the principles of his art, could understand; and no painter can properly represent without the help of inspiration, unless he can see the painting on the margin of the grant.*

Many other examples of a like sort might be produced; but, to those already mentioned, we shall only add that of the bearing granted to one Mr Tetlow, which is so extraordinary, in respect to the coat as well as the crest, that it is not, by any means, to be omitted in this place. In the arms are *five music bars*; and the crest is thus set forth: "*On a book erect gules clasped and leaved* or, *a silver penny argent whereon is written the Lord's prayer; on the top of the book a dove proper, in its beak a crow-quill pen sable;* in commemoration, as is said, of the brother of the grantee having written the Lord's prayer within such a compass.

Neither can any one greatly approve of a grant of arms, wherein we find "*a troubled ocean with Neptune rising therefrom, holding in his sinister hand part of the wreck of the ship Royal George*," to indicate, that the uncle of the grantee had suffered shipwreck along with Kempenfelt; or of a grant, wherein is introduced "*a China porter carrying on a yoke two faggots of cinnamon*," to indicate that the grantee had once made a voyage to the Dutch islands; and yet all these absurdities arise from the present or late system of *charges* adopted in the herald offices.

But to return from this digression, if such it deserves to be called, to notice particularly all those figures which are, even by the most excellent authors, admitted as proper for the practice of heraldry, would be altogether inconsistent with the limits of an article such as this. The principal only can be noticed; and, in the first place, it is fit to observe, that of charges some are round in shape, some square. The former are generally called *roundles* or *roundlets*; and of these, which differ from each other in name

* In the same taste, a la[illegible] tutor and examining master at Oxford assumed as crest, "*on a cap of maintenance a mark of interrogation nebulé.*" Motto "το της πολλης πειρας τελευταιον επιγεννημα." The congenial escutcheon—"*gules, a fair exemplar of* The Ethicks *expanded proper!*"

according as they are of different tinctures, there are nine; seven of them being perfectly globular, and two of them flat like a piece of coin.

*The Roundles, or Roundlets.*

| When they are | | | |
|---|---|---|---|
| 1. Or, | | are then called | 1. Bezants. |
| 2. Argent, | | | 2. Plates. |
| 3. Vert, | | | 3. Pomeis. |
| 4. Azure, | | | 4. Hurts. |
| 5. Sable, | | | 5. Ogresses, or Pellets. |
| 6. Gules, | | | 6. Torteauxes. |
| 7. Purpure, | | | 7. Golpes. |
| 8. Tenne, | | | 8. Oranges. |
| 9. Sanguine, | | | 9. Guzes. |

1. Bezants, when they are armorial figures, are flat pieces of plain gold, without any stamp or impression upon them. When introduced into heraldry, they had their name from the ancient coin of Constantinople, or Byzantium.

2. Plates are likewise flat, as representing thin pieces of silver bullion when fitted for the stamp.

The other seven figures are always globular, viz.

3. Pomeis, which derive their name from the French *pomme*, an apple.

4. Hurts, so called from their resemblance to a small blue fruit, named hurtle berries.

5. Ogresses, or Pellets, resemble bullets for guns. In blazon, they are generally termed pellets, but some of the ancient heralds call them *gun-stones.*

6. Torteauxes take their name from the French appellation of a certain species of round cakes, which, in England, used to be called wastal-cakes, or wastals, by which name we often find them distinguished in ancient blazons.

7. Golpes, according to Gerard Leigh, are wounds; and Guillim even thinks they may be called so in blazoning.

8. Oranges, the well-known fruit.

9. Guzes are said to represent eye-balls; but these are of very rare occurrence even in English heraldry.

When any of these nine figures are in a coat, and countercharged, they lose their beforementioned respective names, and are all indifferently stiled roundles; so that if we look at the painting of a coat-armour, which is blazoned *per pale* or *and gules three roundles*, we shall find, that, of the two figures in chief, one is a *bezant*, and the other a *torteaux;* and that the solitary figure in base being divided *per pale gules and or*, the one half thereof is a *bezant*, and the other half a *torteaux*. When the field is strewed with any of the first five beforementioned figures, or if they are placed on crests, supporters, or any ordinary or charge, they are termed, *bezanté*, *platé*, *pometté*, *hurté*, and *pelletté;* but if the field be strewed, or semée, with any of the four last mentioned roundles, we say, *semé of torteauxes*, *semé of golpes*, *semé of oranges*, and *semé of guzes*.

Foreigners have no more than two specific names for all these round figures. When they are of metal, they call them *bezants;* when of colour, *torteaux;* therefore they say, so many *bezants d'or*, or *d'argent;* or so many *torteauxes d'azure*, *de gules*, *de sable*, &c. and when they are half metal, half colour, if the metal hath precedence in position, they say *bezant-torteaux* of such metal and colour; and so, *e contra*, *torteaux-bezants*, when the colour precedes the metal.

The roundlet voided, is the *annulet*, or ring. When these pass into one another, the French say *vires.*

*Of Guttes.*

Another sort of charge very common in armories receives, in like manner as the roundlets, divers names of blazon, according to the variations of its tinctures. This charge is called *guttes*, i. e. *drops* of things liquid, whether by nature or by art.

| If they are | they are termed | i. e. |
|---|---|---|
| or | guttes d'or | drops of gold |
| argent | guttes d'eau | water |
| vert | guttes d'olive | oil of olives |
| azure | guttes de larmes | tears |
| sable | guttes de poix | pitch |
| gules | guttes de sang | blood |

Guillem, indeed, says these are seldom borne alone; but Edmonstone differs from him, and instances, among other examples of *guttes* borne as a charge,

*Argent three guttes de poix*, for Crosbie.

But it is true they are much oftener borne strewed on fields, ordinaries, charges, crests, supporters, &c. and in such cases, whatever is charged with them is blazoned thus, *Argent gutty de sang*, which denotes that the whole escutcheon is sprinkled with red drops, and so in regard to a crest, *a lion's head gules gutty d'argent.*

There are three square figures deemed to be proper charges, the lozenge, the fusil, and the mascle. Of these the two former have been already mentioned and described as applied to a different purpose. The field or ordinary may be covered with *lozenges* or *fusils*, and it is then called *lozengy*, *fusilly*. If fusils are borne in pale, as *a pale fusilly*, or *six fusils in pale*, they must lie fesswise, *i. e.* their acute angles must be dexter and sinister. But if a *fess fusilly*, their acute angles must be in chief and base.

The *mascle* differs from both lozenge and fusil in this respect, that, according to the sentiments of all authors, it must be pierced through, or *voided.* When any coat in which one or more mascles occur is blazoned, their number is mentioned; and if they be close together, or conjoined, that circumstance is not omitted, thus, *Argent a mascle in fess between three pellets sable.* Osbaldeston, *sable five mascles conjoined in cross or.* Brandreth, *gules seven mascles conjoined or three, three, and one.* The coat of De Quincy, Earl of Winchester, well known by ancient seals. Plate CCXCI. Fig. 2.

The *Billet* is an oblong figure, supposed to take its name from its resemblance to a *billet of wood.*

*Rules for Blazoning.*

When a coat of arms is blazoned, the field is first mentioned, next the ordinary, last of all the charge. If the coat consists of two colours only, as the coat of Hatton, we may say, *azure a chevron between three garbs or*, which implies that both chevron and garbs are *or.* Or thus, *azure a chevron or between three garbs of the last.*

When the charges next to the field are mentioned, then proceed to those which lie more remote, as in the coat of Pratt, sable on a fess between three elephants' heads erased argent as many mullets of the first. Here the mullets, being the most remote from the field, are last mentioned, and as both field and mullets are sable, the words *of the first* are used to avoid repetition.

When a field is divided by lines, they must always be mentioned before the colours, as in the coat of Waldegrave, before mentioned, *parté per pale argent and gules.* Aston, *parte per chevron sable and argent.* Boyle, *parte per bend crenellé argent and gules.*

N. B. Besides the above mentioned charges, there are other two, rejected indeed by our English heralds, but of common enough use among foreigners.

1. A shield is by them called *papilloné*, when it is covered with figures like the scales of fish.

2. "Diaspré, or diaperé, is said, when the field is shadowed with flourishings and various turnings, by *purfels* of gold or silver, or tinctures after the fashion of flowers or leaves, like the weaver's diaper-napery." The Germans practise this most, as the French do the *papilloné*.

Concerning all the figures we have as yet observed, whether under the head of ordinaries, or under the present, heraldic writers are much at variance among themselves. Some arrange them all under the head of ordinaries, dividing them in honourable ordinaries, and subordinaries. Others, and among the rest Edmonstone, adopt that order which we have observed. Indeed, uniformity in this matter could by no means be expected among authors who differ from each other upon matters of so much greater importance in their art. Those figures which are by one set of writers affirmed to be altogether peculiar to heraldry, are by others considered as evident representations of objects the most familiar in nature or in art. As to those figures which we shall next take into consideration, they are all of one mind. Heraldry has, according to every authority, borrowed them from nature.

*Of the Celestial Figures used in Armories.*

27. 1st, The *Sun*. When of the metal *or*, it is said to be proper; when of one of the colours of heraldry, it is called *ombre de soleil de gules*, &c.

2d, The *Moon*. When full, said to be *in* her complement. The half moon is styled *crescent*, *increscent*, *decrescent*, and *crescent reversed*, according to her position in the shield; *crescent*, when the horns are towards the top of the escutcheon; *increscent*, when the horns are towards the right side of the shield; *decrescent*, when the horns are turned to the left; and *crescent reversed*, when they are pointed towards the base. The crescent is the cognisance of the Ottoman emperors. Aben Mahomet, the great Moorish prince, who overran Spain, carried the *crescent reversed*. All over Spain, the crescent is a common bearing, in consequence of the achievements of particular families against the Moors.

3d, *Stars*. They are represented generally with five points. *Mollet* in French and Scottish heraldry means a figure of the same sort, of six points, and *pierced*, supposed to be the *revel* of a spur. But the English call stars of five points, mullets, unpierced, or *estoils* simply. When *pierced* they blazon them so—as, The name of Doughty in England. *Argent two bars between three mullets of six points pierced sable*.

Comets, spheres, and rainbows, are also used in heraldry, as, *argent a rainbow*, by the family of Leiris in Languedoc, in allusion to their name, *L'iris*.

*Of Man and his Parts in Arms.*

28. The use of these charges may be supposed to have arisen in a great measure from the practice of kings and great men, particularly churchmen, having on their seals representations of themselves, their patrons, saints, &c. Thus the arms of the see of St Andrews in Scotland were *azure, St Andrew carrying on his breast his proper cross (or saltier) argent*.

When any part of the human body is represented as cleanly cut off as by a sword, it is said to be *couped*; if *torn off*, *erased*; in French, *arraché*, in Latin, *avulsum*.

Heads are frequently represented as surrounded with a wreath or bandage, and they are then said to be *banded* or *tortille*. Moors' heads (always in profile) are common in Spanish coats as trophies.

*Of Animals.—Lions, &c.*

29. Lions standing upright, with only one eye seen, are called *rampant*; if full faced, *rampant guardant*; and if they are looking behind them, then the word *regardant* is added to that which speaks the attitude, as *passant regardant*, *rampant regardant*. Lions, when represented as feeding, are called *rapin*; and when in an attitude of springing with both their hind legs together, they are termed *saliant*; as are also bears, wolves, unicorns, and all other beasts, except *griffins*, which are termed *segreant* instead of *rampant*. The tongues and claws of all beasts are in general represented in coat-armour, as of a tincture different from that of their bodies, and are termed *langued* and *armed*, as, *argent, a lion rampant rampant regardant gules langued and armed azure*. Farther, it is a general rule, that when any beast is tinctured *azure*, the tongue and claws are *gules*; and *vice versa*, except when it is otherwise expressed.

When any animal proceeds from the bottom of a chief, fess, &c. it is termed *issuant*; and when it proceeds from the fess or ordinary, it is termed *naissant*. A *demi-lion* is half a lion, so proceeding, *couchant passant*, and the rest are sufficiently intelligible.

When any beast in a field has a fess, bend, &c. passing over him, he is said to be oppressed, depressed, or *debruised* with a fess, &c. When a beast is on a field, which is *per chevron*, it is said to be counterchanged. Wherefore the chevron line must continue its course through the beast, and the beast be painted of two colours of the field; for example, *Per chevron argent et sable a lion rampant counterchanged*. The upper part of the lion, so far as to the chevron line, is sable, the lower part, from the chevron line to the base, argent. Again, if the field is *paly, of four or and azure*, and over all a lion rampant counterchanged, some part of the lion must of consequence lie on each of the four pales, and therefore the lion must be painted of the different colour of each pale.

Lions, &c. may be borne of several pieces; as for example, *gules a lion barry wavy of eight argent and or*, by the name of Harrowden. *Gules a lion rampant cheque or and azure*, by the name of Cobham. *Gules a lion rampant barry of ten argent and azure*, by the name of Desney. *Gules a lion rampant vair crowned or*, the old bearing of Marmion. They may also be carried *dismembered* of head, feet, and tail. When a lion is said to be *dismembered*, the parts are put a little distant from each other, yet so as to preserve the form and shape of the lion. If dismembered of any particular part, it should be mentioned; as dismembered of the head, if the head be cut off, &c.

If tongue or claws be cut off, he is said to be *disarmed*. If the parts cut off be not in the field, he is blazoned thus, *argent a lion sans tail gules*, &c.

Some call a lion rampant without tongue or claws a lion *mortue*; and the lion *sans tail* they call *defamed*. A lion rampant holding in his mouth a staff or batton, is said to be *bailloné*. One rampant, or sejant, (*i. e.* sitting) with his face to the sinister, is termed *Contourné*. If the eyes of lions are of a fiery colour, they are called allumés, or incensed; if their tails hang between their hind legs, they are termed *coward*.

When a whole fore-leg of a lion or other animal is borne in an armory, it is called *a jambe*; but if couped or erased near the middle joint, it is termed *a paw*.

As lions may be dismembered, so they may have additions made to them; as a lion with two or three heads, or one head with two or three bodies. Another bearing not uncommon is that of lions with two tails, which are moreover represented under various circumstances, as with *two tails erect*, *two tails forked and wreathed*, i. e. two tails twisted over one another, and having the two ends forked; and with two tails *nowed* or *notted*.

But as beasts of all sorts are blazoned in the same terms as the lion, we have given, in Plate CCXCII. representations of this animal in the principal attitudes in which heralds place him.

Fig. 30. Stattant. 31. Passant. 32. Passant-gardant. 33. Passant-regardant. 34. Rampant. 35. Rampant-gardant. 36. Rampant-regardant. 37. Salient. 38. Sejant. 39. Coward. 40. Couchant. 41. Dormant. 42. Naissant. 43. Issuant. 44. Combattant. 45. Lions endorsed. 46. Lion demi-rampant erased. Lion's head coupé. 47. Lions jambe erased. 48. Lions tails erased.

### *Of the Tiger and Antelope.*

The manner in which these two animals were anciently expressed in armories, is so dissimilar from the real figures of those well known animals, that it is not without difficulty we can recognise them. The heraldic tiger is drawn much in the shape of a wolf, with the tail of a lion, and thereon, as also on the inside of his hind legs, and on his chest, tufts of hair. On the back of his neck is a mane composed of separate tufts, similar to those *tusks* which are used in ornaments, and at the point of his nose is a tusk like that of a boar bending downwards. The imaginary antelope of former days is the same figure as this tiger in every respect, save that on his head he has two horns, whose edges are indented like a saw, and that he is hoofed like a buck.

Besides those two creatures of heraldic fancy, the blazoners of old times invented a third, which they made of the same form, and tufted and maned exactly like their tiger and antelope, but with this variation, that he has two straight horns projecting from the head. This they term an *ibex*.

### *Of Birds*, &c.

30. Birds painted of their natural colours are termed *proper*, and their claws, or talons and beaks, are called *arms;* thus *argent a falcon proper armed* OR, implies that he is taloned and beaked of gold. To distinguish the falcon from the eagle, the former bird is generally depicted with bells on his legs, and this is termed *belled;* but if the thongs of the leather by which these bells are attached, are flying off from the legs, then the falcon is said to be *jessed and belled.* Falcons, eagles, or hawks, drawn feeding, are termed *preying.* When the wings, &c. are both behind the head, and back to back, they are termed *expanded*, *expansed*, or *adossed;* and when the wings are on either side of the head, and the points are erect, they are termed *elevated.* An eagle with wings elevated and legs extended, is termed a *displayed* or *spread eagle.* If the eagle has two heads, the blazon runs thus, *sable an eagle with two heads displayed* OR.

The eagle without legs, wings, tail, &c. is blazoned thus, *gules an eagle with two heads erased in the middle of the body*, *sans wings argent*, by the surname of Barlow. Parts only of eagles, &c. may be carried in coat-armour: wings by pairs are called *wings conjoined;* and if their points be downwards, *inverted* or *in lure*, as in the arms of Seymour. *Gules two wings conjoined in lure* OR. All birds, *not of prey*, having their beaks and legs of a different colour from their body, are called *membered*; as to claws and talons, *armed.*

When SMALL BIRDS are borne in armories, they are all represented after the same shape, of whatever tincture they be, and in our blazon are termed *birds* alone, in French "*alerons.*" *Martlets*, though principally used as a mark of distinction of houses, are nevertheless a bearing by no means uncommon. The English draw them as birds without legs. The French amputate them still more, and give them neither *beak*, legs, nor thighs.

COCKS are said *to be armed*, *crested*, and *jelloped; armed* signifies the beak and spurs, *crested* the comb, and *jelloped* the wattles or gills.

A SWAN, when he has a ducal coronet on his head, and a chain thrown over his back, is termed *a cygnet royal.* When a swan's head is borne, it is always blazoned *a swan's neck* couped, erased, &c.

Birds on wing are said to be *volant.*

FISH, when placed horizontally, are termed *naiant;* when placed perpendicularly, with the head in chief and tail in base, *haurient*, *i. e.* drawing in air; when bent, they are said to be *embowed*, (the dolphin is commonly represented thus.) When two fish are placed face to face, they are said to be *respecting each other;* if back to back, *endorsed.* Flowers of three leaves are called *trefoils*, of four *quatrefoils*, &c. When the human figure is borne clothed, it is termed *vested* or *habited.* Thus for a crest, *on a wreath*, *a dexter arm embowed*, *vested gules*, *cuffed argent*, *holding in the hand proper a rose of the last.* This implies the sleeve of the coat to be red turned up with white. Robes, vestments, and habits of all sorts, crowns, sceptres, crosiers, cardinals' hats, gloves, stockings, shoes, brogues, armour for man and horse, all military machines and engines, arms offensive and defensive, rings, jewels, and other ornaments, coins, dice and chess-rooks, all articles of husbandry, all tools of trade, and in short almost every thing celestial or terrestrial, from the sun in the firmament to a carpenter's nail, have been represented in heraldry; and nothing more frequently than those creatures which have no existence except in the imagination of the poets and romancers: centaurs, unicorns, mermaids, wyverns, (*i. e.* adder-tailed dragons,) montegres, (*i. e.* monsters with the bodies of tygers and the heads of satyrs,) are abundantly to be met with. Nay, in the arms of the elder time, and more particularly in those of churchmen, we daily encounter such combinations of cherubim, seraphim, and angels, (*affrontés volants, and with wings displayed*,) as, to say the least of them, appear not a little indecorous. Astonishing, they certainly cannot be esteemed, if we take into our consideration, that they are the works of the same men, who thought that the art of heraldry itself was one of the important secrets transmitted at once *viva voce* to Adam from his Maker, as being of too great depth and dignity ever to have been discovered by the mere unassisted intellect of man.

### *Of Marks of Cadency.*

31. The several figures or marks of cadency, which have of later times been used for the differencing and distinction of houses, in order that their degrees of descent may be known, are for the first an ALABEL; for the second a CRESCENT; for the third a MULLET; for the fourth a MARTLET;* the fifth an ANNULET; the sixth a FLEUR-DE-LIS;

* This bird represented in heraldry as *απους* or *sive pedibus*, "is given," saith Bekenhawth, "for a difference to younger brethren, to put them in mind to trust to their wings of virtue and merit to raise themselves, and not to their legs, *having little land to put their foot on.*"

the seventh a rose; the eighth a CROSS MOLINE; and for the ninth a DOUBLE QUATREFOIL. See Plate CCXCII. Figs. 50—55.

These marks are said to have been invented by modern heralds, in order that coat-armour might descend to posterity with safety. Certain it is, however, that they are far from answering some at least of the purposes for which they were intended; for these marks, when painted on a shield of arms, are so small, complicated, and confused, that they are scarcely distinguishable. The ancient heralds adopted a better method. They made choice of more conspicuous brizures, and pitched on the border the bend, and armorial additions, as also changes of the tinctures, and of the position of the charges, as being more intelligible tokens of difference. Thus an old family of Salop, the Corbettes, bore *or a raven sable*, the second branch took *two ravens*, the third *three*, the fourth *four*, and a still younger branch bore their *ravens within a border*. It was the most usual method to have these borders of difference composed of the arms of the first marriage, that had established the particular branch of the family which first assumed such border. The Manwarings of Salop bore *argent two bars gules*. The younger branches went on increasing the number of bars, till one took *ten bars*. The Warrens originally bore *cheque or and azure*. But the younger branch took *cheque or and azure on a canton gules a Lion rampant argent*, being the arms of the mother, a Mowbray. Others took a part of the maternal coat, and added to their father's coat, to shew that it was a younger branch descended on the mother's side from such a particular family. At present the above mentioned marks of distinction, *label*, *mullet*, &c. are so combined with each other as to difference almost *ad infinitum*. The daughter of a house bears her father's mark of cadency, but not any to shew that she is first, second, or third daughter.

*Of Additions of Honour.*

32. Certain ordinaries have been, from what cause it is difficult to say, selected as more proper than others for bearing and exhibiting heraldic additions of honour, and augmentations of arms. These are nine in number, viz. the *border*, the *quarter*, the *canton*, the *gyron*, the *pile*, the *flasque*, the *flanche*, the *voider*, and the *escutcheon of pretence*. These have all at various times been in vogue. In the days of King Henry VIII. the *pile* had the preference, and was by him granted to the Lady Jane Seymour, and to the Lady Catharine Parr. But of late years, the *quarter* and *canton* are most in use.

*Abatements of Honour.*

33. By *abatements of honour*, we are to understand "Such figures as heraldic authors affirm were, by judgments of the court military, to be added or annexed to coat-armour, in order to denote some ungentlemanlike, dishonourable, or disloyal act, demeanour, quality stain, or vice in the bearer, and whereby the dignity of the said coat-armour is greatly abased." These abatements of honour are in like manner nine in number, viz.

1st, *A delf* (or turf) *tenné*, for him who revokes or recedes from a challenge.

2d, *An escutcheon reversed sanguine occupying the middle point of the escutcheon of arms*, for him who deflowers a maid or widow, or flies from the banner of his prince.

3d, *A point dexter parted tenné*, for a braggadochio, or vain-glorious boaster of acts unperformed.

4th, *A point in point sanguine*, for a person guilty of cowardice.

5th, *A point champaine tenné*, for him who kills his prisoner after quarter demanded.

6th, *A plain point sanguine*, for him who lieth to his prince or general.

7th, *A gore sinister tenné*, for him who behaveth basely towards his enemy.

8th, *A gusset sanguine*, on the dexter side of an adulterer, on the sinister for a drunkard.

9th, *The whole coat turned upside down, or reversed*, for a traitor.

N. B. These figures are always given in the English systems, but are ridiculed by the Stotch writers, and by the Jesuit Menestrier termed "English fancies." The truth is, no instance is furnished in any of the books of such figures being actually borne for the purposes alleged. Certain it is, that many of these figures are frequently used as marks of honour.

*Of Marshalling Coat-Armour.*

34. "Arms," according to Nisbet, "are said to be marshalled, when ensigns of honour and dominion, or the entire arms of other families, are joined with the paternal arms of the bearer by partition lines, making distinct areas or compartments in one shield." Edmonstone defines marshalling of arms "an orderly disposing of sundry coats belonging to dictinct families in their proper places within one shield, by impaling and quartering." Marshalling is moreover extended to the disposition of the appurtenances of such arms without the escutcheon.

Women, unless they are sovereign queens or princesses, by the rules of heraldry, bear their paternal arms in a lozenge or shield; and therefore, when they marry, it has been the custom to impale their arms with those of their husbands, in order to shew that alliance; which is called "*arms en baron et femme*."

Impaling has been practised in three different manners. First, by *dimidiation*, (Plate CCXCIII. Fig. 1.) that is, by halving or cutting the shields of both husband and wife into two equal parts, and joining the dexter half of the husband's to the sinister half of the wife's, so as to form one shield. In this mode (called in their tongue *accolée*) the French kings used to impale the arms of Navarre. The second mode is dimidiating the husband's arms, and impaling them with the full coat of his wife, (Fig. 2) The third mode (Fig. 3.) and that now in use in England, is that of impaling the two full coats, except when one of them hath a border; for this can never be carried all round an impaled shield, but must stop at both ends where the two shields meet, (Fig 4.)

Dimidiation of arms was much used long before entire impalements were in use. Margaret, sister to Philip IV. of France, and second wife to Edward I. of England, had on her seal, in the year 1299, the arms of England so dimidiated with those of France, and she was the first queen of England who had her arms so marshalled. The same method prevailed in France up to the time of the Revolution. But the reasons which have induced the English heralds to lay it aside are certainly very powerful; for were it practised as of old, no end could be put to the jumble and confusion which it must infallibly create. For example, dimidiate the arms of CLARE, viz. *or three cheverons gules*, and impale them on the woman's side with any coat, and you will have *or three bends gules*. Again dimidiate the coat of Waldegrave, viz. *per pale argent and gules* for the man, and it will be only *a white field*; but do the same for the sister, and then it becomes *a red field*.

Besides this impaling by way of *baron and femme*, the husband in Scotland frequently quarters his wife's coat with his own, on account of her being an heiress, *i. e.* he divides a shield into four equal parts by coupe and party. In the first and fourth *areas* are the husband's arms; in the second and third those of the lady: (See Fig. 5.) But in England the husband of an heiress more commonly places his wife's arms on an inescutcheon in the centre of his coat, and this is termed *an escutcheon of pretence*. See Fig. 6.

The other methods of accumulating many coats in one shield, which have been of common use in other European countries, have never much prevailed in Scotland. Of these the principal are, FIRST, *that by tranchie and taille-lines;* thus a coat parted per saltier, is divided into four conal quarters or areas, &c. called in French *tranchée taillée*, as in the well-known arms of Sicily. *Quarterly per saltier, first and fourth, or four pallets gules* for Arragon; *second and third argent an eagle displayed sable, beaked and membered gules*, for Suabia. (Fig. 7.) SECONDLY, (as in Fig. 8) by surmounting coats already quartered with inescutcheons, by the French termed *surletout*. When this inescutcheon is parted, couped, or quartered with diverse coats of arms, the French call the uppermost *le-tout-du-tout*. This mode was practised in the achievement of the Princes of Orange, of the family of Nassau, before their late elevation to the kingly rank; thus, quarterly, 1st, *azure semée of billets, a lion rampant or*, for Nassau. 2d, *Or a lion rampant guardant gules crowned, langued, and armed azure*, for the country of Catzellenbogen. 3d, *Gules a fess argent*, for the house of Vianden. 4th, *Gules two leopards or langued and armed azure*, for the country of Dietz. Over all an inescutcheon by way of *surtout*, quarterly. 1st and 4th, *Gules a bend or*, for Shallon. 2d and 3d, *Or a hunting horn azure virole and stringed gules*, for the principality of Orange: which inescutcheon is again surmounted by another by way of *le-tout-du-tout*, viz. *cheque or and azure of nine points* as a coat of pretence for the city of Geneva.

Moreover, in foreign heraldry, the quarters are often divided by the *pale* or the *fess*, which ordinaries are then again charged with escutcheons. And the ordinary of the cross is often used in this very way by ourselves, as in the arms of the St Clairs, Earls of Caithness, who bear *quarterly*, 1st, *azure, a ship at anchor*, &c. for the earldom of Orkney. 2d and 3d, *Or a lion rampant gules*, for the name of Sparr. 4th, *azure a ship under sail*, for the title of Caithness; and, *over all dividing the coats a cross engrailed sable*, for Sinclair.

The third way (Fig. 9.) is by *tiercing* and *engrafting*, (by the French called *Entée*,) an instance of which is to be seen in the arms of the King of Great Britain, whose paternal escutcheon is, 1st, The arms of Brunswick, *gules two lions passent guardant or*, impaled with those of Lunenburg *or semée of hearts*. Gules a lion rampant azure armed and langued as the hearts, and *grafted by way of entée between the impaling in point;* the arms of Lower Saxony *gules a horse current argent;* or, more shortly, *Brunswick and Lunenburgh impaled with ancient Saxony entée en pointe.*

The fourth and last method proposed for marshalling of arms, is by dividing the shield into a plurality of areas or quarters by many partée and coupée lines, which when drawn appear like the areas of a chequer, divided by perpendicular and horizontal lines. (Fig. 10.) By this method any number of coats may be brought in; but it seems to be agreed by the best authors, that the number of *marshalled arms* in one shield should not exceed six or eight quarters at most, and these always charged on the warrantable grounds and reasons of the bearer having many territories or feus, or matching with heiresses, or as arms of alliance or pretension. The Germans, it is true, are in use to accumulate twenty or thirty coats in one shield; but this is always on account of their many territories or feus, to shew how many votes they have in the circles of the empire. The French also have many quarterings, though not so many as the Germans, their feus being neither so many nor so free, and the whole succession of these dignities belonging always to the eldest son, whereas in Germany the younger brothers share with the eldest in the dignity and titles of honour of the family. In Scotland, the prejudices of the heralds seem always to have run very strong against many quarterings, in so much that few have followed the example set them by Queen Mary of Lorraine, whose rich and loaded escutcheon is still to be seen in many parts of the kingdom, impaled with the simple bearing of her husband James V.; almost the only instances of the sort being found in the arms of those Englishmen who were honoured with Scots titles after King James VI. succeeded to the crown of the sister kingdom.

The several ways whereby the quarterings to which a family may be collected and marshalled in one achievement, after the English method, are explained in the annexed scheme, to which the reader is referred.

No. I. Suppose the heir of the WILLOUGHBYS to have married the heiress of LATIMER, NEVIL, and BEAUCHAMP, which three coats the heir of Willoughby has an undoubted right to quarter with his own paternal coat.

No. II. Shews how WILLOUGHBY, in consequence of this marriage, may inherit the blood, and become entitled to quarter the arms of no less than fifty-six families: thus, as WILLOUGHBY by this marriage hath a right to quarter LATIMER, so LATIMER had before a right to quarter *Blyke*, who quartered *Brocton* and *Filylode; Astley*, who quartered *Fynes* and *Thynne; Darrel* and *Cheney*, who quartered *Boyle* and *Wilmot*. Secondly, TWENGE, who quartered before *Bulmer*, who quartered *Mallet* and *Beke;* and *Bruss*, who quartered *Fitchet* and *Dean*.

The like as to NEVIL and BEAUCHAMP, and the quarterings by them brought in.

No. III. Supposes THOMAS PYE to be the son and heir of Thomas Pye, and Elizabeth his wife, heiress of John Abbot, whereby he becomes entitled to quarter the arms of sixteen houses; eight by the father's side, and as many by the mother's.

No. IV. is formed upon a plan more extensive than either of the former, and shews how a person may in five descents be heir to thirteen families; so that we can no longer wonder at seeing two hundred coats borne in one achievement.

*Schemes shewing how Quarterings may be Collected and Marshalled.*

No. I. WILLOUGHBY marries the Heiress of . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
- LATIMER.
- NEVIL.
- BEAUCHAMP.

No. II. WILLOUGHBY
- Latimer
  - Ledet
    - Blyke . . . . . Brocton. Filylode.
    - Astley . . . . . Fynes. Thynne.
    - Cheney . . . . Boyle. Wilmot.
  - Thevenge
    - Bulmer . . . . . Mallet. Beke.
    - Bruss . . . . . . Fitchet. Dean.
- NEVIL
  - Clavering
    - Tilliot . . . . . Liff. Fitz James.
    - Creke . . . . . Grenville. Trivers.
  - Middleham . . . . . . . Burley . . . . . Shirland.
  - Maldred
    - Morville . . . . Stafford.
    - Lovetot . . . . Wilby.
- BEAUCHAMP
  - Afflet
    - Engaine . . . . Orreby. Rosceline.
    - Pembridge . . Abbot. Howard.
  - Maudit
    - Gattacre . . . Tillesworth. Gypherwast.
    - Gresham . . . . Pointes.
    - Mallet . . . . . Arden. Acton.
    - Strode . . . . . Audley. Ferraby. Hansard.

## No. III. PYE'S PEDIGREE.

John Nevil = Alice, daughter and heiress of Maudit

Mary, D. and heiress = Thomas Moore

Joan, D. and heiress = John Scrope

Elizabeth, D. and heiress = Thomas Morley

Anne, D. and heiress = James Golding

Harriet, D. and heiress = John Croft

Margaret D. and heiress = Thomas Pye

Abr. Cranfield = Joan, heiress of Pool

Th. Tomkin = Harriet, D. and heiress.

Joesph Caldwell = Margaret, D. and heiress

B. Thornton = Amy, D. and heiress

T. Beauchamp = Anne, D. and heiress

John Finch = Elizabeth, D. and heiress

John Abbott = Mary, D. and heiress

Thomas Pye, only son and heir = Elizabeth, sole daughter and heiress

Thomas Pye, only son and heir.

## No. IV. WARREN'S PEDIGREE.

John Catline = Maud, heiress of Story

John Gray = Anne, heiress of Sloper.

John Warren = Anne, heiress

Thomas Owen = Ellen, heiress of Roper.

Thomas Pulford = Alice Etton.

Thomas Gray = Joan Ely.

Thomas Green = Maud, heiress of Pylewell.

John Warren = Alice, heiress

Thomas Griffith = Joan, heiress of Thomson.

Thomas Pulford = Anne, heiress.

Thomas Green = Joan, heiress of Newton.

Thomas Warren, only son = Jane, heiress.

Tho. Pulford, only son = Jane, heiress.

John Warren only son and heir, = Alice, daughter and sole heiress.

John Warren, only son and heir.

The most approved method of marshalling arms in an achievement of this species is the following: "Begin with the arms of the first heiress who married into the family, and next to them place the several coats which she brought in; then proceed to the second heiress, and those which she brought in; and so on to the rest, without any regard to the rank or station of any of these heiresses before their marriage." Nevertheless, when the royal arms are brought in by any match, it is usual to give that match the second quarter, next to the bearer's paternal coat. Nay, some place it in the first, and the paternal coat in the second quarter. The achievement composed in this way is most properly termed by Edmonstone, "The genealogical pennon."

*Of the External Ornaments of the Shield.*

35. In the first part of this article, wherein we have attempted to trace the origin of armorial bearings to the tournaments of the middle ages, a passage is quoted from the treatise of King René of Anjou, in which the knights who propose to tilt at any tournament, are required to make display of their coats of arms some days before the lists are opened, with their helmets, crests, and other marks of their condition or dignity. In the MS. treatise of John Caxton, preserved in the Advocates' Library of Edinburgh, it is said, that "no man shall wear his cognisaunce on a close basnet, except he has carried arms within the lists and barriers of military exercises." From these passages, and many others of a like nature in the old authors, it seems reasonable to conclude, that after the bearing of shields had begun to be common in Europe, the great nobility and gentry, entitled by their descent to partake in the courtly tournaments of the times, were willing to adopt some method of distinguishing themselves from the herd of those who bore coat-armour, and for this purpose introduced the practice of adorning their shields on seals, &c. with a representation of those helmets, crests, and other articles of apparel, which they were themselves accustomed to wear upon those solemn occasions, and to which those of humbler birth could, it was believed, make no pretension. In process of time, the example of these military nobles was imitated by others, who thought themselves entitled to equal respect, although for different causes. Civil rulers adorned their shields with coronets, consular capes, batons, and such like signs of dignity; and the churchmen were not slow to make the same parade of the symbols of their office. The papal tiara, the cardinal's hat, the patriarch's cross, the mitre, the crosier, and the keys of St Peter, were associated in strange union with the family emblems of worldly honour and advantage, such as a free feu, a feat of chivalry, or a wealthy marriage.

*Of the Helmet.*

36. This ornament in heraldic representations has many varieties of matter, form, and situation.

In Germany, by an imperial edict, helmets of gold belong to sovereign princes, of silver to the high nobility, and of steel to gentlemen.

The French heralds have settled every thing respecting helmets according to these rules.

The helmets of emperors and kings are all of gold damasked fronting, (*tarre de front*,) open without bars or vizor.

Dukes, marquisses, and counts, have silver helmets, damasked with gold, fronting with nine bars, *grille et mise de front*.

Viscounts, barons, and knights, have silver helmets, with gold edges in profile, with seven bars.

Esquires have helmets in profile, with five bars in the guard vizor.

Gentlemen of three descents, a helmet in profile, with three bars.

The English and Scots have their helmets somewhat different.

A gentleman, or esquire, has his in profile close.

A knight has a full-faced steel helmet open.

Earls, viscounts, and barons, have profile steel helmets, with gold bars, &c.

Dukes and marquisses have the full-faced helmet of steel, with five bars of gold.

The king, and princes of the blood-royal, have the full-faced helmet, with six bars, all of gold damasked.

*Of the Ornaments of the Helmet.*

37. The MANTLING, LAMBREQUIN, HELM-DECKEN, or VOLET, is probably a representation of the hood or covering, intended for protecting the helmet in rain, &c. and its ragged form derived from the cuts which that integument must have sustained in battle. (See Plate CCXCIII. Fig. 11.) These ornaments are called *hachements*, from the Italian *azzimare*, (*caput ornare*.) or *ingemmare*. In the *patois* of Picardy, *achemer une epousee*, is still used for *to arrange the bride's head dress*. The *Lambrequin* seems, in old times, to have been ornamented with the bearings of the wearer, for King René speaks of it as "armoyé des armes de celui qui le portera;" even at present it is generally of the *tincture of the field*, in foreign heraldry. Behind the shield itself hangs the manteau, mantle, or cloak, in Latin *chlamys*. In this country the mantles of gentlemen and knights are red without and white within. Those of the nobles red, doubled up with rows of ermine, according to their degrees. The king's mantle is of gold, lined with ermine.

*Of the Wreath, &c.*

38. Menestrier, speaking of this ornament, says, "that some hundred years ago the French nobility used garlands of twisted silk, with which they kept fast on their heads their hoods or capes, as may be seen in the pictures of the old Dukes of Burgundy," &c. These wreaths were commonly of the *colours of the lady** of the bearer. The wreath is now always of the colour of the shield. See Plate CCXCIII. Fig. 12.

*Of the Crest or Cimier.* (See Fig. 13.)

39. This ornament of the helmet seems to have been very early in use among the Greeks or Romans. After its introduction among the moderns, the use of it was long restricted to sovereign princes and military commanders. But in imitation of King Edward III. (the first English prince who wore a crest,) the knights of the garter, and afterwards, by degrees, all the bearers of coat armour adopted crests. The crest is first seen on a seal of Philip Earl of Flanders in the year 1101.†

Though crests are hereditary, yet a greater latitude is allowed respecting them than any of the essential parts of armoury. They are looked upon somewhat in the nature of devices, and accordingly are varied by the caprice of individuals, so that the sons of the same family often wear different crests.

*Of the Motto, Cry of War, and Device.*

40. The *Motto* is a short sentence placed in a scroll above the crest, very often allusive to it, or to some part of the bearings. If it alludes to the crest, the two together form what is called *a complete device*; as in the case of Stewart, Earl of Galloway; the crest *a pelican vulnered feeding her young*; the motto "*virescit vulnere virtus*." Kirkpatrick of Closeburn has for crest a hand grasping a dagger; motto, "I'll make sicker," alluding to the remarka-

* Here take thy lover's token on thy pate. SPENSER, *Fairy Queen*, 1. 6. 47.

† Had Mr Campbell been acquainted with heraldry, he would never have written
But he, her loved-one, bore *in* FIELD
*A meaner crest upon his* SHIELD. O'Connor's Child.

ble feat of his ancestor, who slew the Red Cummin in the days of Bruce and Baliol. Often they have no such relation, and merely express some predominant passion of piety, love, or war, of the first who assumed them.

Camden tells us that the earliest instances of mottos painted on shields, which he had met with in this island, were those of William de Ferrariis, Earl of Derby, who carried round his escutcheon, *vair with a bordure of horse shoes*, "Lege, Lege;" and Sir Thomas Cavill, who bore for arms *a horse*, under which was written "Thomæ credite cum cernitis equum ejus:" these are both of the age of Henry III. The more abundant use of mottos was, without question, owing to King Edward III. who having founded the order of the garter, and given it the motto "*Honi soit qui mal y pense*;" each of the original knights of that order took to himself a motto of his own choice, and put it under his arms. From that period the fashion grew more and more in vogue, as may be seen from the accounts which we have of the standards and pennons of the noblemen and gentlemen, both of England and Scotland, particularly during their French wars.

N. B. Women wear neither crests nor mottos.

The *cry of war* was the battle shout of the house; and was also worn in a scroll, as the "Mountjoye St Denys" still is over the pavilion of the French king. Many families have, in consequence of the change of manners, retained these cries of war as mottos. Of old they consisted very often of the name of the noble, as "A Home! A Home!" "A Douglas! A Douglas!" &c.

*Of Devices.*

41. The *Device Proper* is a badge or emblem independent of any part of the family bearing; the legitimate descendant of the emblems of the ancients. The device is always assumed by the bearer personally, and either may or may not be the same, or that of his ancestor, as he pleases. The roses, red and white, were the *devices* of York and Lancaster. The portcullis was a device belonging to the Beauforts (descended from John of Gaunt, fourth son of Edward III.) and carried as such by the Jameses of Scotland. The said John of Gaunt, when he pretended a right to the crown in the reign of Richard II. adopted for his device "an eagle standing on a padlock assaying to force open the same." This was a strictly personal device. From these *devices* of the kings, some of the English pursuivants derived their names, as *Portcullis*, *Falcon*, &c.

*Of Supporters.*

42. These likewise are exterior ornaments, being placed on the sides of the achievement as matters of embellishment, and formally to timbre or support it. Menestrier assures us that they had their origin from tilts, tournaments, and justings. "On these occasions," says he, "it was usual for the knights to have those shields of their arms, (which we have already seen they were obliged publicly to display some days before the opening of the lists), guarded by their pages, armour-bearers, or other attendants, clothed in fancy dresses, sometimes making them appear as savages, Moors, Saracens, lions, &c. The business of these *supporters of the shield* was to take notice who, by touching the shield, accepted the challenge of their master." This custom was revived with perhaps greater magnificence than was ever before known, at a tournament in Paris before Louis XIV. in which the esquires who attended the nobles entering the lists, were dressed in the most superb manner that art could invent, representing Moors, Persians, Armenians, Turks, &c. &c. From these attendants thus disguised many heraldic writers bring the use of supporters, which, say they, every one who (being noble or gentle by father or mother's side) was admitted to tourney, had ever after a right to carry.

This doctrine is, however, strongly combated by many able writers, and particularly by the celebrated John Anstis, in his curious manuscript treatise, entitled *Aspilogia*, (now in the Astle collection,) who has these observations.

"In these later ages, the nobility have been distinguished from persons of inferior rank, by having supporters and coronets cut on their seals; but, as far as I am able to observe, there was not anciently any particular mark in the seals of the nobility that differenced them from the knights. As to supporters, they were, I take it, the invention of the graver, who, in cutting on seals shields of arms which were in a triangular form, and placed on a circle, finding a vacant space at each side, and also at the top, thought it an ornament to fill up these spaces with vine-branches, garbs, trees, flowers, plants, ears of corn, feathers, fret-work, lions, wiverns, or some other animal, according to his fancy.

If supporters had been esteemed formerly, as at this time, the marks and ensigns of nobility, there could be no doubt but there would have been then, as now, particular supporters appropriated to each nobleman, exclusive of all others; whereas, in the seals of noblemen affixed to a paper addressed to the Pope, A. D. 1300, the shields of arms of twenty-seven of them are in the same manner supported (if that term may be used) on each side by a wivern, and seven of the others by lions. John de Hastings hath the same wivern on each side of his shield of arms, and also on the space over it, in the same manner as is the lion in the seals of *Hache*, *Beauchamp*, and *De Malolacu*. The seals of Despencer, Basset, and Badlesmere, pendent to the same instrument, have each two wiverns or dragons for supporters; and that of Gilbert de Clare three lions placed in the manner above mentioned. The promiscuous use of wiverns to fill up the blanks in seals, is obvious to all who are concerned in these matters.

But what is a stronger argument is, that the same sort of supporters are placed in the seals of divers persons never advanced to the peerage. Instances of this kind are often met with; nay, the engraver hath frequently indulged his fancy so far, as to insert such figures as do not seem proper, according to our present notions of supporters of arms; as *two swords* on each side the arms of Sir John de Harcla; and *St George fighting with the dragon* on one side, the *Virgin with our Saviour in her arms* on the other side of a seal affixed to a deed of the Lord Ferrers, whose arms on the impress of a seal pendent to a deed of the 17th May, 9 Henry VI. have not any supporters.

When supporters were assumed, if there were two on one seal, they were generally the same; but sometimes there was only one, and at other times three, as may be seen on various seals."

"After having considered the observations of Mr Anstis," says Edmonstone, "I am persuaded that not a doubt can remain of supporters having originated from the fancy of seal engravers. However this may be, it is certain, that in England supporters were of old worn by many persons of the commons. All those, particularly, who bore offices of dignity in the state, as the lord deputy of Ireland, the lord of the marches of Wales, the warden of the stannaries, &c. and even by families altogether in private life; as the Stevenings of Sussex, the Stawells of Somerset, the Wallops of Hants, Savage of Cheshire, &c.; and certainly the supporters still worn by the descendants of some of these families, rest on a much more honourable foundation than any modern grant of supporters that can be obtained from a college of arms."

It is worthy of remark, that supporters were formerly changed very frequently, according to the choice of individuals, and by no means considered as fixed and unalterable marks of descent, like the proper armorial bearings. From King Edward III. till James I. few of the English kings wore the same supporters as their predecessors. The lion, the falcon, the hart, the antelope, the swan, the leopard, the bull, the boar, the greyhound, the dragon, and the eagle, were all successively used by the monarchs of England; and one of them, (Edward IV.) altered his no less than three times. Edward VI. was the first who bore the lion crowned with the imperial crown. This was retained by Mary and Elizabeth; and James also used it as his dexter supporter, placing the Scottish unicorn* on the left side; on which arrangement, no alteration has been made by any of his successors.

Henry VIII. was the first king of England who formerly granted supporters to the peers of the realm. He gave the like ornaments to the knights of the garter and of bath. The kings of arms in England are authorised to grant supporters to all persons not under the degree of a knight of the bath; and whoever of an inferior rank bears supporters in that kingdom, does so by an express grant from the crown.

In Scotland, the right to bear supporters is commonly supposed to rest on somewhat a different footing. Some of the baronets of Nova Scotia have taken up the notion, that they are, by the terms of their patents, entitled to add supporters to their paternal coats, and they accordingly wear them in their armorial ensigns. But an impartial consideration of the clause in the patents will convince them of their mistake, more particularly as it is not pretended, that there ever was any other royal grant or warrant issued, whereon they can found a claim to any such privilege. In the patents previous to the year 1629, it is ordained, "that the baronets and their heirs-male shall, as an addition of honour to their armories, bear, either on a canton or inescutcheon, at their option, the ensign of Nova Scotia, being *Argent, a cross of St Andrew azure charged, with an inescutcheon of the royal arms of Scotland, supported on the dexter by the royal unicorn, and on the sinister by a savage or wild man proper*," &c.; all evidently referring to what is within the canton or inescutcheon, and not to any exterior ornaments of the baronet's own shield, of which the said canton or inescutcheon is henceforth to form a part. As for the patents posterior to the year 1629, the whole of the clause just quoted is omitted, and the patentee is not allowed to carry a canton or inescutcheon of honourable augmentation to his coat; but, in lieu thereof, "*around his neck an orange tanny silk ribbon, whereon shall be pendent in a scutcheon argent, a saltier azure, therein an escutcheon of the arms of Scotland*,"† &c. This alteration, in all probability, took place on account of the manifest impropriety of blazoning supporters, mottos, &c. on a canton or inescutcheon; an objection which could never have occurred, had the construction which has been put on the clause of gift been the proper one.

During the reign of Charles II. a letter was addressed to the Lyon-office, strictly prohibiting any grants of supporters to persons under the degree of nobility. But many of the old barons of Scotland, (and particularly *the chiefs of names*,) who had always been in use to sit in parliament in their own right, and who with justice considered themselves as inferior in degree indeed, but as members of the same order with the titled Lords of Parliament, protested with great zeal against being obliged to discontinue the use of those supporters which had been borne by their ancestors for several centuries, and originally retained, either as the marks of the patriarchal superiority over their clansmen, or in consequence of some feat of skill or valour in tournament or in battle. The matter was not pressed, and these families have continued their supporters ever since without any objection being made. Of later years, however, a much more questionable extension has been given to the use of supporters. From whatever cause the laxity may have arisen, the fact is certain, that we have seen supporters assumed by persons who, so far from having any claim to being descended from the old barons who had power of *pit* and *gallows*, and were in reality the nobles of Scotland, as much as either dukes, marquisses, or earls, are sprung from the very dregs of the people, and are in truth the very men, to guard against whose presumption and insolence was one of the first great objects for which a college of heralds was instituted in this country. The utmost latitude which can be given to the interpretation of the law on this head, either as it is expressed in the King's own words, or as it has been modified by the practice of the heralds, is, that those of the lesser barons, who can shew proofs, by old seals or otherwise, of their ancestors having borne supporters previous to the passing of the act, 10th September, 1672, are *excepted from the general rule*, and permitted to carry supporters. The letter above referred to was quoted by the Lord Lyon himself, as *his authority for refusing supporters* to persons of rank very different from most of those who have of late procured these ornaments by the good offices of his successors.

> ——*At titulos* Regina PECUNIA *donat,*
> *Et genus, et proavos, sordesque parentis honestat.*
>
> SECTANUS.

No women have a right to bear supporters, except those who are peeresses by descent or by patent. If they are peeresses by patent, they have in consequence a grant of supporters to themselves and their heirs-male; if by descent, they retain the ancient supporters of the barony, to which they have an indisputable right, in as much as they represent peers whose insignia and titles are all through them to descend to their posterity.

### *Of Crowns and Diadems.*

43. Crowns or coronets may be used in armorial bearings in four different ways.

1*st*. As essential or internal parts of arms, that is, when they are the chief figures of the escutcheon, as the three crowns in the shield of Sweden. Many families throughout all the European kingdoms bear similar arms; and crowns so worn are no marks of sovereignty or dignity, of whatever form they may be.

2*dly*. When they are used as additional charges, or ornaments within the shield, they are in like manner no marks of sovereignty or dignity.

3*dly*. When crowns are placed upon helmets, which *timbre* coats of arms, they are then marks of dignity, being commonly so placed by sovereign princes. Yet many gentlemen who have no pretensions to such rank bear crowns on this way in their helmets, a custom which, according to Menestrier, is derived from the tournaments, "especially those solemnized in Germany, where knights were allowed to adorn their helmets in that manner, in memory of their

* The unicorn was originally, with great propriety, assumed by the Scottish kings, in allusion to the words of Scripture, Job xxxix.—"Canst thou bind the unicorn with his band? Will he be willing to serve or abide by thy crib?"

† Vide Fountainhall's *Decisions*, MS. (in the Advocates Library) p. 17. This important document was pointed out by John Riddell, Esq. advocate, a gentleman whose attainments in every part of the antiquarian learning of his country are above all praise.

having been exercised in such disports." And though indeed there are many helmets placed over the German coats, according to the number of feus, whereby the bearers voted in the circles of the empire; yet we see but few of them adorned with crowns, which, according to our author, can only be explained by supposing that some of these feus are not privileged to carry a crown, the ancient possessors of them not having been present at the tournaments.

*4thly*. Crowns placed immediately above the top of the escutcheon, are ensigns of sovereignty or nobility, whereof the degrees are set forth by their shapes. The arched crowns topped with *monds* were first introduced by the emperors, and from that circumstance are called imperial crowns, although now worn by all the kings in Europe, since Charles the Eighth of France assumed an imperial crown, in token probably of his pretensions to the empire of the East.

"The imperial crown of England is composed of four crosses pattee, and as many fleur-de-lys of gold placed on a rim or circlet of gold, embellished with precious stones. From these crosses arise four circular bars, ribs or arches, which meet at the top in form of a cross; at the point of intersection whereof is a pedestal, whereon is a mound. On the top of the mound is a cross of gold, all embellished likewise with precious stones, and three very large oval pearls; one of them being fixed in the top, and two pendent at the transverse beams of the cross. The cap within this crown is of purple velvet, lined with white taffeta, turned up with ermine. See Plate CCXCIV. Fig. 1.

The crown or coronet of the Prince of Wales resembles the king's crown, save only that it hath not four arches, but two only. See Fig. 2.

The younger sons of the king bear coronets, composed of crosses pattee and fleur-de-lys.

A duke (not of the blood-royal) has a circle of gold, with eight leaves of equal height above the rim, commonly called strawberry leaves, the whole richly chased; a crimson velvet cap, turned up with ermine of one row, and topped with a golden tassel. See Fig. 3.

A marquis has a circle of gold, with four leaves placed between four pearls, raised on points of equal height with the leaves. See Fig. 4.

An earl has eight pearls raised on as many points, between every two points a strawberry leaf lower down. See Fig. 5.

A viscount has pearls to the number of twelve or sixteen, placed on the edge of the rim. See Fig. 6.

A baron has only six pearls placed on the rim of his golden circle. See Fig. 7.

*Of the Cap of State.*

44. This cap is of crimson velvet, faced with ermine, with two points turned to the back.

Of old, by the practice both of England and Scotland, this cap was borne by princes or dukes only, as an ensign of dignity, whether on the helmet itself, or timbring the whole achievement. Mr Sandford, in his *Genealogical History of the Kings of England*, informs us "that King Edward III. and his successors, as low down as Edward VI. had on their seals of arms this cap of state. For on one side is always to be seen the figure of the monarch on horseback and in armour, with this cap of state on his head, and the crest of England set thereon."

The cap was originally therefore granted to certain nobles on account of pre-eminent dignity or merit, as we find in the case of Henry II. Duke of Lancaster in England, and Archibald Earl of Douglas, Duke of Torraine, and Great Constable of France, whose seal, affixed to several charters still extant in Scotland, always represents the helmet as adorned with this cap. But now the cap of state hath lost all its former eminent dignity by the evil usage of certain heralds, and is now borne not only by all degrees of nobility, but by many of the inferior gentry, and indeed by some of the lowest extraction. See Fig. 8.

*Of Ensigns belonging to Ecclesiastical Dignities.*

45. The Pope carries his arms in an oval shield or cartouche, which form has become common in Italy, in consequence of other ecclesiastics imitating their chief. This shield is adorned externally with the ensigns of his dignity, which are, 1st, *The Tiara*. This is an high cap, or mitre, of silk, environed with three crowns of gold, and topped with a mound and cross like the imperial crown. This triple crown (or as it is called by the Italians the *regno*) is the sign of his supremacy, and placed over the cartouche. See Fig. 9.

*2dly*. The keys, one of gold, and one of silver, (symbols of the Pope's power of opening and shutting the gates of Paradise) are placed in saltier behind the cartouche.

*3dly* The staves. The two angels which support the proper arms are placed in a sitting posture, one on each side of the cartouche; each with one hand upholding the *regno*, and with the other grasping a long staff, having three traverses near the top; which traverses end in trefoils, and are of the same metal with the keys.

The cardinal's external armorial mark of dignity is the *red hat*, with which they timbre their shields, having red strappings, with fifteen tassels hanging down at each side of the shield. Innocent III. charged the cardinals to discontinue all symbols of secular dignities; but this was never complied with except by the Italians.

Archbishops of the Roman church, primates, and legates, place a cross staff with two traverses in pale behind the shield, and above the same a green hat with ten tassels hanging down on each side.

Our modern archbishops in England place a mitre *affrontée* on the top of the shield, (Fig. 11.) issuing from a ducal coronet, and having two labels or pendants hanging from it, and behind the shield two crosiers in saltier. Bishops use their mitre alone, proceeding from a plain circlet of gold, without any other exterior ornaments.

Abbots of the Roman church use a mitre in profile, and a crosier in pale behind the shield; above both a black hat with a knotted cord, and six tassels on each side, as may be seen in many of our Scottish abbeys, such as Holyroodhouse, Paisley, &c. Priors, provosts, deans, and chanters of the church of Rome, are all distinguished by similar marks, such as palm-branches, pastoral staves, &c.

*Ensigns of Civil and Military offices.*

46. In France and Germany, it has always been the custom of the great civil officers to denote by some exterior ornament of the shield their station and dignity. In Scotland likewise this practice was common before the union; but in spite of the unceasing endeavours of the heralds of England, the great officers of that kingdom have never complied with the customs of their brethren in the other European states. The only established civil officer in England who is distinguished by any armorial ensign of his official dignity, is the Earl Marshall, who carries behind the shield of his arms *two batons in saltier sable, the ends gold.* When there is a deputy Earl marshall, he is permitted to carry *one baton in bend dexter*, exactly as was used in Scotland.

The chancellor of Scotland bore behind his shield *two maces in saltier, ensigned with imperial crowns*; as also under the shield *a purse* with the strings open, *pendant*, *fretted*, *nowed*, buttoned, and tasselled gules, embroidered with the royal arms.

In addition to these, the chancellor of France has a proper cap of gold, (*mortier d'or*) turned up ermine on the helmet.

The presidents of the parliaments in France had in the same way their proper cap of black velvet edged with gold galloon.

The lord high chamberlain in Scotland had two keys disposed in saltier behind his shield, in the same manner as the *grand chambrier* of France.

The justice general of Scotland carried two naked swords in saltier behind his shield, the points being upward.

The lord high treasurer in Scotland carried a white staff ensigned on the top, with an imperial crown in pale behind his shield.

The office of cup-bearer being of old hereditary in the house of Southesk, these Earls carried a golden cup in their arms.

The king's foresters carried hunting horns; as Burnet in the northern forest, and Forester of that ilk, in the southern. So did the *grand veneur* of France.

The *grand pannetier* of France carries under his arms a rich cover and knife and fork in saltier.

The lord high constable of Scotland carries *on each side of the base part of his shield, an arm gauntletted fessways, issuing out of a cloud, and grasping a sword erected in pale at the dexter and sinister sides of his shield, all proper hilted and pomelled* OR.

In France many other exterior marks of the same sort were in use, all sufficiently intelligible without previous description, as the grand master of artillery, who carried under his arms *two field pieces*, &c.

But in no kingdom were either external or internal ensigns of dignity so extensively used, or so systematically arranged, as in France, during the empire of Napoleon. Not only were princes, grand dignitaries, dukes, counts-senators, counts-archbishops, counts-military, barons military, baron-bishops; and chevaliers, distinguished by mantles, lined in different manners; but for each of these ranks of persons there was set apart some one of the honourable ordinaries, which, either by its charge, its colour, or its position, immediately denoted that order in the state to which the bearer belonged: Thus the princes grand dignitaries had a chief of azure charged with bees of gold; dukes, a chief of azure charged with stars of silver; counts-senators, a canton dexter azure charged with a mirror in pale *or*, in which a serpent wreathed argent regards itself; counts-archbishops, on a canton dexter azure a cross patee *or*; counts-military, on a canton-dexter azure, a sword erect in pale *argent* mounted *or*, &c. The canton dexter always denoted a count, the canton sinister a baron. Chevaliers of the legion of honour placed the cross of their order on any one of the nine honourable ordinaries which they preferred. In this heraldry supporters are entirely laid aside, and the nobility, under the rank of princes, are distinguished by the number of feathers in the plume of the bonnet with which the shield is timbred. See Plate CCXCIV. Fig. 12. shewing the *Arms of a Duke* under Napoleon.

*Of Ensigns of Chivalry or Knighthood.*

47. Knights of the different sovereign orders in Europe are in use to surround their shields with the collars of their orders; and if any one has more orders than one, the collar of the most ancient order ought of right to be placed nearest the shield. In Britain, however, it has become the practice for knights of the garter to place their shields within the garter itself, not the collar of the order, and always to give this most dignified order the preference over every other, by assigning to its ensign the place of honour nearest to the escutcheon. For a particular account of the several orders now so much in vogue among the sovereigns of Europe, see the article KNIGHTHOOD.

*Of the Compartment.*

48. The compartment is that figure, on which the shield and supporters usually rest. When the bearer has more mottos than one, if one of them relate to the supporters or figures of the shield, it should be placed in the compartment; if one relate to the crest, it should be in an escrole thereupon. Heralds agree, that the compartment is in general intended to represent the lands or feu of the person below whose shield it lies, although it be sometimes granted or assumed in memory of some remarkable action. An instance of the compartment thus applied, is to be found, says Nisbet, "in that of the Earls of Douglas, who obtained the right of having their supporters placed within a *pale of wood wreathed*, because the Lord James, in King Robert Bruce's time, defeated the English in the forest of Jedburgh, and, that they might not escape, caused wreath and impale that part of the wood, by which he conjectured they might make their escape." The territorial compartment may, in like manner, be illustrated from the same family. William, first Earl of Douglas and Mar, has "a compartment like to a rising ground, with a tree growing out of it, and semée of hearts, mullets, and cross crosslets, the armorial figures of this Earl's escutcheon, to shew that the compartment was meant to represent his lands and feus." Others seem to have assumed a compartment from more fanciful motives; as the old Earls of Perth, who had a green hill semée of galtraps, which, with their motto "Gang warrily," forms a complete device.

*Of the Pavilion.*

49. After treating of these external marks of honour common to the nobles of the European kingdoms, it remains to take notice of one entirely confined to sovereign princes, although not assumed by all of them, viz. the pavilion. This is a tent or tabernacle, with a canopy roof, under which the arms of the emperors, of the kings of France, and of some other princes, are usually represented. Menestrier is of opinion, that the first who invented this use of the pavilion was Philip Moreau, and that from its having made its first appearance on the coins of Philip of Valois, it derived the name by which we know it. As a specimen of the mode of blazoning arms, we have inserted the royal achievement of Scotland, in Plate CCXCIV. Fig. 13. in which the blazon, according to Mr Nisbet, runs thus: "The sovereign ensign armorial of the kingdom of Scotland—*or* a lion rampant *gueules*, armed and langued *azure*, within a double tressure counter flowered with flower de lysses of the second; timbred with a helmet affrontée with bars *or*, adorned with lambrequins *or*, doubled ermine, and ensigned with the imperial crown of Scotland; and thereon for crest a lion sejant full-faced *gules*, crowned *or*, holding in his right paw a naked sword proper, and in the sinister a scepter *or*, both erected; and above, in an escrole, the motto "IN DEFENSE." The shield is encircled with the colour of the most noble order of the thistle, with its badge thereto appended of gold, enamelled azure, having the image of St Andrew surmounted of his cross argent; and supported by two unicorns argent,

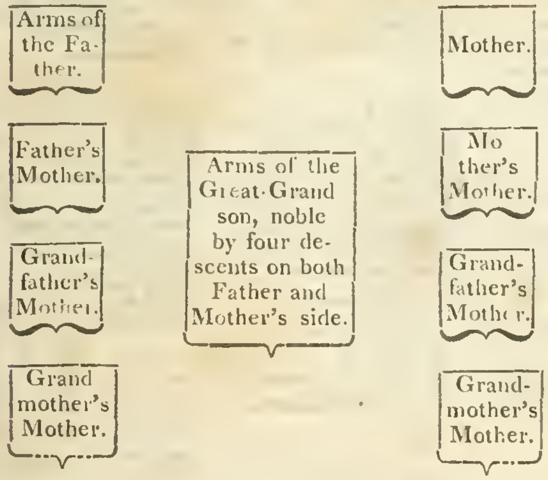
crowned with imperial and gorged with open crowns, to the last chains affixed passing between their fore-legs and reflected over their backs *or*; he on the dexter bearing up a banner *or*, charged with the red lion of Scotland; he on the sinister, a banner azure charged with the white cross of St Andrew, both standing on a compartment cheque or and azure like a pavement, on the first the lion of Scotland, and on the second St Andrew's cross. All within a royal pavilion of cloth of gold, semée of thistles slipped proper, doubled ermine, the comble or canopy rayonnée, and adorned with precious stones, and topped with the crown of Scotland, over all on an escrole the device of Scotland (alluding to the thistle,) "NEMO ME IMPUNE LACESSET."

### *Of Funeral Escutcheons, &c. in Scotland.*

50. Although our code calls no man noble under the degree of a baron, yet there is an old and well known distinction between *nobiles majores* and *nobiles minores*: the first comprehending all titled nobles from the prince to the baron; the second, all between the baron and the gentleman inclusive.

A gentleman is one descended of three descents of nobles (viz. of name and arms) by both father and mother, for gentility is not perfect in the person who first obtains arms among us, or letters patent of noblesse on the continent; as, among the Romans, though the father was free born, and of the equestrian census, yet it was requisite that the grandfather should be so also, otherwise the son could not obtain the *annulus*, or symbol of the equestrian rank. Gentility, then, begins in the grandfather, increases in the father, and is perfect in the son.

The proofs of this nobility are the armorial ensigns or gentilitial tesseras of these ancestors, arranged in due order on the sides of the escutcheon, (and therefore fitly here treated of among the external ornaments of the shield), not indeed commonly, but on particular occasions, as on that of the funeral of the bearer. The arrangement of these tesseræ is the same, to whatever number they amount. If the nobility be of four descents or lineages, the mode of arrangement is as follows:




The full funeral escutcheon of the Duke of Athole is represented in Plate CCXCIV. Fig. 14.

In England, the place of this genealogical escutcheon is supplied by the genealogical pennon before described in p. 339.

### *Of Precedency.*

51. It is, as was formerly observed, the part of the *heralds* to settle the order or precedency of all those assembled in public meetings. The rules by which the precedency of individuals is ascertained, seem to be more fixed and determinate in England, than with us of Scotland. Sir William Blackstone, in his *commentaries on the law of England*, book i. chap. 12, gives a Table of Precedence, which is here copied as the most safe authority.

## TABLE OF PRECEDENCE.

The King.
The King's Children and Grand-children.
——— Brethren.
——— Uncles.
——— Nephews.
The Archbishop of Canterbury.
Lord Chancellor or Keeper, if a baron.
Archbishop of York.
Lord Treasurer. } If Barons.
Lord President of the Council. } If Barons.
Lord Privy Seal. } If Barons.
Lord Great Chamberlain. } Above all peers of their own degree.
Lord High Constable. } Above all peers of their own degree.
Lord Marshall. } Above all peers of their own degree.
Lord Admiral. } Above all peers of their own degree.
Lord Steward of the Household. } Above all peers of their own degree.
Lord Chamberlain of do. } Above all peers of their own degree.
Dukes.
Marquisses.
Dukes eldest sons.
Earls.
Marquisses eldest sons.
Dukes younger sons.
Viscounts.
Earls eldest sons.
Marquisses younger sons.
Secretary of State, if a Bishop.
Bishop of London.
——— Durham.
——— Winchester.
Bishops.
Secretary of State, if a Baron.
Barons.
Speaker of the House of Commons.
Lords Commissioners of the Great Seal.
Viscounts eldest sons.
Earls younger do.
Barons eldest do.
Knights of the Garter.
Privy Counsellors.
Chancellor of the Exchequer.
Chancellor of the Duchy.
Chief Justice of the King's Bench.
Master of the Rolls.
Chief Justice Common Pleas.
Chief Baron of the Exchequer.
Judges and Barons of the Coif.
Knights Bannerets Royal.
Viscounts younger sons.
Barons do. do.
Baronets.
Knights Bannerets.
Knights of the Bath.
Knights Bachelors.
Baronets eldest sons.

Knights eldest sons
Baronets younger do.
Knights do. do.
Colonels.
Serjeants at law.
Doctors (of Divinity, Law, Medicine.)
Esquires.
Gentlemen.
Yeomen.
Tradesmen.
Artificers.
Labourers.

*N. B.* Married women and widows have the same rank among each other as their husbands would have among themselves, except such rank be merely professional or official. And unmarried women to the same rank as their eldest brothers would bear among men during the lives of their fathers."

Father Menestrier has expressed the principal rules of heraldry in a very few verses, which may easily be retained in the memory.

"Le Blazon composé de differens emaux
N'a que quatre couleurs, deux panes, deux metaux.
Et les marques d'honneur qui suivent la naissance
Distinguent la noblesse, et font sa recompense.
Or, argent, sable, azure, gueules, sinople, vair,
Hermine au naturel, et la couleur de chair,
Chef, pal, bande, sautoir, fasce, barre, et bordure,
Cheveron, pairle, orle, et croix de diverse figure,
Et plusieurs autres corps nous peignent la valeur
Sans metal sur metal, ni couleur sur couleur.
Support, cimier, bourlet, cri de guerre, et devise,
Colliers, manteaux, honneurs et marques de l'Eglise,
Sont de l'art du blazon les pompeux ornements;
Dont les corps sont tirés de tous les elements,
Les astres, les rochers, fruits, fleurs, arbres, et plantes,
Et tous les animaux en leur formes differentes,
Servent a distinguer les fiefs et les maisons,
Et de communautés composent les blazons.
—De leur termes precis enoncer les figures
Selon qu'ils auront de diverses postures.
Le *blazon plein* echoit en partage a l'aisné;
Tout cadet doit briser comme il est ordonné."

*Abrege, p. 62.*

See the works of Menestrier, de la Colombiere, Palliot, Henniker, Upton *de Militari Studio*; Johannes de Bado Aureo *de Armis*; Spelman *Aspilogia*; Morgan's *Sphere of Gentry*; Spenerus *de Heraldica*; Favin *Theatre d'Honneur*; Guillim's *English Heraldry*; Edmonstone's *English Heraldry*; Dallaway's *English Heraldry*; Nisbet's *Scots Heraldry*; Leigh (Hearne's *Eminent Antiquaries*), Carter, Camden (*Remains*); Sir George Mackenzie's *Treatise*; Bartolus *de jure Armorum*; Ducange, &c.

# INDEX.

HERAT is a city of Persia, and formerly the capital of Khorassin. It is the ancient *Aria* or *Artacoana*, the capital of Ariana. Herat is situated in a spacious and highly cultivated plain, encircled by lofty mountains, and traversed by the river Herirood, which runs into the Caspian Sea near Zaweh. The city, which covers an area of four square miles, is surrounded with a lofty wall and a wet ditch, and is defended by a citadel in the western face, which is a small square castle, built upon a mound with burnt brick, and flanked with towers at the angles. On each face of the city is a gate, and two in the northern face, and from each gate a spacious and well supplied bazar leads to the centre of the town. The street which leads from the southern gate to the cattle-market, opposite to the citadel, is covered with a vaulted roof. Independent of the public fountains on either side of the Bazars, almost every house has a separate fountain of water. The principal public buildings are the residence of the prince, and the chief mosque. The former is a mean building, with a common gateway. In the front of the building is an open square, with the gallows in the centre. The mosque, which is called the Mesghed Jama, was formerly a magnificent building, and covered a space of eight hundred square yards. It is now, however, falling rapidly into decay.

Herat carries on a very extensive trade, and has therefore received the appellation of *Bunder* or *Port*. It is the emporium of the commerce carried on between Cabul, Cashmere, Bukhara, Hindostan, and Persia. Cabul supplies the inhabitants of Herat with shawls and raw sugar, chintz, muslin, leather, and Tartary skins, which they export to Meshed, Yezd, Kerman, Ispahan, and Tehraun, and receive in return dollars, tea, china-ware, broad cloth, copper, pepper, and sugar-candy. Kerman furnishes dates and shawls, and they receive carpets from Ghaen. The staple commodities of Herat, are silks, saffron, and assafœtida, which are exported to Hindostan. The gardens are filled with mulberry trees for the use of the silk worms, and the assafœtida is produced on the plains and hills near the city. The trade is principally carried on by the Hindoos, who alone possess capital and credit, and who are highly distinguished by the government, in consequence of their great commercial concerns.

The severity which sometimes characterises the winter at Herat, is often injurious to the crops; but nothing can surpass the fertility of the plain, which produces the most abundant crops of wheat, barley, and every kind of fruit known in Persia. The roses in the vicinity of the town are so plentiful, that it has obtained the name of *Sargultzar*, or the city of roses. The cattle are small, and by no means numerous, but the broad tailed sheep are abundant. The revenue of the town is estimated at 4½ lacks of rupees. It is raised by a tax on caravanseras, shops, and gardens, and a duty on exports and imports. The town is governed by Prince Hadjy Firooze, son of the late king of Cabul, who pays an annual tribute of 50,000 rupees to Persia. The population of Herat is 100,000, of whom 10,000 are Patans, 600 Hindoos, and the remainder Afghans, with a few Jews. East Long. 63° 14′, North Lat. 34° 12′. See Macdonald Kinneir's *Geographical Memoir of the Persian Empire*, p. 181—183.

HERAULT is the name of one of the departments of France, formed out of the dioceses of St Flour, Lodeve, Montpellier, Bezieres, and Agde in Lower Languedoc. It is bounded on the north by the departments of the Gard and the Aveyron, on the west by those of the Tarn and the Aude, on the south by that of the Aude and the sea, and on east by the Gard. Its principal rivers are the Herault and the Orbe; the Herault passes by Pezenas, and runs into the sea at Agde. The Orbe waters Bezieres. This department consists of hills, vallies, and plains of different soils. It produces all sorts of grain, wines, brandy, olives, chesnuts, fruits, silk, verdigris, and salt. The trade of the department is greatly facilitated by the canal of the South, which begins at Cette, passes within 12 myriameters of Montpellier, coasts along the Mediterranean, and after passing before Agde, it re-ascends to Bezieres and from this, after crossing the Orbe, it goes on to Narbonne. The woods in this department are very fine, but not numerous. They occupy only from 28 to 29 hectares, or from 54 to 55 acres, one half of which belongs to the nation. The contributions in 1803 were 334,317 francs. The principal towns are

| | |
|---|---|
| Montpellier, the capital, | 33913 |
| Bezieres, | 14211 |
| Lodeve, | 7843 |
| St Pons, | 4506 |

The population of the department is 291,957 See France.

HERCULANEUM, is an ancient city of Italy, situated on the Bay of Naples, and supposed to have been either founded by Hercules, or in honour of him, 1250 years before the Christian era. About 957 years later, the Romans seem to have taken possession of the city, and to have retained it ever after. In the year 63, it suffered severely from an earthquake, which, according to Seneca, occasioned the total ruin of part of it, and left the remainder in a tottering state. But in the year 79, an eruption of Vesuvius, for the first time exhibiting volcanic fires to the existing generation, buried the whole many feet deep, under repeated showers of stones and ashes; while other cities were overwhelmed by torrents of liquid lava, or swallowed up by the earthquakes which accompanied them.

*Cuncta jacent flammis et tristi mersa favilla.* Martial.

All memorials of the devoted cities were lost; and discussions on the places they had once occupied, were excited only by some obscure passages in the classical authors. Six successive eruptions contributed to lay them still deeper under the surface. But after sixteen centuries had elapsed, a peasant, in digging a well beside his cottage in 1711, obtained some fragments of coloured marble, which attracted attention. Regular excavations were made, under the superintendance of Stendardo, a Neapolitan architect; and a statue of Hercules, of Greek workmanship, and also a mutilated one of Cleopatra, were withdrawn from what proved to be a temple in the centre of the ancient Herculaneum.

Twenty or thirty years afterwards, the king of the two Sicilies, with a laudable love of science, directed a complete search to be made among the remains of the subterraneous city, and all the antiquities to be preserved. This was long and ardently prosecuted; and the entrance is now gained by a narrow passage, descending gradually to more than 70 feet from the surface, where it branches into numerous alleys leading to different streets and buildings. Neither the precise extent or population of Herculaneum can be ascertained, though it is probable that both were considerable; and we know that it was a city of the second order. All the streets run in straight lines; they are paved with blocks of lava, which indicates the vicinity of more ancient volcanic eruptions; and there is, for the most part, an elevated foot-path along their sides, for the convenience of pedestrians. The houses, whose exterior does not seem to have been ornamental or regular, consisted only of one story, built of brick. The walls of many are thrown out of the perpendicular, and some are covered with coloured stucco, upon which are executed paintings in fresco. From the general appearance exhibited by the different edifices, we may safely conjecture that the volcanic matter consisted of very fine dust, or ashes, which fell in repeated showers, and perhaps in a humid state, until the city was totally buried under it. Indeed it was so fine, that the most perfect impressions of the objects thus covered were imprinted there, and, on their being now removed, the cavity may serve for a plaster or metallic cast. By this means innumerable articles were preserved entire, and scarcely displaced from their original position, for the incumbent load received gradual accessions, unaccompanied by any extraordinary degree of heat or violence.

The remains of several public buildings have been discovered, which have possibly suffered from subsequent convulsions. Among these are two temples, one of them 150 feet by 60, in which was found a statue of Jupiter. A more extensive edifice stood opposite to these, forming a rectangle of 228 feet by 132, supposed to have been appropriated for the courts of justice. The arches of a portico surrounding it were supported by columns; within it was paved with marble; the walls were painted in fresco; and bronze statues stood between 42 columns under the roof.

Before the year 1738, the theatre was discovered; the size of which has afforded some conjectures regarding the population of Herculaneum. The building was nearly entire; very little had been displaced; and we see in it one of the best specimens extant of the architecture of the ancients. It seems to have had two principal gates, with inscriptions over the architraves of each, besides seven entrances, called *vomitoria*, communicating with the benches. Many columns and pilasters, with laboured entablatures, appeared in the *Proscenium*, and some supported bronze or marble statues. The walls were covered with paintings in the arabesque, and the floor paved with marble; that of the orchestra, consisting of the finest yellow antique, is preserved nearly entire; and similar decorations adorned the various apartments connected with the theatre. Twenty-five rows of high and wide marble benches accommodated the audience; which, rising gradually above each other, gave a full and distinct view of the arena below. The greatest diameter of the theatre, taken at the highest benches, is 234 feet; whence it has been computed, that it could contain 10,000 persons, which proves the great population of the city. This theatre was rich in antiquities, independent of that ornamental part to which we have already alluded. Statues, occupying niches, represented the muses; scenic masks were imitated on the entablatures; and inscriptions were engraven on different places. Analogous to the last were several large alphabetical Roman characters in bronze, and a number of smaller size, which had probably been connected in some conspicuous situation. A metallic car was found, with four bronze horses attached to it, nearly of the natural size; but all in such a state of decay, that only one, and the spokes of the wheels, also of metal, could be preserved. A beautiful white marble statue of Venus, only 18 inches high, in the same attitude as the famous Venus de Medicis, was recovered; and either here, or in the immediate vicinity, was found a colossal bronze statue of Vespasian, filled with lead, which twelve men were unable to move; besides many objects entire, there were numerous fragments of others, extremely interesting, which had been originally impaired, or were injured by attempts to obtain them. The Herculaneans are said to have had a particular taste for theatrical entertainments; and some authors have maintained, that, disregarding the danger which menaced them, they remained so intent on the performance, that both here, and at Pompeii, they were surprised by the eruption of Vesuvius, and buried under it. But we may reasonably conclude, that, with regard to Herculaneum, the theatre did not suffer materially from the earthquake, and that it was not attended with the destruction of the spectators. Remarkably few skeletons have been found in this city, though many occur in the streets of Pompeii; but one appears under the threshold of a door, with a bag of money in his hand, as if in the attitude of escaping, leaving its impression in the surrounding volcanic matter. Nevertheless, it might be here, as we are told of a different city, where the Emperor Nero, appearing on the stage, was surprised by a sudden earthquake; but the audience had time to escape, and the theatre fell without doing any injury. A similar incident occurred within these few years at Naples, where the decorations of the theatre were in visible motion before the terrified spectators, but the strength of its parts resisted the shock.

The exfodiation was prosecuted along the walls of the buildings, turning the corners, and entering by the doors and windows as they occurred. Two marble equestrian statues of the finest workmanship, which had been erected in honour of the two consuls, Balbi and son, were found opposite to the theatre: and in prosecuting the researches into the public edifices and private houses, or even through the streets, the workmen met with many things worthy of observation. A well, now containing good water, was seen surrounded by a parapet, and covered by an arch which had excluded the ashes. A capacious bath of a circular form was penetrated, and also repositories of the dead, still more ancient than the overthrow of Herculaneum. Fragments of columns of various coloured marble, beautiful mosaic pavements entire, and mutilated statues, were abundantly disseminated among the ruins. Some of the pavement, representing figures, has been taken up and again disposed in its original order, in a spacious museum prepared for the reception of the antiquities. The public edifices afforded a copious collection corresponding to their different uses; but many were utterly destroyed, such as the statues in the building containing forty-two columns. Numerous sacrificial implements, however, such as pateræ, tripods, cups, and vases, were recovered in excellent preservation, and even some of the knives with which the victims are conjectured to have been slaughtered. Numerous domestic utensils employed in the exercise of the arts, and contributing to the amusements of the existing generation, were all preserved.

When we reflect that 1600 years have elapsed since the destruction of this city, an interval which has been marked by numerous revolutions, both in the political and mental state of Europe, a high degree of interest must be experienced in contemplating the venerable remains of antiquity recovered from the subterraneous city of Herculaneum. Pliny the Younger, in his letters, brings the Romans, their occupations, manners, and customs, before us. He pictures in feeling terms the death of his uncle, who perished in the same eruption as the city we now describe: and that event is brought to our immediate notice by those very things which it was the means of preserving. Among these we see the various articles which administered to the necessities and the pleasures of the inhabitants, the emblems of their religious sentiments, and the very manners and customs of domestic life.

Articles in vast variety were obtained from the houses, wherein the beams appeared as if converted to charcoal; but it is to be observed, that all the remains of wood exhibit the same aspect to the very heart. They are not consumed or turned to ashes, owing probably to the exclusion of the external air by the showers of volcanic matter. It is singular, that while wood, which has remained during ages buried in the earth, or immersed in water, acquires additional consistence, this has entirely lost what it possessed. Pieces of thin and delicate texture have preserved their shape, but blocks of a large size are converted throughout to charcoal.

If the subjects recovered from Herculaneum be classed according to their value, the statues should be enumerated first, both as being of the finest workmanship and of the most difficult execution. Some are colossal, some of the natural size, and some in miniature; and the materials of their formation are either clay, marble, or bronze. They represent all different objects, divinities, heroes, or distinguished persons; and in the same substances, especially bronze, there are the figures of many animals. Sculpture, in its various branches, had attained a high degree of perfection among the ancients; their religious prejudices and manners greatly contributed to the perfection of the art; and we have ocular demonstration, that the reputation of their celebrated artists was not overrated. Paintings are interesting, but the small portion of the object represented, renders them far less so than statues which afford complete imitations, and are thence to be ranked as the most precious relics of antiquity. Here there are two statues seven feet high of Jupiter, and a woman in clay; and two of gladiators, in bronze, about to combat, are much admired. The same may be said of Nero in bronze, naked and armed as a Jupiter *tonans*, with a thunderbolt in his hand. A Venus *pudica* of white marble in miniature, is extremely beautiful, and also the statue of a female leaving the bath. In the year 1758, a fine bronze statue of a naked Mercury, supposed to have been the work of a Greek artist, was discovered: and in the course of the excavations extending beyond the confines of the city, a Silenus, with a tiger, sometimes his attribute, was found, which had formerly adorned a fountain. Several fauns or other sylvans, with vases on their shoulders, were obtained in the vicinity of Silenus, which are of bronze; and it is singular to observe, that the younger figures have silver eyes, a disagreeable deformity sometimes adopted in marble statues. The figure and attitude of a drunken faun, stretched on a lion's skin, and supported by one full of liquor, presents all that vacuity of thought and sensation of animal pleasure which accompany ebriety: another faun asleep, as large as life, presents a state of absolute repose. We have named two fine equestrian statues of full size. There is also a bronze equestrian statue of an armed Amazon, only sixteen inches high. There are many elegant statues of the goddesses and graces only eight or ten inches in height: and we likewise see some of the monstrous Egyptian divinities with which the Herculaneans were acquainted. Several fine busts or simple heads of the ancient philosophers, as Zeno, or Epicurus, stood in the houses; the name being inscribed below, or on a pedestal. Bas-reliefs likewise occurred, but few coins or medals. Gold coins of Augustus were found, and silver medallions, two or three inches in diameter, bearing uncertain devices.

The ancient pictures of Herculaneum are of the utmost interest, not only from the freshness and vividness of colour, but from the nature of the subjects they represent. All are executed in fresco; they are exclusively on the walls, and generally on a black or red ground. It has been supposed, from passages in the classics, that the ancients used only four colours, white, black, yellow, and red; but here are added blue and green.* Some are of animated beings, large as life, but the majority are in miniature. Every different subject of antiquity is depicted here: deities, human figures, animals, landscapes foreign and domestic, and a variety of grotesque beings. Sports and pastimes, theatrical performances, sacrifices, all enter the catalogue. Having occasion afterwards to speak cursorily of some of these subjects, we shall content ourselves with observing, that they are more remarkable for variety than for their intrinsic quality. One of larger size found in a temple, and the most celebrated, represents Theseus vanquishing the Minotaur, which lies stretched at his feet, with the head of a bull and the body of a man. A female, supposed to be Ariadne, and three children, form part of the group. This, along with a picture, composed of several figures as large as life, of which Flora is the most conspicuous, adorned a temple of Hercules; each is six or seven feet high and five broad. Another represents Chiron teaching Achilles the lyre; and female centaurs are seen suckling their young. The interior of a shoemaker's shop is exposed on a smaller scale; a feast, baskets of fruit, a grasshopper driving a parrot yoked to a car, a cupid guiding swans in the same manner, and many allegorical subjects are represented. It is impossible within these limited bounds to enumerate their varieties, but we shall immediately refer the reader to a specific work upon the subject, from which much entertainment will be derived. The king, desirous of preserving these pictures, directed them to be sawed out of the walls, a work of great labour and perseverance, after which they were put in shallow frames and kept in the museum.

It is said that a triremis or vessel, with three banks of oars, was discovered, with the iron or copper tackle and wood work complete, and that a drawing was taken of it; but the more material parts immediately fell to dust. A sea piece with vessels is among the paintings.

It is extraordinary, that numbers of perishable substances should have resisted the corrosions of time. Many almonds in the shell, imprinted with all the lines and furrows characterising their ligneous envelope, were dug out of the ruins of Herculaneum; figs and some kinds of wild apples were in preservation; and a sort of pine cone yet growing in the woods of Italy, the seeds of which are now ate, or used for culinary purposes. Grain, such as barley, and also beans and peas, remained entire, of a black colour, and offering resistance to pressure. The stones of peaches and apricots are common, thus denoting the frequency of two trees reputed indigenous in Armenia and Persia. But what is still more singular, a loaf, stamped with the baker's name in Roman characters, or the quality of the wheat, was taken from an oven, and was apparently converted to charcoal. Different parts of plants, prepared for pharmacy, were obtained from the dwellings of those who had been apothecaries. After such an amazing lapse of time, liquids have been found approaching to a fluid state —an instance of which cannot be sufficiently admired in a phial of oil conceived to be that of olives. It is white, greasy to the touch, and emits the smell of rancid oil. An earthen vase was found in the cellars containing wine, which now resembles a lump of porous dark violet coloured glass. We acknowledge, however, that there is great difficulty in comprehending how this change should have taken place. The ancients speak of very thick wines, requiring dilution previous to use, which would keep 200 years, and would then acquire the consistence of honey. Eggs are also said to have been found whole and empty. Solid pitch was found at the bottom of a vessel, wherein it had probably melted, as it afterwards did from heat in the museum at Portici, which stands near the entrance to the subterraneous city.

An entire set of kitchen furniture has been collected, which displays several utensils exactly similar to our own.

* See Sir Humphry Day's interesting paper on the colours used by the ancients, in the *Phil. Trans.* for 1815.—Ed.

The copper pans, instead of being tinned, are internally coated with silver, probably a better precaution, as more of the poisonous metals are expelled from the latter. These have not been attacked by verdigrease, whence the ancients perhaps understood some branches of metallurgy as well as the moderns. Here is a large brass cauldron, three feet in diameter, and fourteen inches deep, an urn or boiler for hot water similar to those on our tables, and also having a cylinder in the centre for a heater. There are pestles and mortars, and all kinds of implements for cutting out and figuring pastry; and, in short, a complete culinary apparatus. Utensils of finer quality were likewise collected, which had been employed at tables, as silver goblets, and vases, silver spoons, and the remnants of knives. But from the absence of forks, both among the other remains and in pictures, it is doubtful how far they were known to the ancients. It is probable, indeed, that their invention and common use are to be dated several centuries later.

Several articles belonging to personal ornament and decoration occurred: We shall not speak of the colours still in a condition fit for painting, because it is questioned whether they were such as it is known the ladies of that generation were accustomed to use for more ordinary purposes. Besides, they are red, blue, and yellow. Those with which females heightened their complexion were prepared both from minerals and vegetables, the latter being chiefly marine plants. Two silver bodkins, with which they pinned up their hair, eight inches in length, are preserved; the end of one appropriately sculptured with a Venus adjusting her tresses before a looking-glass held by Cupid. Gold armlets, bracelets, necklaces with pieces of plate gold suspended to them as a locket, are preserved. Small nets also with fine meshes, which some have supposed the ladies employed to tie up their hair; and others of coarser texture, which must have been used for other purposes. Pieces of cloth, coloured red on one side, and black on the other, were found on the breast of a skeleton; the texture of which, whether silk, woollen, linen, or cotton, antiquaries have not been able to decide. Very few jewels are discovered, which favours the idea of the inhabitants having had time to escape. There was a wooden comb, with teeth on both sides, closer on one of them than on the opposite; and portions of gold lace fabricated from the pure metal. Sandals of laced cords are seen, though it is more commonly believed that leatner was in general use among the Italians; and a folding parasol, absolutely similar to what we esteem a modern invention, was likewise discovered.

There is kept in the museum a case of surgeon's instruments, complete, with pincers, spatulæ, and probes; also a box supposed to have contained unguents; and pieces of marble, employed in braying pharmaceutical substances. A variety of carpenters' and masons' tools, as chissels, compasses, and trowels, were found, resembling our own; and bolts and nails, all of bronze.

The weights and measures of the ancients have excited considerable discussion, which those preserved in Herculaneum may elucidate: Different balances appear, of which the most common is analogous to the Roman steelyard: but those with flats for scales, though wanting the needle, are likewise seen. The weights are either of marble or metal, of all gradations up to thirty pounds; and from the marks exhibited by a set, well made of black marble, in a spherical shape, it is supposed the pound was divided into eight parts. A weight is inscribed *eme* on one side, and *habebis* on the other. There are pocket long measures, folding up like our common foot rule, which may throw some light on the length of the Roman foot. Neat copper vases are supposed to have been measures for grain; the capacity of one is 191 cubic inches.

The various implements for writing repeatedly occurred; and among the pictures is a female apparently listening to dictation. That the ancients were perfectly acquainted with the art of making glass is proved by the varieties discovered in these exfodiations. Considerable numbers of phials and bottles, chiefly of an elongated shape, are preserved; they are of unequal thickness, much heavier than glass of ordinary manufacture, and of a green colour. Vessels of cut white glass have been found, and also white plate glass, which antiquaries suppose was used in lining chambers, called *cameræ vitreæ*. Coloured glass, or artificial gems, engraved, frequently occur: and the paintings exhibit crystal vessels. We may remark in this place, that any one who studies the antiquities of Herculaneum, will find his researches greatly facilitated by frequent reference to the epigrams of Martial, whom nothing used in ordinary life seems to have escaped.

The beauty and variety of the vases have attracted particular notice, and they serve as excellent models for the moderns; for all the skill of the ancient artists seems to have been exhausted in their execution. There is one preserved four feet in diameter of fine white marble; others are of earthen-ware or silver, and the majority of bronze or copper. Some are low, wide, and flat; others tall and narrow, plain, fluted, or sculptured. Sacrificial vases were supported on tripods, whose construction seems to have been attended with equal care. Some of the latter are richly sculptured with real and imaginary figures of men and animals. One is ornamented with three lions heads, and is supported by as many paws: another rests on three Priapeian satyrs of elegant workmanship, or on the feet of eagles. The god of the gardens seems to have been treated with peculiar regard by the Herculaneans. He appears with all his attributes, of every possible variety, figure, and dimensions, in tripods, lamps, and household utensils. The articles on this subject are so common as to constitute a large branch of curious antiques, concerning the emblematic use of which we can only entertain conjectures. Several tripods are very ingeniously constructed, so that the feet may be closed or expanded by double sets of hinges. Endless diversity and infinite elegance are displayed in the lamps and candelabra, which are now affording models for the works of the moderns; but we do not know whether chandeliers have been discovered, at least they are so rare, that we may doubt whether the inhabitants often resorted to lights from wax or resinous substances. Sometimes a lamp appears as a shell, sometimes as a bird; then a human figure, or resembling a quadruped. The vases, lamps, and tripods, were particularly used in sacrifices, several of which are represented in the pictures; and among others, are sacrifices to the Egyptian deities. There were many funeral urns and sepulchral lamps, such as those regarding which vague ideas have been entertained as formed for containing perpetual fire.

In regard to sports and pastimes, numerous remains render us familiar with those of the ancients. Here we find dice, with the same disposal of points on a cube; and dice-boxes of bone or ivory, like those now used, besides some of a flattish shape. Several are false, being loaded on one side: and the manner of throwing the dice appears on a picture. No musical instruments were found but the sistrum, which we imperfectly understand, cymbals, and flutes of bone or ivory, are yet obtained. However, a concert is represented on a picture sixteen inches square, containing a lyrist, a player on a double flute, probably by a mouth piece, and a female apparently singing from a leaf of music; besides other two figures. Several theatrical masks, of different fashions, were found in clay and metal, along with moulds for their formation. Their use in dramatic representations, regarding which the reader may consult a work by *Ficoroni*, is well known, and is the subject of many of the pictures. The theatre, we repeat, was a favourite resort of the ancients; and some ivory tickets of admission, with the author's name, and that of the piece, are preserved from Herculaneum. Rope-dancing is exhibited on the pictures, wherein all the modern dexterity, of playing on musical instruments, pouring out liquids into cups, and other feats of address are shewn. The most elegant and graceful of the Herculaneum pictures are perhaps female dancers, suspended as it were among the clouds.

It is to be observed in general, with regard to the numerous articles relative to this brief detail, that the quality of the statutes infinitely surpasses that of the pictures; and that the vases, tripods, lamps, and candelabra, are frequently of the finest workmanship. Of many once complete, only fragments at this day remain; and while gold, silver, bronze, or clay, remain entire, iron has altogether wasted away.

After a vast collection of antiquities had been made, the king resolved on publishing a laborious and expensive work, containing engravings of those which appeared most curious. In the course of thirty-eight years, from 1754 to 1792, this was accomplished in nine folio volumes, including the pictures, bronzes, lamps, and candelabra: The first is devoted to a catalogue, five to pictures, two to the bronzes, and one to the *lucerne*. No less than 738 pictures are named in the catalogue, and the other articles are proportionally numerous. The work was, with royal munificence, presented to the principal public libraries in Europe; but owing to the succession of the king of the Sicilies to the crown of Spain, it is seldom to be seen complete. At the same time, it has been affirmed, that some of the engravings of the pictures appear with a perfection and delicacy which do not belong to the originals, although their general character be not lost.

In penetrating an apartment of a villa in the neighbourhood of Herculaneum, a number of supposed pieces of charcoal were carried off, which, by accidental fracture, exposed the remains of letters, and proved so many ancient manuscripts. Here Camillo Paderni, the keeper of the museum, buried himself during twelve days, and succeeded in carrying away 337 manuscripts; and, by subsequent careful research, the total number recovered now exceeds 1800. They were in various stages of decay; some so much disfigured and obliterated, that nothing could be determined regarding their nature from the beginning. However, the king instituted a society for investigating them completely. High expectations were formed by the European literati, of the knowledge which would be acquired respecting the history, the manners, and the customs of antiquity; more especially as the materials themselves indubitably remounted to a period of more than 1600 years. The manuscripts consisted of rolls, scarcely a span in length, and two or three inches in thickness, formed of pieces of Egyptian papyrus glued together. Some had a label in front, at one end of the roll, exposing the name of the work, or the author, as it occupied its place in the library. But the substance of the involutions was so crushed together, the ink or pigment employed for the character had faded to such a degree, that, united to the general injury which they had received from time, and the heat to which they had been exposed, the opening of them seemed at first sight to be impracticable. Accordingly, some snapped asunder like burnt wood, others flew into fragments, or they exposed nothing. The assistance of Piaggi, a monk, was obtained from the Vatican, who invented an ingenious method of unfolding the manuscripts without destruction, by means of a mechanical apparatus. The process was slow, but tolerably certain; and the first manuscript put on the machine, being unrolled in the year 1754, proved to be a treatise in Greek capitals, written by Philodemus, an Epicurean Philosopher, against music, with his name twice inscribed at the end, or interior of the roll. Similar means were adopted with other manuscripts, and they were partly successful. Almost the whole manuscripts are in Greek, very few having hitherto been found in Latin; and some of the rolls are forty or fifty feet in length. The entire surface of the roll is divided into successive columns, resembling our ordinary pages, each containing from forty to seventy lines in different manuscripts, this being dependent on the size of the roll; but each line is only about two inches long, and the column is no broader. In the original state, therefore, the reader held the roll before his eyes with one hand, while he unwound it with the other, as is represented by some of the Herculean pictures. Uncommon difficulties were experienced, from the decay of the substance, from frequent blanks and obliterations within, and from the absence of punctuation. Four volumes, all by Philodemus, were successively unrolled; and, in 1760, Piaggi reached a fifth by another author, on botany. But the king was induced to order it to be withdrawn, and a sixth volume was put on the machine, where it remained thirty-six years. After twenty years preparation, the work on music was published, with illustrations by Mazzocchi, a learned Italian, under the title *Herculanensium voluminum quæ supersunt*, *tomus* I. Napoli, 1793. It must have been anxiety for publication, not the desire of enlightening the world, that led to the selection of this volume, reputed a dull and controversial performance, which the most ingenious commentary is incapable of enlivening. Cicero, notwithstanding, has called the author *optimum et doctissimum;* Piso, the supposed owner of the manuscripts, derived his philosophy from him, and he was well skilled in the polite literature of the period. In the course of forty years from the discovery of the manuscripts, which were gradually withdrawn, only eighteen were unfolded. The accession of Charles, indeed, to the crown of Spain, and the death of Mazzocchi, had enervated the Herculanean Society, which was renewed in 1787 by the Marquis Caracioli, and the secretary of state thenceforward placed at its head. Yet the work advanced very tardily; few persons were employed, either from the difficulty, or want of interest in its prosecution; and it was perhaps totally interrupted by the political events which disturbed the peace of Europe. Mean time, six of the manuscripts were presented, along with other Herculaneum curiosities, to Bonaparte in 1802, by the sovereign of the Sicilies, in whose reign, indeed, we believe that both Philodemus and the volume of Lucerne were published; and ten volumes are said to have been sent, on some occasion, to the Prince of Wales.

At length a proposal was made on the part of this country, to co-operate with the Neapolitan government on a subject so important to the diffusion of literature as that of elucidating the Herculaneum manuscripts; and Mr Hayter, chaplain to the Prince of Wales, was appointed, with a regular commission to superintend their subsequent developement. A parliamentary grant of 1200*l.* was next obtained to aid its prosecution; and Mr Hayter, having commenced his operations under the most favourable auspices in 1802, employed thirteen persons in unrolling, deciphering, and transcribing. Some improvements seem to have been attempted in the evolution of the manuscripts by a chemical process; but of those subjected to it, we are told that "the greatest part of each mass flew under this trial into useless atoms; besides, not a character was to be discovered upon any single piece: the dreadful odour drove us all from the museum." Mr Hayter continued his operations from 1802 to 1806, during which time he affirms, that more than 200 papyri had been opened wholly or in part, and he calculated that the remainder would have been unrolled and copied within six years farther at latest. But as to the precise nature and description of these manuscripts, the accessions which literature has gained or would gain by the work, we are only informed that certain fac similes of some books of Epicurus were engraved.

It cannot but be considered particularly unfortunate that the public expectation, so repeatedly excited regarding what are to appearance among the most interesting memorials of antiquity, should be as often disappointed. Admitting every possible difficulty, and all the opposition which might have been experienced, unquestionably there were sufficient materials to make a specific report regarding the state and description of the manuscripts, towards the developement of which the public had so liberally contributed.

In 1806, during Mr Hayter's operations, it became necessary to evacuate Naples; but the existing government acquainted him, that the king had prohibited the removal of the manuscripts; and in the flight of the court, every thing was abandoned to the French, who seem to have continued the assistance in unrolling and deciphering as before. From the opposition which Mr Hayter experienced, he could do nothing more than retire with some of the fac similes to Palermo, where it appears he superintended engravings of them. Yet misunderstandings with the secretary of the state prevented him from procuring a complete copy of the whole, until the British ambassador interfered.

Ninety-four fac simile copies were then obtained, partly engraved it would seem, and partly in manuscript. These were carried to England by Mr Hayter on his final recall in 1809, and presented by the Prince Regent to the university of Oxford. However, a very confused and indistinct account of the whole of this matter has reached the public, which compels us to be thus brief regarding the history of the Herculaneum manuscripts.

Perhaps it may ultimately be found that they are less worthy of notice than was anticipated, particularly if we are entitled to form any judgment regarding the rest, from the inconsiderable portions that have already been published. See *Antichita d'Ercolano*, 9 vols. in folio; Bayardi *Prodomo delle Antichita d'Ercolano ;—Notizie. del Scoprimento dell' Antichita citta d'Ercolano ;* Venuti *Descrizione delle prime scoperte dell' Antichita citta d'Ercolano ;* Murr *de Papyris Herculanensibus ;* Drummond and Walpole *Herculanensia* ; Hayter, *Letter and Report on the Herculaneum Manuscripts ; Philosophical Transactions* for 1751, 1753, 1754, 1755, 1756 ; and Sir W. Hamilton *Campi Phlegræi*, p. 58. (*c*)

HERCULES, one of the most illustrious heroes of antiquity, and the first of the *Dii Minorum Gentium*, or demi-gods. He was descended from the kings of Argos; but in the Pagan mythology, he is said to have been the son of Jupiter by Alcmena, the wife of Amphitryon, king of Thebes. The period of his birth is uncertain; Herodotus places it about the year 1282, before the commencement of the Christian æra ; and in Blair's *Chronological Tables*, his death is placed in the year 1222 B. C.

The history of this celebrated personage consists of a tissue of prodigies. His first, or what may be called his infantine, exploits, were his strangling two serpents, which were sent to destroy him in his cradle ; and his killing a large lion, near his native city, Thebes. Next come those adventures, which are commonly known by the name of his twelve labours, undertaken by order of Eurystheus, and of a decree of the Delphian oracle, as it is said, by way of expiation for the crime of killing the three children which he had by his wife Megara, and in order to acquire immortality. The first of these was his combat and victory over the Cleonæan lion, in the forest of Nemæa ; the second, his conquest of the hydra, by which he is said to have cleared the fens of Lerna, near Argos, of the serpents that infested them, and which seemed to multiply as fast as they were destroyed ; the third, his destruction of the Erymanthian boar ; the fourth, his slaying the brazen-footed stag on Mount Menalus ; the fifth, his shooting the harpies, or stymphalides ; the sixth, his cleansing the stables of Augeas ; the seventh and eighth, his destroying the Cretan bull, and Diomede, the barbarous tyrant of Thrace, with his horses or mares who were fed on human flesh ; the ninth, his combat with Geryon, who is generally represented with three bodies ; the tenth, his conquest of the Amazons ; the eleventh, his dragging Cerberus up from the infernal regions ; and the last, his killing the serpent, or dragon, and carrying off the golden fruit from the garden of the Hesperides. The remainder of his exploits were those which he undertook voluntarily ; such as his slaying the giant Antæus, and Cacus, the notorious robber of Italy, fixing pillars in the *Tretum Gaditanum*, or Straits of Gibraltar, &c. It would appear, that this redoubted champion was by no means insensible to the influence of the tender passion, or proof against the allurements of vicious pleasure. The principal scene of his effeminacies was in Asia, whilst he lived with Omphale, queen of Lydia ; and he at length fell a sacrifice to the jealousy of his wife, Deganira, who, dreading the influence of his passion for Iole, the daughter of Eurytus, king of Æchalia, poisoned his robe, so that he died in great agonies on Mount Oëta. Ovid represents him as preparing his own funeral pile, and laying himself upon it with great composure.

Such is the substance of the traditional histories of this celebrated hero of antiquity, whose adventures have afforded ample materials to the sculptor and the poet. These traditions seem to contain a mixture of truth and fable. It appears from ancient authors, that there were several individuals of the name of Hercules, whose heroic actions were probably exaggerated, and ascribed to one man ; and to him, as his fame increased and spread abroad, was likewise transferred the credit of all great and valorous enterprises, the authors of which were unknown. Thus the Theban Hercules became, as it were, the representative of heroism and manly virtue, according to the notions of antiquity. Accordingly it has been observed, that none even of the twelve great pagan deities have so many monuments relating to them, as Hercules. The famous statue, called the Farnese Hercules, is well known. The hero is there represented as resting after the last of his twelve labours, leaning on his club, and holding in his hand the apples of the Hesperides. In this, and in all the other figures of him, he is formed by the breadth of his shoulders, the spaciousness of his chest, the largeness of his size, and the firmness of his muscles, to express prodigious strength, and a capacity of enduring great fatigue. His other attributes are, his lion's skin, his club and his bow. See Plate CCXXXIV. Fig. 2.

Hercules was peculiarly honoured among the Greeks, by the epithet of *Musagetes*, the conductor of the Muses ; and among the Romans, by that of *Hercules Musarum*. In reference to these titles, he is represented, on medals, with a lyre in his hand ; and the reverse is marked with the figures of the nine Muses, with their appropriate symbols. (*z*)

HEREFORD is a town of England, in the hundred of Grimsworth, 135½ miles W. N. W. from London. It is situated on the left bank of the river Wye, over which it has a stone bridge of six arches, constructed in the 15th century. The streets are in general wide: the inns are particularly good, one or two of them being equal to any in the kingdom. The public buildings particularly worthy of notice are, the cathedral, bishop's palace, college, county gaol, and theatre. The general plan of the cathedral is that of a cross. The interior is very interesting, though not nearly so much so as it was before the removal of the sepulchral memorials, painted glass, &c. The see of Hereford comprehends Herefordshire, and part of Shropshire. It is rated in the king's books at 768*l.*: its real value is supposed to be about 3000*l.* The civil government of the city is vested in a mayor, six aldermen, a common council consisting of 31 members, an high steward, and a recorder. It returns two members to Parliament, the right of election being vested in the citizens and freemen, to the number of about 1200. The situation of this city, on the banks of the Wye, would be extremely favourable to its trade, if the navigation of that river were less precarious. The principal manufacture carried on is gloves. Cyder, grain, and oak bark, are conveyed in considerable quantities down the river to Bristol and other places; and by means of the same navigation, the city is supplied with coals from the forest of Dean. This city suffered much during the wars between the houses of York and Lancaster, and also during the wars between Charles and his parliament. In 1803, its population was 6828; in 1811, it amounted to 7306. See Duncombe's *Agriculture of Hereford; Beauties of England and Wales*; vol. v.; and Marshall's *Rural Economy of Gloucestershire, &c.* vol. ii. p. 221, &c. (W. S.)

HEREFORDSHIRE is an inland county in the west of England, and on the borders of Wales. It is situated between 51° 53′ 7″, and 52° 29′ 43″ North Latitude, and 2° 28′ 30″ and 3° 19′ 32″ West Longitude from London. It is bounded on the north by Shropshire; on the west by the counties of Radnor and Brecon, from the latter of which it is separated by the Hatterel Hills, or Black Mountains; on the south by Monmouthshire and Gloucestershire, being separated from the former by the river Wye, and from the latter, partly by the river Munnow; and on the east it is bounded by Worcestershire. Its outline forms nearly a circle, but its circumference is made irregular by many windings and indentations. The extent, from Ludford on the north to the opposite border, near Monmouth on the south, is 38 miles; and from Clifford on the West, to Cradley on the east, 35 miles. Some detached parts are situated beyond the general outline; the parish of Farlow being wholly insulated by Shropshire—that of Rochford by Worcestershire; Lytton hill by Radnorshire; and a considerable tract of land, called the Futhog, by Monmouthshire. According to the original report to the Board of Agriculture, the gross number of acres is 781,440; but in Mr Duncombe's report they are stated to be only 600,000. In the returns to Parliament respecting the poor rates, they are stated at 621,440; while Mr Marshall estimates them so high as 800,000. On the supposition that there are 600,000 acres, which is the most probable, it is computed that 30,000 are the sites of towns, roads, water, &c. and 50,000 waste lands and woods; hence there are about 520,000 acres of cultivated ground; a much larger proportion than most of the other counties of England contain.

Herefordshire is divided into eleven hundreds, viz. Broxash, which contains 26 parishes; Ewias Lacey, which contains seven parishes; Greytree, which contains 17 parishes; Grimsworth, which contains 23 parishes; Huntingdon, which contains eight parishes; Radlow, which contains 24 parishes; Stretford, which contains 15 parishes; Webtree, which contains 27 parishes; Wigmore, which contains 14 parishes; Wolphey, which contains 24 parishes; and Wormelow, which contains 30 parishes; making in all 215 parishes, besides six parishes in the city of Hereford. Besides this city, which is also the county town, there are in Herefordshire two borough towns. Weobley and Leominster; and five other market-towns, Ross, Ledbury, Kington, Bromyard, and Pembridge. It returns eight members to parliament, viz. two for the county, two for the city, two for Leominster, and two for Weobley. It is in the province of Canterbury, and diocese of Hereford, and in the Oxford circuits.

The general aspect of this county is extremely beautiful; its surface is finely diversified, and broken by swelling heights in such a manner as to resemble the more central parts of Kent; no wide open vale, nor any extensive range of hills, appear in the north-western quarter; some separated links of the Welch mountains rise above the hillocks and minor hills, which are scattered over the rest of the county. In short, Herefordshire may be said, without exaggeration, to be altogether beautiful. From many of the elevations, the prospects are uncommonly fine; rather rich and luxuriant, however, than grand, or even picturesque. The forest prospects are from the Malvern hills on the east, and the Hatterel, or Black Mountains, on the west.

It is equally favoured in respect to soil, which is every where fertile; no watery bottoms, nor thin-soiled barren hills, except perhaps in the northern and western outskirts; every other part is uniformly productive. The eastern side of the county is mostly a stiff clay, of great strength and tenacity; for the most part red, but in some places of the ordinary colour. The western side is lighter, but still a productive soil. The county is clothed in almost perpetual verdure: on every side luxuriance of vegetation is exhibited, in widely extended corn fields, rich orchards, expansive meadows, and flourishing plantations. The subsoil, as well as the soil, contributes to this wonderful and almost unrivalled fertility. It is mostly limestone of different qualities. In some parts, particularly near Snodhill castle, it assumes the appearance and properties of marble, being beautifully variegated with red and white veins. Deep beds of gravel are occasionally met with in the vicinity of the city of Hereford, and the subsoil of several of the hills is of siliceous grit. Fullers earth is sometimes dug near Stoke; and red and yellow ochres, with tobacco pipe clay, are found in small quantities in various parts of the county. Iron ore has been met with on the borders of Gloucestershire, but none has been dug for many years.

The principal rivers in Herefordshire are, the Wye, the Lugg, the Munnow, the Arrow, the Frome, the Teme, and the Leddon. The Wye, so highly and deservedly celebrated for its picturesque beauties, enters Herefordshire near Clifford. Between Whitney and Hereford, its general character is mild and pleasing, consisting of delightful reaches, with the most agreeable landscapes and luxuriant scenery on both sides. From Hereford to Ross its features occasionally assume greater boldness; but, at the latter town, it resumes the brightness and rapidity of its primitive character, and forms the admired bending scen from the churchyard of Ross. Beneath the arches of Welton bridge it flows through a charming succession of meadows: the peninsula of Symond's rock succeeds, round which the river flows in a circuit of seven miles, though the opposite points of the isthmus are only a mile apart. New and pleasing objects now rapidly succeed one another; and the romantic village of Whitchurch, stupendous hills, and hanging rocks, exhibit a rare union of what is grand, beautiful, and picturesque. Shortly afterwards, the Wye quits the county and enters Monmouthshire. This river is navigable to Hereford in barges from 18 to 40 tons; but either a large or small supply of water is fatal to the navigation. The Lugg, which rises in Radnorshire, enters Herefordshire on the north-west side: near Stapleton castle, below Leominster, it is joined by the Arrow and the Frome. Soon after its junction with the latter, it falls into the Wye. The Munnow rises on the Herefordshire side of the Hatterel mountains; and, after many windings, forms the boundary between the county and Monmouthshire, till it quits the former. The Teme enters Herefordshire a short distance north-west from Brampton Bryan, but it soon enters Shropshire; thence again it enters Herefordshire, but soon leaves it for Worcestershire, where, having made a considerable circuit, it once more flows on the borders of this county, after which it falls into the Severn. The Leddon rises on the east side of Herefordshire, and after running south, and giving name to the town of Ledbury, it flows into Gloucestershire, and unites with the Severn. The Arrow enters Herefordshire from Radnorshire, and, flowing to the east, falls into the Lugg near Leominster.

The inland navigation of this county is very imperfect. The Hereford and Gloucester canal, which was begun in 1791, is not yet completed. It begins at Hereford, and is to fall into the Severn near Gloucester. Its total length is to be 35 miles 5 furlongs. At the beginning of it is a tunnel of 440 yards, and another about the middle of the summit 1320 yards long. The Kingston and Leominster canal begins at the former place, crosses the Lugg, and afterwards the Teme, and is to unite with the Severn near Stourport in Worcestershire. The total length is to be 45 miles: on it there are two tunnels, one of 1250, and the other of 3850 yards.

The greatest estates in this county belong to Guy's Hospital, the Duke of Norfolk, the Earls of Oxford and Essex, Sir George Comerall, R. P. Knight, Esq. &c. In that part of the hundred of Wormelow, called Irchenfield, the tenure of gaval-kind prevails, by which, in cases of persons dying intestate, landed property descends in equal divisions to all the sons. In the manor of Hampton-Bishop, which belongs to the see of Hereford, the tenure of borough-english prevails, by which the youngest son succeeds, to the exclusion of his brothers. Copyhold property is not so common in this as in many other counties of England. Leasehold estates are more common. They are for the most part held under the dean and chapter of Hereford, the corporation of that city, &c. It is estimated, that two-thirds of the whole county is freehold, and the remaining third under the other tenures. The size of farms varies from 200 to 400 acres.

The produce of Herefordshire is uncommonly various. In a general view, however, it may be regarded as a corn county. The bottoms, nevertheless, furnish great quantities of grass; and the sides of the hills produce in great abundance, and of excellent quality, most kinds of woods, especially oak. The immediate banks of the vallies, and the skirts of the higher hills, are covered with orchards. The objects of husbandry are, principally, cattle, sheep, swine, corn, hops, and fruit liquor; but two products render Herefordshire particularly famous, its cyder and its wool.

The principal cultivated lands are under tillage. The wheat grown in the vales, in the vicinity of Hereford, and thence through the clays towards Ledbury, is of a remarkably fine quality. The lighter lands produce excellent barley. Ross is the centre of the principal barley district. Oats are grown in most abundance on the borders of Wales, and on the eastern confines of the county. Neither turnips, nor artificial grasses, are sufficiently attended to.

The most fertile meadows lie on the banks of the Wye, Frome, and Lugg. For fattening cattle they cannot be exceeded; but Herefordshire has no pretensions to rank among the dairy counties. Mr Knight has proved by experiments, that equal quantities of milk in Herefordshire and Cheshire will produce unequal quantities of curd, highly to the advantage of the latter county.

Considerable quantities of hops are grown in this county, particularly about Bromyard, in that part of Herefordshire bordering on what may be called the hop district of Worcestershire. They are of two kinds, the white and the red; but the former are the most delicate, and are preferred by the buyers.

Plantations of fruit trees are found in every aspect, and on every soil; but the most approved site is that which is open to the south-east, and sheltered in other points, but particularly in the opposite direction. The period when the orchards of this county acquired the high character which they still retain, seems to have been the reign of Charles I. when, according to Evelyn in his *Pomona*, by the noble exertions of lord Scudamore of Holm Lacey, and other gentlemen, Herefordshire became in a manner " one entire orchard." Of the apples that are cultivated, there are various kinds, yielding liquors of different quality and strength. The Styre cyder is remarkable for a strength and body unusual to this liquor, and keeps very well. The pears most in estimation are the Squash, so called from the tenderness of its pulp; the sack pear, the red pear, and the Longland. Every pear tree, when nearly fully grown, will afford an annual average produce of 20 gallons of liquor. Many single trees in this county have produced a hogshead in one season; and an extraordinary tree growing on the glebe land in the parish of Holm Lacey, has more than once filled fifteen hogsheads in one year. In other respects, this is a most extraordinary tree; for its branches becoming long and heavy, their ends fell to the ground, where they took root, each branch becoming as it were a new tree, and in its turn producing others in the same way. Nearly half an acre of land is covered with this tree.

The produce of an acre planted with apple trees, will generally be found nearly one-third less than the produce of pear trees on the same space; but the former begin to bear at an earlier age. As an object of sight, the pear tree is far superior. The orchards are of various sizes, from 4 or 5 to 30 or 40 acres. The principal markets for the fruit liquors of Herefordshire, are London and Bristol. From the latter, great quantities are sent to Ireland, to the East and West Indies, and to foreign countries, in bottles. The principal part of the liquor is bought immediately from the press by the county dealers. They prefer it in that state, in order that the fermentation and subsequent management may take place under their own direction.

In the opinion of Mr Marshall, the Herefordshire breed of cattle, taking it all in all, may, without risk, be deemed the first breed of cattle in the island. Those of Devonshire and Sussex approach nearest to them in general appearance; but they are of a larger size, and an athletic form. The prevailing colour is reddish brown, with white faces. As beasts of draught, their form is nearly complete; and the females at least fat kindly at an early age. In Herefordshire, working oxen are the principal object of breeding. Half the plough teams are of oxen, and they are also used frequently in carriages. They are bred chiefly in the north-western quarter of the county; but more or less in every other quarter, except the Ryeland. The most valuable collection of cattle to be seen out of Smithfield, are often met with at the Hereford Michaelmas fair.

This county has long been celebrated for a peculiar breed of sheep, called the Ryeland breed, from an indeterminate district in the southern quarter of the county which goes by the name of Ryeland, on which this breed of sheep are principally reared. These sheep are remarkable for the sweetness of their mutton, but still more so for the fineness of their wool: they are a small white-faced, hornless breed, their form being extremely beautiful. In the management of the store flocks of this breed, what is provincially termed a *cot* is used: this is a building in which they are shut up during the night, instead of being folded in the open field. The Merino has been crossed with this breed to great advantage. Leominster is the principal wool market in the county, hence Leominster wool has long been famous.

The roads in Herefordshire, even so late as 1788, when Mr Marshall visited the county, were very bad, indeed proverbially bad; but since that time they have been much improved.

There are no manufactures of any extent or consequence in the county; for the manufactures of gloves and flannel in Hereford, and of cloth at Ledbury, are by no means so important as to deserve particular notice.

The returns made under the act of the 26 George III. report the nett expences for maintaining the poor throughout the county, in the year 1776, to have been 10,393*l*. The average of the years 1783, 1784, and 1785, as returned under the same authority, was stated at 16,727*l*. In the year 1805, Mr Duncombe estimated them at 20,000*l*. By a return made to the House of Commons in February 1806, containing an account of all money raised by poor's rates, or other rate or rates, in the several counties of England and Wales, in the year ending 25th of March, 1815, it appears that 243 parishes and places in Herefordshire paid, under these rates, the sum of 81,182*l*.: sixteen parishes or places had made no return.

The earliest inhabitants of this county, of whom we have any notice, were the Silures; after a long and strenuous opposition to the Romans, they were subdued in the 73d year of the Christian era. Under the heptarchy, Herefordshire formed part of the kingdom of Mercia, and was the last which submitted to the Saxon authority.

According to the act of 43 George III. for taking an account of the population of Great Britain, the number of inhabitants in the year 1801 amounted to 89,191. The following is the result of the population returns in 1811:

| | |
|---|---|
| Houses inhabited | 18,572 |
| Families inhabiting them | 20,081 |
| Houses building | 154 |
| Houses uninhabited | 724 |
| Families employed in agriculture | 12,599 |
| Ditto in trade | 5,044 |
| Ditto in other lines | 2,438 |
| Males | 46,404 |
| Females | 47,669 |
| Total inhabitants | 94,073 |

HERESY, (Lat. *Hæresis*, Gr. αἱρεσις, from αιρεω, *I chuse*,) signifies an error in some essential point of Christian faith, publicly avowed, and obstinately maintained; or, according to the legal definition, *Sententia rerum divinarum humano sensu excogitata, palam docta, et pertinaciter defensa*. Particular modes of belief or unbelief, therefore, which have no tendency to overturn Christianity itself, or to sap the foundations of morality, cannot be held as falling within the above definition. It is properly the obstinacy, and not the error, that is considered as constituting the character of heresy. When a man embraces any opinion, however erroneous, but is at the same time humble and ingenuous, ready and desirous of receiving farther light and instruction, and of giving its due weight to every argument that is urged against him, he is not guilty of heresy. *Errare possum, hæreticus esse nolo*, is a celebrated maxim of St Augustine.

Among the ancients, the word *heresy* appears to have had nothing of that odious signification, which has been attached to it by ecclesiastical writers in later times. It only signified a peculiar opinion, dogma, or sect, without conveying any reproach; being indifferently used, either of a party approved, or of one disapproved, by the writer. In this sense, they spoke of the heresy of the Stoics, of the Peripatetics, Epicureans, &c. meaning the sect, or peculiar system, of these philosophers. In the historical part of the New Testament, the word seems to bear very nearly the same signification, being employed indiscriminately to denote a sect or party, whether good or bad. Thus we read of the sect or heresy of the Sadducees, of the Pharisees, of the Nazarenes, &c. See *Acts* v. 17, ch. xv. 5. ch. xxiv. 5. ch. xxvi. 5. ch. xxviii. 22. In the two former of these passages, the term *heresy* seems to be adopted by the sacred historian merely for the sake of distinction, without the least appearance of any intention to convey either praise or blame. In *Acts* xxvi. 4, 5, Paul, in defending himself before king Agrippa, uses the same term, when it was manifestly his design to exalt the party to which he had belonged, and to give their system the preference over every other system of Judaism, both with regard to soundness of doctrine, and purity of morals.

It has been suggested, that the acceptation of the word αἱρεσις, in the Epistles, is different from what it has been observed to be in the historical books of the New Testament. In order to account for this difference, it may be observed that the word *sect* has always something relative in it; and therefore, although the general import of the term be the same, it will convey a favourable or an unfavourable idea, according to the particular relation which it bears in the application. When it is used along with the proper name, by way of distinguishing one party from another, it conveys neither praise nor reproach. If any thing reprehensible or commendable be meant, it is suggested, not by the word αἱρεσις itself, but by the words with which it stands connected in construction. Thus we may speak of a strict sect, or a lax sect; or of a good sect, or a bad sect. Again, the term may be applied to a party formed in a community, when considered in reference to the whole. If the community be of such a nature as not to admit of such a subdivision, without impairing and corrupting its constitution, a charge of splitting into sects, or forming parties, is equivalent to a charge of corruption in that which is most essential to the existence and welfare of the society. Hence arises the whole difference in the word, as it is used in the historical part of the New Testament, and in the Epistles of St Peter and St Paul; for these are the only apostles who employ it. In the history, the reference is always of the first kind; in the Epistles, it is always of the second. In these last, the apostles address themselves only to Christians, and either reprehend them for, or warn them against, forming sects among themselves, to the prejudice of charity, to the production of much mischief within their community, and of great scandal to the unconverted world without. In both applications, however, the radical import of the word is the same; and even in the latter, it has no necessary reference to doctrine, true or false.

During the early ages of Christianity, the term *heresy* gradually lost the innocence of its original meaning, and came to be applied, in a reproachful sense, to any corruption of what was considered as the orthodox creed, or even to any departure from the established rites and ceremonies of the church. In the present article, we do not intend to enter into a minute history of the various heresies, which have at different times disturbed the repose of the church, and given occasion to persecutions, which are revolting to the milder genius of modern times. All that we propose is, to give a short view of the progressive doctrines of the law upon this subject.

In our definition of the word *heresy*, we have marked the essential character of the offence, as it falls under the view of the law. In the law of England, however, it seems difficult to determine precisely what errors amount to heresy, and what do not. By our ancient constitution, this was left generally to the determination of the ecclesiastical judge, who, in this respect, had a most arbitrary latitude allowed him. For the general definition of an heretic given by Lyndewode, (*cap. de Hæreticis*,) extends to the slightest deviations from the doctrines of the holy church: *hæreticus est qui dubitat de fide Catholica, et qui negligit servare ea, quæ Romana ecclesia statuit, seu servare decreverat.* Or, as the statute, 2 Hen. IV. c. 15, expresses it in English; "Teachers of erroneous opinions, contrary to the faith and blessed determinations of the holy church." Very contrary this to the usage of the first general councils, which defined all heretical doctrines with the utmost precision and exactness. And the uncertainty of the crime, which ought to have alleviated the punishment, seems to have enhanced it in those days of blind zeal and pious cruelty. It is true, that the sanctimonious hypocrisy of the Canonists went at first no farther than to enjoin penance, excommunication, and ecclesiastical deprivation, for heresy; though afterwards they proceeded boldly to imprisonment by the ordinary, and confiscation of goods *in pios usus.* But, in the mean time, they had prevailed upon the weakness of bigotted princes, to render the civil power subservient to their purposes, by making heresy not only a temporal but even a capital offence; the Romish ecclesiastics determining, without appeal, whatever they pleased to be heresy, and shifting off to the secular arm the odium and drudgery of executions, with which they themselves were too tender and delicate to intermeddle. Nay, they even pretended to intercede and pray, on behalf of the convicted heretic, *ut citra mortis periculum sententia circa eum moderetur*; (*Decret.* l. 5. t. 40. c. 27.) well knowing, at the same time, that they were delivering the unhappy victim to certain death. Hence the capital punishments inflicted on the ancient Donatists and Manichæans, by the emperors Theodosius and Justinian, (*Cod.* l. 1. tit. 5.); hence also the constitution of the emperor Frederic, mentioned by Lyndewode, (*cap. de Hæreticis*,) adjudging all persons, without distinction, to be burnt with fire, who were convicted of heresy by the ecclesiastical judge. The same emperor, in another constitution, ordained, that if any temporal lord, when admonished by the church, should neglect to clear his territories of heretics within a year, it should be lawful for good Catholics to seize and occupy the lands, and utterly to exterminate the heretical possessors. And upon this foundation was built that arbitrary power, so long claimed, and so fatally exerted by the Pope, of disposing even of the kingdoms of refractory princes to more dutiful sons of the church, which formed a fruitful source of contention and animosity during the dark ages of Europe.

While Christianity was thus deformed by the demon of persecution upon the continent, it was not to be expected that our own island should be left entirely free from the same scourge. Accordingly, we find among our ancient precedents a writ *de hæretico comburendo*, which is thought by some to be as ancient as the common law itself. It appears from thence, however, that the conviction of heresy by the common law, was not in any petty ecclesiastical court, but before the archbishop himself in a provincial synod; and that the delinquent was delivered over to the king to do as he should please with him; so that the crown had a controul over the spiritual power, and might pardon the convict, by issuing no process against him; the writ *de hæretico comburendo* being not a writ of course, but issuing only by the special direction of the king in council.

But in the reign of Henry IV. when the eyes of the Christian world began to open, and the seeds of the Protestant religion (under the opprobrious name of Lollardy) took root in this kingdom, the clergy, availing themselves of the king's dubious title to demand an increase of their own power, obtained an act of parliament, (2 Hen. IV. c. 15.) which sharpened the edge of persecution to its utmost keenness. By that statute, the diocesan alone, without the intervention of a synod, might convict of heretical tenets; and unless the convict abjured his opinions, or if after abjuration he relapsed, the sheriff was bound *ex officio*, if required by the bishop, to commit the unhappy victim to the flames, without waiting for the consent of the crown. Another and subsequent statute (2 Hen. V. c. 7.) made Lollardy also a temporal offence, and indictable in the king's courts; which did not thereby gain an exclusive, but only a concurrent jurisdiction with the bishop's consistory. When the final reformation of religion began to advance, the power of the ecclesiastics became somewhat moderated; for although what heresy *is*, was not then precisely defined, yet we are told, in some points, what it *is not.* Thus the statute 25 Hen. VIII. c. 14. declares, that offences against the see of Rome are not heresy; and the ordinary is thereby restrained from proceeding in any case upon mere suspicion; that is, unless the party be accused by two credible witnesses, or an indictment of heresy be first previously found in the king's courts of common law. Yet the spirit of persecution was not then abated, but only diverted into a lay channel. For in six years afterwards, the bloody law of the Six Articles was introduced by the statute 31 Hen. VIII. c. 14. which established the six most contested points of Popery, viz. transubstantiation, communion in one kind, the celibacy of the clergy, monastic vows, the sacrifice of the mass, and auricular confession. These points, it seems, were "determined and resolved by the most godly study, pain and travail of his Majesty; for which his most humble and obedient subjects, the lords spiritual and temporal, and the commons, in parliament assembled, did not only render and give unto his highness their most high and hearty thanks," but did also enact and declare all oppugners of the first to be heretics, and to be burnt with fire; and of the five last to be felons, and to suffer death. The same statute established a new and mixed jurisdiction of clergy and laity, for the trial and conviction of heretics; the reigning monarch being then equally intent in destroying the supremacy of the bishops of Rome, and confirming all the other corruptions of the Christian religion.

Passing over the detail of the various repeals and revivals of these sanguinary laws in the two succeeding reigns, we shall proceed directly to the period of the final establishment of the Reformation in the reign of Queen Elizabeth. By statute 1 Eliz. c. 1. all former statutes relating to heresy are repealed, which leaves the jurisdiction of heresy as it stood at common law: viz. As to the infliction of common censures in the ecclesiastical courts; and, in case of burning the heretic, in the provincial synod only; or, according to Sir Matthew Hale, in the diocesan also. But, in either case, it is agreed, that the writ *de hæretico comburendo* was not demandable of common right, but grantable or otherwise merely at the king's discretion. 1. Hal. P. C. 405. The principal point, however, was now gained; for by this statute a boundary is, for the first time, set to what shall be accounted heresy, which is restricted, for the future, to such tenets only which have been heretofore so declared by the words of the canonical scriptures, or by one of the first four general councils, or by such other councils as have only used the words of the Holy Scriptures, or which shall hereafter be so declared by the parliament, with the assent of the clergy in convocation. For the writ *de hæretico comburendo* remained still in force; and there are instances of its being put in execution upon two Anabaptists in the seventeenth of Elizabeth, and upon two Arians in the ninth of James I. But this odious writ was at length totally abolished, and heresy again subjected only to ecclesiastical correction, *pro salute animæ*, by virtue of the statute 29 Car. II. c. 9. The matter, therefore, is now brought into its proper situation, with respect to the spiritual cognizance and spiritual punishment of heresy, unless, perhaps, that the crime itself ought to be more strictly defined, and no prosecution permitted, even in the ecclesiastical courts, until the tenets in question are, by proper authority, previously declared to be heretical. Under these restrictions, it seems necessary for the support of the national religion, that the officers of the church should have power to censure heretics, yet not to harass them with temporal penalties, much less to exterminate or destroy them.

The fury of persecution, indeed, has been greatly allayed, both by the prudence and the humanity of modern times; and the gradual repeal of the savage laws enacted against heretics, as well as the mitigation of cruelty in the legal punishments which were devised by barbarous ages, must be considered as a natural consequence of the advancement of civilization. With regard to one species of heresy, indeed, the legislature still thought it proper for a long while, that the authority of the civil magistrate should be interposed. For by the statute 9 and 10 W. III. c. 32. it was enacted, that if any person educated in the Christian religion, or professing the same, should by writing, printing, teaching, or advised speaking, deny the Christian religion to be true, or the Holy Scriptures to be of divine authority, or deny any one of the persons in the Holy Trinity to be God, or maintain that there are more gods than one, he should, upon the first conviction of professing his peculiar doctrines, be rendered incapable of enjoying any office or place of trust, civil or military, as well as ecclesiastical; and upon a second conviction, he should be disqualified from bringing any action, or from being guardian of any child, executor, legatee, or purchaser of lands, and besides suffer imprisonment for three years without bail. But if, within four months after the first conviction, the delinquent should, in open court, publicly renounce his error, he was to be discharged at once from all disabilities. But even this comparatively mild law could not well be executed in an enlightened age, and seemed to be retained merely *in terrorem*, until it was at length repealed in the year 1813. And it is the wish of many in this land of free inquiry, of knowledge, and liberal sentiment, that our statute books may be entirely rescued from the opprobrium of penal laws in the province of religion, and that the rights of conscience may be for ever confirmed, as not controlable by human laws, nor amenable to human tribunals. See Campbell's *Prelim. Dissert. to the Four Gospels, &c.*; Suicer's *Thes.* vol. i. p. 120, 124; Lardner's *Works*, vol. ix. p. 223, &c.; Blackstone's *Comment.* b. iv. ch. 4; Furneaux *Letters to Judge Blackstone*, p. 30; *Popular Reflections on the Progress of the Principles of Toleration*, &c. Newcastle, 1814; and *Edinburgh Review*, No. 51, p. 51, *et seq.* (z)

HERITIER, Charles Louis L' de Brutelle, an eminent French botanist, was born at Paris in 1746. In the year 1772, he was appointed Superintendant of the Waters and Forests of the Generalité of Paris; and, with the view of acquiring a knowledge of forest trees, he applied himself with diligence to the study of botany. The first work of L'Heritier was entitled *Stirpes Novæ.* The first fasciculus, with eleven finely engraved plates, appeared in 1784. It was completed in six fasciculi, containing in all eighty-four plates, with their descriptions, which were dated in 1784 and 1785, though they did not appear till some years afterwards. This circumstance gave rise to a controversy between the Abbe Cavanilles of Madrid and L'Heritier. In order to secure some of his own discoveries, L'Heritier published them in the form of monographs, with one or two plates. The subjects were *Louichea*, *Bucholzia Michauxia*, *Hymeno-pappus*, and *Virgilia*; and twelve of each only were printed.

After the Herbarium of Dombey had been put into the hands of L'Heritier in 1787, with orders to publish its contents, the influence of the court of Spain induced the French government to give orders that the Herbarium should be withdrawn; but L'Heritier having received notice of the measure, carried it over to London, where he remained for fifteen months, chiefly under the hospitable roof of Sir Joseph Banks. The state of his country, however, compelled him to return to Paris: and at this time the MSS. of his *Peruvian Flora* was complete, sixty drawings were finished, and many of the plates engraven. During his stay in England, he had collected the materials of his *Sertum Anglicum*, an unfinished work, of which he published several fasciculi, on the same plan as his *Stirpes Novæ*.

In the year 1775, L'Heritier married Madamoiselle Doré, who brought him five children, and died in the year 1794. In the year 1775, he became a *Conseiller à la cour des aides*, and was a long time the dean of that court. After the death of his wife, L'Heritier devoted himself to the education of his children; but his hopes were frustrated by the unprincipled conduct of his son. When he was one evening returning from a meeting of the National Institute, in August 1800, he was murdered, and his body was found next morning, with his money and other articles of value untouched. No discovery was ever made respecting this barbarous event; but suspicions of the most unnatural kind were confidently entertained. See Rees's *Cyclopedia*.

HERKEMER, a post town of Herkemer county, in New York, is situated on the north side of Mohawk river. The township includes the village called Little German Flats, and the celebrated plain called German Flats. The village contains a court-house, gaol, a Dutch church, and about 40 dwelling houses, which last are very indifferent buildings. It is 80 miles N. W. by W. of Albany, 16 S. E. of old Fort Schuyler, and 20 in a like direction from Whitestown. In the midst of the flats is a shrub oak plain of 80 or 100 acres, barren and stony, of no use but for building lots. It contained in 1796, 2073, and in 1800, 2554 inhabitants.

HERMANSTADT, Hermenstadt, or Szebeny, the *Cibinium* and *Hermanopolis* of the ancients, is a town of Hungary, and the capital of the province of Transylvania. It is situated in a champaign country, near the river Cibin, or Szeben, from which it derived the name of *Cibinium* and Szebeny. The principal public buildings are three monasteries for men, and one convent for women. One of the monasteries is for Ex-Jesuits, another for Catholics of the Franciscan order, and another for Greek monks of the order of St Basil. There is also a theatre, which is open during summer, a cassino, a public school for Protestants, and another for Greeks. In the great square there is a statue. The town is fortified with a double wall and deep moat. The museum of Baron Bruckenthal, a venerable nobleman, contains one of the finest collections in Europe of pictures, antiquities, and natural history. Dr Clarke has given a very minute description of it. The soap works of this town have been long celebrated; and the tallow candles manufactured here are so white, that there is a great demand for them at Vienna. The chateau of Freck, in the vicinity of the town, is worthy of being visited. The town was founded by Hermannus, a Greek emperor. It is well built, large, and populous, and contains from 15,000 to 16,000 inhabitants. The climate is said to be insalubrious. See Clarke's *Travels*, part ii. sect. iii. Supplement, p. 603, &c.; and *Hermannstadter Handlungs, gewerbs-und Reise-Kalender*, by M. Hochmeister, 1790.

HERMAPHRODITE, is a living being possessing the organs of generation belonging to both sexes.

On surveying the origin, the progress, and decay of the animal creation, there is sufficient reason to infer, that nature is infinitely more solicitous about preserving the different genera and species than the individuals of the race. Thus where their continuation is required by mutual concourse, as among the larger and more perfect creatures of the earth, it is necessary that the sexual organs of each should be reserved distinct and entire. Though accidental monstrosities ensue in other parts, the animal functions can be carried on, and sometimes with little injury; but imperfections in that portion of the frame appropriated for procreation, is for the most part an impediment to the laws which regulate the reproduction of living beings.

Nevertheless, the sexual organs, like other parts of animated matter, are liable to exhibit malformation, or monstrosities; and hence an idea has originated, that in man and different animals, the qualities of a perfect male and female may be united in the same individual. The fables of the ancients have perhaps conspired to give probability to these opinions. According to their allegories, a son of Mercury and Venus, who had been fostered by the Naiads of Ida, became enamoured of the nymph Salmacis, who fled from his embraces. But he joined her in a fountain where she could escape no longer, and besought the gods that their bodies might be united in one. His prayers were heard.

> "Vota suos habuere deos: nam mista duorum
> Corpora junguntur, faciesque inducitur illis
> Una . . . . . . . . . . . . . . . . . .
> Nec duo sunt et forma duplex nec femina dici
> Nec puer ut possint: neutrumque et utrumque videntur."
> Ovid *Metam.* lib. iv. cap. 9.

This androgynous being was thenceforth called Hermaphroditus, (whence the derivation of hermaphrodite,) and affords a subject for many beautiful sculptures from the hands of the ancients, which are still preserved.

No question has been more keenly agitated than the existence of human hermaphrodites; and the difficulty of the subject has been greatly increased, by that anxiety with which mankind conceal their nakedness; and, by an unjust abhorrence entertained against whatever seems beyond the standard of ordinary configuration. The Jews, for example, have a long catalogue of denunciations against persons labouring under disease or infirmity, natural or accidental; and even in the islands which we ourselves inhabit, monstrous productions of animals are almost invariably destroyed, as also those of mankind, where it can be effected with safety. But the vehemence of civil institutions seems to have been more conspicuously directed against those unfortunate beings known to labour under malformation of the sexual organs. At an early period of Roman history, a law was enacted, that every child of this description should be shut up in a chest and thrown into the sea; and Livy gives an instance where, on some difficulty with respect to the sex of an infant, it was directed to be thrown into the sea, *tanquam fœdum et turpe prodigium.* Nay, such a visitation seems to have been considered a mark of divine vengeance, for the execution was always followed by religious rites. The Jewish law is extremely solicitous regarding the disposal of hermaphrodites: the civil and canon law contain numerous hypotheses and enactments concerning them, and their succession is provided for by the laws of England.

The general scope of these laws tends to form regulations which shall apply according to the apparent predominance of sex; for the ancient legislators, though sufficiently aware of this distinction, do not seem to have admitted hermaphrodites as possessing a complete duplication of the generative organs. Being undoubtedly founded on experience, they cannot be considered void of interest. The numerous and diversified ordinances of the Talmud divide hermaphrodites into four classes; under which aspect they are to be treated partly as male, partly as female; next, as both male and female; and, lastly, as neither male nor female. First, they are like men, in being obliged to dress in male attire, and marry their brothers widows. Secondly, they are like women, because they may not converse with the male sex alone in private; they may walk among the dead; and are prohibited from bearing testimony: also, because they may shave their heads after a particular fashion, and pluck out their beards. Thirdly, they are to be esteemed both men and women, from having their share of the paternal and maternal inheritance, and such other succession, which they may claim as of either sex; they may retire to a sanctuary in case of accidental slaughter, and remain there as if it had been of either a man or woman; and if it be murder, they shall be put to death as for killing either a man or woman. Fourthly, hermaphrodites are to be considered neither man nor woman, by the law of Moses, in striking or calumniating another, but the judge shall ordain reparation; nor in making vows to the Deity, or in withdrawing from the world to devote themselves to his service. Many other partitions are made under these divisions. The canon and civil law displays all that uncertainty which is the natural offspring of prejudice, and the want of knowledge. Doubts and questions are started, useless to society, and oppressive to those affected by them; and in general they are, as in the Jewish law, to be solved according to the predominance of sex. Notwithstanding the numerous and absurd restraints put upon supposed hermaphrodites, it does not appear that they are precluded from marrying; on the contrary, if the two sexes in themselves be equal, a choice of the object is left, while other cases of marriage are regulated by sexual predominance. However, should the question be regarding an oath, the ordinances of the church seem to declare, that under the same equality of organization the testimony must be rejected. Hermaphrodites may not be promoted to holy orders, on account of deformity or monstrosity; nor can they be appointed judges, "because they are ranked among infamous persons, to whom the gates of dignity should not be opened." These are but a few of the prohibitions levelled against them. Many are cruel and unnecessary; and of so singular a kind, that a learned and humane physician exclaims, "would not any one conceive, that these supposed androgyni, instead of being of the same nature with us, however marked and deformed their parts of generation might be, were rather another race of animals, *sui generis*, than what they really are, when a string of laws compiled with so much accuracy, and in such a formal manner, has been exhibited and increased in all ages?" Yet rational enactments, founded on experience, are by no means void of utility; for observance of the law may prevent contention in all the mazes of doubt. Thus M. Ferrein, a modern physician, acquaints us, that he was consulted by the relatives of a young nobleman, labouring under a dubious conformation, who, if a male, as was commonly believed by them, would inherit a considerable estate, to which he could have no right if belonging to the other sex. Having afterwards occasion to illustrate the case, we shall not here anticipate the result. The subject of succession is doubtless fit for regulation, and consequently must frequently be determined by the predominance of sex. Happily the absurd penal laws, directed against this portion of our fellow creatures, are obsolete among us.

We shall now proceed to the opinions of recent philosophers and naturalists, which afford more copious sources of knowledge and entertainment. These are widely different from what were received of old, and most of the moderns incline to a different opinion: they doubt whether there is any well authenticated instance of a person having been seen with the organs of both sexes complete.

The origin of sex is in itself a dark and mysterious subject. That of no living animal can be distinctly recognised at an early period of existence; and some naturalists affirm, that there is reason to believe that the organization is such as to admit the evolution of the parts of the embryo, distinguishing either male or female; and that this evolution takes place during some period of gestation. Thus Ackermann adopts the principle, that *in omni individuo latent utriusque sexus genitalia, a modo dictis dependet circumstantiis an hæc an illa evolvi et increscere debeant.* The cause of evolution, however, if we rightly understand the author, will scarcely be admitted by naturalists; for he seems to ascribe it to matter of which the presence can only be presumed; *Discrimen quod a sexu est non absolutum sed ad ceteras partes respectivum dici debet. Sicut fœtus vel ex materiei plasticæ excessu vel ex oxygenii abundantia, coaluit, et prout in prima uterinæ vita epocha in fœtus incrementum vires agunt extraneæ, ita jam vir jam femina nascitur.* Sir Everard Home also appears to consider "the ovum, previous to impregnation, to have no distinction of sex, but to be so formed as to be equally fitted to become a male or female fœtus." On descending to the insect tribes, we find an intermediate kind between the two sexes, in those called neuters, incapable of generation. But certain naturalists have shewn, by ingenious experiments, that among bees, where this distinction is most prominent, the imperfection may be removed by a particular sort of food early supplied, and the sexual organs of females amply unfolded.

Leaving the subject of proper hermaphrodites, or those with the combined sexual organs entire, and capable of performing the generative functions, we shall now give some account of the three classes into which hermaphrodites may be divided. First, individuals exhibiting a mixture of the sexual organs, neither being complete; secondly, men labouring under a malformation of the parts; and, thirdly, females with analogous imperfections, by enlargement or defect. Examples of the first are extremely rare. Such perhaps is a case mentioned in Dr Baillie's *Morbid Anatomy*, where the person was 24 years of age, and examined as a patient of Nottingham hospital; and such perhaps was an androgynous child, which is the subject of discussion by Ackermann. Another instance is related in the *Journal de Medicine*, of a person who was long considered a woman, treated as such in society, and who was either married or lived in concubinage with a man. At the same time, others may consider all these as more strictly belonging to the class of males with malformation. The androgynous child of which we speak was born at Mentz in June 1803. Its singularity of structure was supposed indicative of the masculine gender by those present, and it was baptised as such. Having died at the age of five or six weeks, Ackermann, who had previously inspected the external configuration, obtained an opportunity of dissection, though the organs had declined along with the decay of the body during sickness. He found an intermixture of the sexual distinctions, removing the infant from a perfect male or female; the glans imperforate, scrotal labia, an uterine sac, and other doubtful indications, of which he has given an ample detail, illustrated by engravings; and at the same time he expresses his conviction of the androgynous nature of the subject.

A remarkable case came under the notice of some of the most learned continental physicians in the preceding century, respecting Michel Ann Drouart, a native of Paris, born about the year 1734. This individual was baptized, treated, and dressed as a girl, but having attained the age of 16, a report was circulated of her being a hermaphrodite, which led to a minute inspection by M. Moraud, who has presented us both with the result in detail, and several engravings. He found the external configuration partly masculine, partly feminine, but the former predominated. It corresponded to the age of the person, whereas the female characteristics belonged to a period of childhood, or early adolescence. An organ denoting virility appeared, but the urethra was absent; neither could he determine the exact point of a deep fissure, occupying the scite of the scrotum, into which the urine was discharged; and other medical men were equally unsuccessful. The breast was quite flat, and it always remained so; the person had the gesture, step, and voice of a youth, some rudiments of a beard on the upper lip, and a decided propensity for females. Yet, "says M. Moraud," there was a strange intermixture of the sexes in all respects; for the bason was more enlarged; and in comparing the two thighs together, one resembled that of a male, and the other that of a female." From these and concomitant circumstances, he formed an opinion that the subject was a male. Michel having left Paris some time after, underwent another inspection by M. Cruger, principal surgeon to the King of Denmark, who was induced, on the other hand, to consider the female character predominant; but he concludes, on the whole, that in strict definition the subject was neither male nor female. At the age of 21, some Genevese physicians had an opportunity of making their observations. The principal organ now exceeded the ordinary human dimensions in every respect; a thin black beard, nearly such as a young man of that age should have, appeared; and the breast and stature were completely those of the same sex. But now the propensities for males were supplanted by those formerly entertained; for at the age of 17, those evacuations characterising females of the human species had commenced, but experienced many irregularities and interruptions; and in 1761, had ceased for nearly three quarters of a year. Cotemporary observers were then inclined to depart from M. Moraud's sentiments, and to believe that there was a predominance of the female sex. However, some of the most recent authors, and those who have studied the subject most profoundly, seem to rank Michel Ann Drouart with hermaphrodites, exhibiting an intermixture of the sexual organs. M. Ferrein found the appearances in the more youthful subject above alluded to, completely the same as in the preceding individual in the essential parts. The whole external mien, intimately resembled that of girls at twelve years of age; the breast was quite flat, and the voice rather masculine. The external sexual organ, which would have indicated a male, was much smaller, though of the same structure as before; those of the female were somewhat misplaced, but the position of the urethra could be easily ascertained. Enough was disclosed, to induce M. Ferrein to declare, that this young nobleman was in fact a female, and would consequently be deprived of the expected inheritance. If his opinion be correct, the present case should be removed to the third class of persons designed hermaphrodites, though, from the doubts of the learned respecting the former, we are induced still to retain it here. It is not the structure of the sexual parts which is alone to be taken into view, but the total organization combined. The personal configuration, the habit of the body, the presence of a beard, the quality of the voice, propensities and dispositions, and other characteristics, added to any uncommon structure of these parts, shew that some of the male and female properties are confounded together. At an early period of gestation, human females are frequently mistaken for males; and hence an erroneous opinion has prevailed, of abortions at certain stages being more commonly of males. Many such fœtuses have been exhibited by Dr Parsons and others in illustration of the fact: and M. Ferrein concludes his observations on the preceding case with words of the following purport: "If to constitute a hermaphrodites wherein the sexes are combined, it is necessary to have the distinctive character of the male united to the female parts, there never was any woman who has not been a male during several months of her existence. In the earlier stages of pregnancy, that distinctive organ is prominent, and fashioned very nearly after the manner of males, so that those unskilful in anatomy, may suppose the embryo a male, though truly a female; nor on narrow inspection is the difference easily ascertained." The possibility of a complete duplication of the male and female organs is questioned, from there being no place in the human body which they could occupy, or wherein they could be contained. The same difficulty does not occur to us, and perhaps it can only be admitted where all the other parts, independent of them, are meant to be exactly of the natural structure and proportions. If so intimate a resemblance prevails in the sexual parts of the male and female embryo, something of an intermediate kind may be produced, should the position and developement of either be deranged; and thus exhibit an intermixture of sex; or, as we have some times witnessed, a complete duplication of some essential organ, as the head, hands, or feet, the like may happen to other parts. Among animals, very extraordinary instances have occurred of some decidedly males, to external appearance, nevertheless possessing female properties, such as the power of secreting milk. This faculty, indeed, is said in rare examples to reside in the nipples on the breast of men, the use of which is yet unknown by anatomists. A bull, which is reported to have generated five calves, had a small udder and small teats, which afforded a quantity of milk that on one occasion is said to have amounted to an English pint. In the *Philosophical Transactions* also, there is preserved an account of two wedders giving suck to lambs. Yet we cannot be too scrupulous in admitting such wonderful deviations from the course of nature. At the same time it must be recollected, that the rudiments of the mammæ exist in all the males of mankind and quadrupeds; and that before the age of puberty in the former, and when the the powers of procreation cease, there is a more intimate resemblance between the sexes than at other periods. Nor is it to be omitted, that emasculation produces a decided approximation to the feminine character. But, in prosecuting the intermixture of sexes in animals, an example is generally given in the free martin, on which the late celebrated Mr John Hunter observes—"When a cow brings forth two calves, and one of them a bull calf and the other to appearance a cow, the cow calf is unfit for propagation, but the bull calf becomes a very proper bull. This cow calf is called in this country a *free martin.*" Mr Hunter, on dissection, found such an intermixture of organization, that the animal always partakes of the nature of both sexes, though that of the one is sometimes more predominant than that of the other. Its external aspect is also different from the appearance of each, and it never betrays any sexual propensities. The muscular texture and the voice are peculiar, and the size is considerably larger than that of either bull or cow. Apparently there is much analogy between the free martin and an emasculated animal. Mr Hunter observes, that he has frequently seen hermaphrodite horses; that he dissected a hermaphrodite ass; and that sheep of this description are also to be found. The dissection of a hermaphrodite dog is given by Sir Everard Home in the *Philosophical Transactions* for 1799, where there was only one characteristic of the female decidedly present. However, there appear several reasons to conclude, that some of the animals quoted as undoubted hermaphrodites, ought rather to be classed with females labouring under vicious conformation. The intermixture of the masculine organs is not sufficiently prominent.

It has been observed, that among wild pheasants, a hen sometimes appears with the feathers of a cock; yet, on dissection, the female organs are found complete. Mr Hunter conceives, that this is a change which ensues at a certain age, and subsequent to the cessation of the procreative faculties; and he traces the history of three, where the alteration took place. But on descending still lower among the animal tribes, we find a multitude of beings apparently possessing the absolute character of hermaphrodism. Many of the mollusca contain individually the perfect organs belonging to either sex, not by accidental admixture or malformation, but by regular, natural arrangement. A sexual union takes place; all impregnate, and are impregnated; and this ensues by a singular and interesting distribution of the parts. Such is the case with many of the mollusca, or soft bodied animals with external organs, and those in general included under the order Helminthology. There can be no generation, however, without their mutual concourse; but in the animalcula infusoria, some seem perfect hermaphrodites, in so far as they propagate in an isolated state, while in others the sexual union seems requisite. In the numerous genus of polypi, the young animal protrudes from the side of the mother, and in its turn becomes a parent in the same way, while no union with another sex follows; or, as in the actinia, the young are formed within, and then discharged by the mouth. The subject of hermaphrodism may be still farther illustrated by a series of experiments which have recently been made on an extraordinary race of animals, bearing some analogy to the leech and snail, called *planariæ*. In one species, the sexual union takes place, and the result is eggs including young. In another, this union is never observed, but a portion of the tail separates by spontaneous division. It remains a shapeless mass, and absolutely quiescent, until the evolution of wanting organs enables it to perform all the functions of the parent. Having remained a certain time complete, this new animal loses a fragment of the tail, to become another perfect being; and thus their race is carried on. These creatures, therefore, seem to possess such structure as to enable each individual to reproduce its like.

Instances of mixed organs are of very rare occurrence in the human race. The most uncommon kind of configurations, indeed, are those which pass by the name of hermaphrodism. The older authors, nevertheless, on finding any monstrosities or imperfections in the sexual parts, immediately pronounced the individual a hermaphrodite; but as they were constantly in search of the marvellous, we must repose the less confidence in their observations. Nay, the moderns have, in some cases, too hastily bestowed this character; and we are told of an instance where, "the fore parts of the unhappy object were entirely wanting; even the bladder was not entire. It had the appearance as if the external parts of generation, and the anterior part of the bladder, had been cut off. Yet this unhappy object was vulgarly called a hermaphrodite."

The malformations of men are more frequently seen, and constitute the second class of hermaphrodites. Mr Brand relates, that being consulted in 1779, on occasion of some complaint in the groin of a child seven years of age, he found a vicious structure of the sexual organs, consisting of the unnatural presence of an integument confining the parts. This child had been baptized and brought up as a girl; but it was evident to him erroneously, for the male organs were present. By a slight incision of the integument, he liberated the restricted parts, and proved, to the great admiration of the parents, that they had mistaken a boy for a girl. The operator narrates these facts in a pamphlet, accompanied by three engravings, as large as life, of the appearances before and after the operation. Wrisberg, a German anatomist, in discussing a case of malformation, quotes an instance of a child probably labouring under a similar restriction. The parents, who were Jews, entertained so much doubt regarding the sex of their offspring, that they had deferred the accustomed rite of circumcision, until it should be determined whether it was actually a boy or a girl. But it died at the age of eight months. The same author mentions, that he removed a lesser restriction in a young man; and speaks of another person aged 46, reputed a hermaphrodite, who would not consent to undergo an operation, which, perhaps, would easily have determined his sex. His wife, to whom he had been married five years, then obtained a divorce against him, on account of impotency. An example of a mistake in sex, under more doubtful circumstances, is given by Abraham Kauu Boerhaave, a member of the Petersburgh Academy of Sciences. The child of a trumpeter was baptized Charlotte, and for some time brought up and treated as a girl. But the parents afterwards entertained some doubts regarding its real sex, and at the age of seven resorted to skilful persons to establish the truth. Instead of being a girl, as had been supposed, it was declared to be a boy. Sex, however, is much more doubtful, though the predominance of organization indicates the male, where the scrotum is absent, with a fissure in the perinæum, or a misdirection of the urethra. In the Transactions of the Academy of Siena, a person, named Augustine Broli, is described as being reputed a hermaphrodite, and having so little of the male configuration, that he doubted whether he ought to marry. On consulting Dr Caluri, however, he was assured he might do so with safety. If the description be correct, procreation was impossible. Persons have been mistakenly educated and employed as of a sex to which they did not belong. This was the case with a young man, who was brought up and dressed as a woman, yet, after he died, he was found to be essentially a man. Caspar Bauhin, likewise, speaks of a servant hired by a peasant, who being viewed with remarkable favour by his wife, led to an unexpected discovery of sex, under a malformation. An instance of doubtful sex, though more probably referrible to the third class, is quoted by Ackermann, in the case of Dorothea Derrier. Here opposite opinions were entertained by three medical men, Hufeland, Mursinna, and Stark, from the sexual formation conjoined with the general character of the whole body. The malformation of the male seems to be much more uncommon in animals, or perhaps it has attracted less attention.

But the third class, into which beings with a preternatural sexual structure may be divided, namely, females with malformations, is the most comprehensive of the whole. Nay, there are reputable authors who include all the rest under it, maintaining, that among the human race especially, the issue of every questionable case is, proving the subject a woman. Many examples are collected by Dr Parsons, to whose *Mechanical and Critical Enquiry into the Nature of Hermaphrodites*, we shall refer for the detail. The females of this class are sometimes designed the *macroclitorideæ*, from the preternatural enlargement they exhibit, and which is frequently such as to assume the appearance of virility, even in an adult. In the warmer climates, this being more usual, though probably not to a great extent, but attended with other circumstances, the operation of excision, concerning which the reader may consult the eastern travellers Niebuhr, Bruce, and Browne, is resorted to. Yet this malformation generally has other concomitants, either in corresponding restrictions in the rest of the sexual organization, flatness of the breast, woolliness on the chin, or a hoarser voice than belongs to females. De Graaf, a celebrated anatomist, mentions a female child which, from a preternatural enlargement, had been taken for a male, and baptised as such. It died, and he, along with several physicians and surgeons, having obtained an opportunity of dissecting the body, first had a drawing made of the external appearance; and then proceeding to a more strict examination, pronounced the organs those of a female only. An account has been given of a hermaphrodite in France, which merits particular attention, either in establishing the fact of hermaphrodism, or in illustrating how the learned may be deceived. Towards the year 1686, a maid-servant named Margaret Mauluse, born near Tolouse, was brought to the hospital of that city. She was about 21 years of age, with a feminine mien and appearance, a handsome face and agreeable expression, her bosom well formed, but she presented the male sexual organization, intermixed with the female structure. The evacuations peculiar to the sex were regular and abundant, as was testified by the attending physician; and, according to what he understood, the secretions denoting virility were proportionally copious. These facts being known to several physicians, the vicars general were consulted on the subject, and the result was, to compel the hermaphrodite to adopt the apparel of a man, under the name of Arnaud Mauluse, and to learn some profession. We are further told, that those concerned had no difficulty on the point, because "the hermaphrodite was sufficiently capable of the functions of a man, but of none belonging to a woman." Notwithstanding the necessity of compliance, however, this individual seems to have been dissatisfied with such a compulsory change of sex; and not finding it congenial to her nature, she afterwards solicited the king's permission to resume female attire. Some persons have supposed, that she merely exhibited a *prolapsus uteri* of an unusual form. Even within these few years, a woman was shewn as a hermaphrodite in London, pretending to the capacities of a male, who suffered under the same disease. The deception was detected, but not until a large sum had been realised by her, when she changed her abode. However, the enlargement exciting the idea of the presence of virility, is beyond dispute in adult females. Realdus Columbus says, a gipsey, whom he conceived to be a hermaphrodite, requested him to perform an amputation of the superfluous organization, which he declined from apprehensions of danger. Between 1730 and 1740, an African slave being brought from Angola to Bristol, and carried from thence to London, was exhibited as a hermaphrodite. She was about 26 years of age, presented nothing masculine in voice or appearance, but exhibited the like enlargement as before, attended with some other slight malformations. Dr Douglas made drawings of the whole; and Mr Parsons, having also seen the individual, concluded that she was absolutely a female. In the year 1750, a French woman, aged 18 years, was shewn also in London as a hermaphrodite, with what was called, "an inordinate enlargement" of the organ, and corresponding restrictions of a preternatural appearance. Sir Everard Home speaks of a Mandingo woman, carried from Africa to the East Indies, with flat breasts, a rough voice, and masculine countenance; who exhibited, besides, all the appearance of virility in enlargement, while the rest of the sexual organization seemed in the natural state.

It is exceedingly probable that almost the whole animals vulgarly esteemed hermaphrodites are of this class, females with malformations; because, whatever uncertainties prevail, there is always a decided predominance of the latter sex, though the masculine nature be very obscure. From these and similar uncertainties, a change of sex is said to have sometimes ensued in mankind. Nor is it improbable that this was firmly credited, since a diseased female may, to cursory inspection, manifest the semblance of virility. This imaginary change is most usually of women into men, and rarely of men into women. However Caspar Bauhin relates, that a child was baptised as a boy, became a soldier, and married a woman, with whom he lived seven years. But the supposed husband himself becoming pregnant, was most unexpectedly delivered of a daughter; and upon an investigation by the magistrates of the place of his residence, it appeared there was a malformation, never disclosed by the wife, and that the husband had on some occasion cohabited with a Spaniard. Thus the person supposed to be a male, proved in fact to be a female. Another instance, which seems to have been first related by Dr Douglas, an eminent anatomist, happened in London, where one of two waiters living in a tavern in like manner became pregnant by the other, to the great astonishment of the neighbourhood, at the reputed change of sex; and her dress was thenceforward changed to that of a female. The examples above given, shew that it is possible to mistake the sex of an infant from preternatural organization, but that the real nature of the individuals may be disclosed with the evolution, if we may so call it, of the sexual propensities.

The masculine and feminine character is deeply influenced by the state and condition of those organs which nature has appropriated for the perpetuation of the species. Thus the analogy between the sexes, hardly separable in the embryo, is infinitely greater during childhood, before the complete developement of the generative faculties, and after the procreative powers have ceased, than in the intermediate period. A corresponding analogy is produced by the destruction of the essential parts, or by their vitiated expansion. The eunuch is weak and timid, the beard is wanting, the voice shrill, and he seldom possesses a vigorous intellect. His whole personal configuration and mental disposition are approximated to those of females. On the other hand, where the essential organization of women is injured, there is some tendency by nature to remove them from their original sex. Cases of this kind can seldom occur, but such was the effect in the necessary extirpation of an ovary on account of disease; and also in another instance, where the full developement of the ovaries had not ensued. It is impossible to admit the last class of hermaphrodites, females with preternatural enlargements, accompanied by a hoarse voice, indications of a beard, flat breasts, and masculine propensities, along with women exhibiting none of these peculiarities. They are somewhat removed from females, as men whose person and mind are of a corresponding description, are somewhat removed from the entire and vigorous sex. The difference arises from sexual organization. It has also been conjectured by some learned authors, as Wrisberg, that women of masculine manner and appearance, and men exhibiting an extraordinary degree of effeminacy, may be divided into two distinct classes, the former characterised by ten, the latter by six, peculiarities, among which sterility is common to both. These he supposes to be dependent on sexual organization; and it is worthy of remark, that weakness of intellect is almost invariably concomitant on the imperfect expansion of the generative parts, whether this is prevented by natural infirmity, or by violence in childhood.

Perhaps all the varieties of configuration, which we have thus endeavoured to reduce to three classes, may be ranked in general under monstrosities. Nothing can be more interesting than to investigate the elements of sexual distinction. In whatever manner the expansion of these elements may be deranged, the result is monstrosity, as in other cases, by excess or defect, or some unnatural combination of what would constitute a male or female imperfectly developed. This vicious configuration, though for the most part the lot of some solitary individual, as other monstrosities, prevails in families where there are also perfect beings. One instance is given by Kauu Boerhaave in two young Siberians, and another by Sir Everard Home, in two children born in Devonshire. The latter were males with malformations: They were idiots, and they were of an uncommon size. The parents had an intermediate child, who was a perfect girl. See Ackermann *Infantis Androgyni Historia*. Haller *Commentatio ap. Gottingen Transact.* tom. i. *Novi Comment. Academ Petropolit.* tom. i. and xvi. *Memoires de l'Academie Royale*, 1720—1725, and 1750, 1756, 1767. *Philosophical Transactions*, 1751, 1799. 1805 Parson's *Enquiry*. Brand's *Case of a boy who had been mistaken for a Girl* Hunter *On the Animal Economy* p. 45. *Phenomena of Planariæ*. (c)

HERMOPOLIS. See Civil Architecture.

HERNIA. See Surgery.

HEROD, King of Judea, surnamed the Great, on account of his power and talents, as it frequently happens, rather than of his virtues, was the second son of Antipater the Idumæan, and was born at Ascalon in Judea, about seventy years before the Christian æra. At the age of twenty-five, he was appointed by his father to the government of Galilee, where he distinguished himself by the suppression of a band of robbers, and the execution of their leader Hezekiah, with several of his comrades. Having performed this service of his own authority, and executed the culprits without even the form of trial, he was summoned to answer for his conduct before the Sanhedrim; but he escaped both punishment and censure, through the strength of his party, the zeal of his friends, and his own abilities and dexterity.

In the civil wars of Rome, Herod at first embraced the party of Brutus and Cassius, and was, in consequence, made governor of Cælesyria; and, after their death, when Mark Antony arrived victorious in Syria, he and his brother contrived to ingratiate themselves with him, and were appointed tetrarchs in Judea. But in a short time afterwards, in consequence of an invasion by Antigonus, who was assisted by the Jews, Herod was compelled to make his escape from Jerusalem, and to retire, first to Idumæa, and then to Egypt. He at length arrived at Rome, and upon occasion of a disputed succession to the crown of Judea, between the two branches of the Asmodean family, he found means through his own intrigues, and the influence and powerful recommendations of Mark Antony, to obtain a decree of the senate, conferring that kingdom upon himself. Immediately thereafter he repaired to Judea, and in the course of about three years, succeeded in getting possession of the whole country. But this success was not obtained without bloodshed. The throne was at that time in the possession of Antigonus; and, although aided by the Roman army, Herod was obliged to lay seige to Jerusalem, which held out for six months, when it was at length carried by assault, and a great slaughter made of the inhabitants. Antigonus was taken prisoner and put to death. The attention of Herod, upon assuming the government, was first directed towards the replenishing of his treasury, and repressing the Asmodean faction, by whom he was regarded as an usurper. In the pursuit of these objects, he was guilty of many oppressive acts of extortion and cruelty. Soon after this, an accusation was lodged against him before Mark Antony by Cleopatra, who, it is said, was influenced, upon this occasion, by his mother-in-law, Alexandra. Having been summoned to appear before the triumvir, to answer to the charges exhibited against him, he contrived, by great pecuniary sacrifices, to make his peace with Antony, and returned in high credit to his kingdom. It was upon this occasion that he displayed that conflict of passions, which for ever embittered his domestic life. Being distractedly fond of his wife Mariamne, and unable to endure the thought of her falling into the hands of another, he exacted a solemn promise from Joseph, whom he appointed to govern in his absence, that, if the accusation should prove fatal to him, he would put the queen to death. Joseph disclosed the secret to Mariamne, who, indignant at this savage proof of his affection for her, conceived from that moment a deep and settled aversion to her husband. Upon his return, some hints were thrown out respecting Joseph's familiarity with Mariamne during his absence. These suspicions he communicated to his wife, who immediately recriminated, and upbraided him with his cruel order concerning her. His fury then became unbounded. He put Joseph to death for betraying the secret confided to him, and threw his mother-in-law Alexandra into prison. About this time he received a visit from Cleopatra, who is said to have entertained amorous inclinations towards him. These, however, Herod did not gratify, but endeavoured to glut her avarice with profuse donations.

In the war which broke out between Antony and Octavius, Herod levied an army for the support of the former; but was obliged first to encounter Malchus, King of Arabia, whom he defeated, and compelled to sue for peace. After the decisive battle of Actium, his great object was to make terms with the conqueror; and, as a preliminary step, he put to death Hyrcan, the only surviving male of the Asmodean family. Having taken this precaution to secure himself, he embarked for Rhodes, and appeared before Augustus in all the ornaments of royalty, excepting his diadem. With all the appearance of noble and ingenuous confidence, he related the faithful services he had performed for his benefactor Antony, and hinted that he was ready to transfer his gratitude and allegiance to a new patron, from whom h eshould hold his crown and kingdom. Augustus was struck with the apparent magnanimity of this defence of his former conduct, and replaced the diadem on the head of Herod, who continued to be the most favoured of his tributary sovereigns.

But the good fortune which Herod experienced, as a prince, was poisoned by domestic broils, and particularly by the insuperable aversion of his wife Mariamne, whom at length he brought to trial, convicted, and executed. She submitted to her fate with all the intrepidity of conscious innocence, and was sufficiently avenged by the dreadful remorse of her husband, whose peace of mind was for ever afterwards destroyed. In vain did he endeavour to banish her memory by scenes of dissipation and cruelty: the charms of his beloved Mariamne haunted him wherever he went; and he would frequently call aloud upon her name, as if willing to forget that she was no longer among the living. At times he would fly from the sight of men: and on his return from solitude, which was ill suited to a mind stricken with the consciousness of guilt, he became more brutal and ferocious than ever, and in his fits of phrenzy spared neither friends nor foes. Alexandra, who had always exhibited the utmost malignity towards her daughter, fell the unpitied victim of his rage. At length he appears to have recovered some portion of self-possession, and employed himself in projects of regal magnificence. He built at Jerusalem a magnificent theatre and amphitheatre, in which he caused games to be celebrated in honour of Augustus; to the great displeasure of the zealous Jews, who discovered Gentile profanation in the theatrical ornaments and spectacles. These, and other offensive acts, excited a most serious conspiracy against him, which he, fortunately for himself, discovered, and exercised the most brutal revenge on all the parties concerned in it. He next built Samaria, which he named Sebaste, and adorned with the most sumptuous edifices; and for his security, he erected several fortresses throughout the whole of Judea, of which the principal was called Cæsarea, in honour of the emperor. At the dedication of this last new city, he displayed such profuse magnificence, that Augustus said, "his soul was too great for his kingdom." The same taste for sumptuous magnificence was exhibited in his palaces, on which he lavished the most costly materials and workmanship. To supply the place of his lost Mariamne, he married another wife of the same name, the beautiful daughter of a priest, whom he raised to the high rank of the supreme pontificate. His two sons by the first Mariamne he sent to be educated at Rome, and so ingratiated himself with Augustus and his ministers, that he was appointed imperial procurator for Syria.

With the view of acquiring popularity among the Jews, and of exhibiting an attachment to their religion, he undertook the vast enterprize of rebuilding the temple of Jerusalem, which he completed in the course of about a year and a half, in a noble style of magnificence. During the progress of this work he visited Rome, and brought back his sons, who had grown up to manhood. These, however, at length conspired against their father's person and government, and were tried, convicted, and executed. It was in reference to this transaction that Augustus is reported to have said, that "it was better to be Herod's hog than his son."

In the thirty-third year of his reign occurred the memorable event of the birth of our Saviour; upon which occasion, acccording to the Gospel of St Mathew, the jealousy of Herod was so highly excited by the prophetic intimations of the future greatness of the Messiah, that he slaughtered all the infants in Bethlehem, in hopes of destroying him among the number. About this time Antipater, returning from Rome, was arrested by his father's orders, and accused of treasonable practices. He was found guilty of conspiring against the life of the king. This and other calamities, combined with a guilty conscience preying upon a broken constitution, threw the wretched monarch into a loathsome and mortal disease, which has been represented by historians as a just judgment of heaven for the many foul enormities and impieties of which he had been guilty. In truth, his cruelty appeared to increase as he approached the termination of his career. A premature report of his death caused a tumult in Jerusalem; and those who had been imprudently concerned in it were immediately seized, and put to death, by order of the dying king. He also caused his son Antipater to be slain in prison, and his remains to be treated with every species of insult and ignominy. Even on his death-bed, he had planned a scene of more atrocious cruelty than he had ever devised or attempted at any former period of his life. He summoned the most considerable persons among the Jews to Jericho, and caused them to be shut up in the hippodrome, or circus, and gave strict orders to have them all massacred, as soon as he should have expired. "This," said he, "will provide for my funeral all over the land, and make every family in the kingdom lament my death." Fortunately, however, this savage order was not executed by those to whom it was entrusted.

Herod expired in the sixty-eighth year of his age, and the thirty-fourth of his reign. He bequeathed his kingdom to his son Archelaus, and left tetrarchies to his two other sons. The character of this monarch exhibits a combination of great talents and great vices. The success which attended his enterprizes, and which shed a false though dazzling lustre around his government, has given him an eminent rank in the list of sovereigns; while the savage disposition, which appears to have taken delight in the most revolting and horrible acts of cruelty, has consigned his memory to merited detestation. He was the first, it may be remarked, who shook the foundations of the Jewish government. He appointed the high-priests and removed them at his pleasure, without any regard to the laws of succession; and he entirely destroyed the authority of the national council. In short, his reign was similar to that of most able tyrants; splendid and glorious to outward appearance, but, in reality, destructive of the prosperity of the kingdom over which he presided. See Josephus, Prideaux, Lardner; *Univers. Hist.*; and *Gen. Biog. Dict.* (z)

HERODOTUS, the most ancient of the Greek historians whose works are extant, and thence called by Cicero the Father of History, was born at Halicarnassus in Caria, in the first year of the 74th Olympiad, or about 484 years B C. The name of his father was Lyxes; that of his mother Dryo. The city of Halicarnassus being at that time oppressed by the tyranny of Lygdamis, grandson of Artemisia, Queen of Caria, Herodotus quitted his country, and retired to Samos; from whence he travelled over Egypt, Greece, Italy, &c. collecting every where all the information he could procure concerning the origin and history of nations. He then began to digest the materials he had thus collected, and composed that history which has preserved his name and reputation even to our times. He is generally supposed to have written it in the island of Samos, where he studied the Ionic dialect, in which his history is composed; his native dialect being the Doric. He afterwards revisited his native place, and is said to have greatly displeased and irritated his countrymen, in consequence of having contributed, by his influence, to the overthrow of the government, and the expulsion of the tyrant Lygdamis, which obliged him again to go into exile. When he had attained his thirty-ninth year, he was induced, by the desire of fame, to recite his history to the people assembled at the Olympic games. It was received with universal applause, and procured him a general and permanent celebrity throughout all the states of Greece. The place and period of his death are uncertain; but it is probable that he died in exile in a town of *Magna Græcia*.

The history of Herodotus embraces a period of about 240 years, from the time of Cyrus the Great to Xerxes; and contains, besides the transactions between Persia and Greece, a sketch of the affairs of other nations, as of the Lydians, Ionians, Lycians, Egyptians, and Macedonians. The work is divided into nine books, which are called after the nine muses, not by the historian himself, but, as it is thought, by the Greeks at the Olympic games, when they were first recited, as a compliment to the author.

As an historian, Herodotus has been generally censured for betraying too great a partiality for the marvellous. But it may be remarked in his justification, 1*mo*, That the truth of many of the physical phenomena which he relates, and which were considered as incredible prodigies by the ancient writers, has been abundantly confirmed by modern discoveries; and, 2*do*, That Herodotus compiled a great part of his history from popular traditions, and expressly cautions his readers against an implicit belief of many of the wonderful things he relates upon the authority of mere hearsay. And it is an argument much in favour of this ancient writer, that his chronology requires less correction, according to Newton's Canons, than that of any of the subsequent Greek historians. With respect to those great transactions which took place in Greece after his own birth, he is generally thought to be worthy of credit; and the publication of his work, at a general assembly of the nation, may be considered as a voucher for his veracity. He has, nevertheless, been suspected of partiality in particular instances; and Plutarch, the most formidable of his critics, wrote a small treatise *On the Malignity of Herodotus*, in which he expressly taxes him with injustice towards the Thebans and Corinthians, and, indeed, towards the Greeks in general. His history, however, is still accounted one of the most precious relics of antiquity. The greatest inconvenience attending the perusal of this historian, results from his method and arrangement, which are extremely awkward, irregular, and discursive; some entire histories being introduced, by way of parenthesis, in the bodies of others. His style is easy, graceful, flowing, and copious even to exuberance. Its chief excellence lies in narrative, as it seems to want force and conciseness for sentiment and remark, in which he is surpassed by Thucydides. Herodotus is esteemed the model of the Ionic, and Thucydides of the Attic dialect.

Besides this work, Herodotus is supposed to have written an history of Assyria; which, if it was ever published, (which seems doubtful,) is now lost. The life of Homer, which is usually printed at the end of his works, has also been ascribed to Herodotus; but the best critics are of opinion that it is the production of a different author.

The two best editions of Herodotus are that of Wesseling, fol. Amsterdam, 1763; and that of Glasgow, in 9 vols. 12mo. 1761. A very excellent edition of Herodotus, in Greek and Latin, was published in Edinburgh by Mr Laing, in 7 vols. 12mo. in the year 1806, corrected by Professor Porson and Professor Dunbar. The *editio princeps* is that of Aldus, Venet. fol. 1502. There are two English translations of this historian; the one by Littlebury, in 2 vols. 8vo. and the other by Mr Beloe, in 4 vols. 8vo. with many useful and entertaining remarks and annotations. There is also an excellent French translation, with very learned notes, by M. Larcher. The geography of Herodotus has been examined and explained by the ingenious Major Rennell, in one volume 4to, 1800. (z)

# HERPETOLOGY.

HERPETOLOGY, from ἑρπετος, *a reptile*, and λογος, a *discourse*, is that department of ZOOLOGY, in which is considered the natural history and economy of reptiles.

Under the term *Reptiles*, naturalists have generally comprehended all those tribes of oviparous animals commonly called AMPHIBIA, including both oviparous quadrupeds and serpents; and accordingly Linnæus has arranged both under this name in his third class of animals. See AMPHIBIA.

In the present article, we mean to confine ourselves entirely to the first order of amphibia, according to the latest modification of Linnæus's system, or the oviparous quadrupeds, to which the term *Reptilia* has, though improperly, been restricted by the writers of the Linnæan school. We shall reserve the history of the serpent tribes for the article OPHIOLOGY.

The animals, of which we are now to consider the structure, economy, habits, and manners, belong to the second great division of vertebral animals, as characterized in our *Comparative* ANATOMY, namely, those with a single heart and cold blood. They have all articulated members, though, in a few instances, especially in one stage of their existence, these are only two in number, and very short. Many of them have tails, which, in some species, serve the purpose of hands, in others that of a fin or rudder. Most of them walk, or leap, or both; many swim with facility; and a few species are capable of supporting themselves in the air for a time, so as to imitate the action of flying. In these animals, the cavities of the chest and belly are not separated from each other, as in quadrupeds, by a fleshy partition or midriff.

In the reptile tribes we observe two remarkable circumstances, which will presently occupy a considerable share of our attention. These are, the great tenacity of life which they possess, and the extraordinary degree of reproductive power that prevails in many of the species. Several of them support abstinence, and apparently total seclusion from atmospheric air, for a surprising length of time; and even their heads and hearts are capable of being excited to muscular action long after they have been separated from the body. Again, when deprived of some less important organ, as the tail, a limb, or an eye, this is in no long period reproduced.

Though called *amphibia*, they do not all live equally well on land and in the water. Some prefer the former, and some the latter element, and a few seem fitted indifferently for either.

The general appearance and habits of these animals are not very prepossessing. Few of them possess that elegance of form and brilliance of colour, which we so much admire in most of the birds and in many of the quadrupeds. Lurid in their aspect, clumsy in their mien, and awkward in their gait, they tend rather to excite our abhorrence and disgust; and though few of them can properly be said to be poisonous, several are, from their bulk and ferocity, just objects of terror even to the human race.

Those who are fond of illustrating the idea of a regular scale or chain of being among the works of nature, may find several connecting links among the reptile tribes. Thus the crocodile may be said to connect the *viviparous* and *oviparous* quadrupeds, as resembling, in external appearance, the genus *manis*, or scaly lizards; the turtles, especially those with soft coverings, may be regarded as connecting the *cetacea* and reptiles; the flying lizards, or *dragons*, may be said to form the link of connection between reptiles and *birds;* the *seps* and *chalcis* nearly resemble *serpents ;* and the *siren* is so very near the *fishes*, that some naturalists still enumerate it among the finny tribes.

It is scarcely possible to point out correctly how many species of reptiles are known to naturalists at the present day; especially as many are considered *species* by one writer, and only *varieties* by another. According to the latest edition of Linnæus's *System of Nature*, only 170 species were *then* known; but in the systematic work of a late French writer, Daudin, the distinct species enumerated or described exceed *three hundred*.

## HISTORY OF THE SCIENCE.

MANY of the reptiles are noticed in the oldest writings that have escaped the ravages of time, or the destructive ignorance of barbarians. Several are alluded to in the Sacred Scriptures; and we are clearly of opinion with Scheuchzer (*Natural History of the Book of Job**) and Dr Young, (*Notes on his Paraphrase on Job*,) that the sublime description of leviathan, given in the 41st chapter of the book of Job, applies to no other animal with which we are acquainted, if not to the crocodile. His ample jaws and dreadful teeth, his compact impenetrable scales, his large and fiery eyes, his strength, ferocity, and courage, agree exactly with our best descriptions of the crocodile; and though some passages might lead us to conclude that the poet was describing an inhabitant of the ocean, this objection is trivial, when we reflect that the large rivers and lakes, which form the ordinary habitation of crocodiles, might, in the glowing and figurative languages of the East, without too much hyperbolical exaggeration, be designated by the terms *deep* and *ocean*.

Of the ancient classic naturalists who have written on reptiles, we need mention only Aristotle and Pliny. The former, in his *Historia Animalium*, has described the crocodile, the salamander, and some other species; but the latter, in his *Historia Naturalis*, has furnished the fullest account of reptiles, especially in his second, eighth, ninth, tenth, and twenty-eighth books, in which he relates all that was then known, and all that was believed, respecting the crocodile, the sea and land tortoises, the chameleon, and the basilisk. In the second book, he shows himself acquainted with the fact, that reptiles are not destroyed by cutting off their limbs or tail; in the eighth, he mentions the spectacle of five living crocodiles exhibited by Scaurus, the edile, to the people of Rome; in the ninth, he describes the mode then practised in India for taking turtles; in the tenth, speaking of the crocodile, he tells us very gravely, that the male and female sit alternately on the eggs laid by the latter; and in the twenty-eighth, besides mentioning the utility of the skink, and several parts of the crocodile, as medicines, he details at considerable length the fabulous history of the chameleon.

* See his *Physica Sacra*, published in 1731.

Among the modern writers on natural history, Gesner, in part of his *Historia Animalium*, treats of oviparous quadrupeds, though the number which he describes is by no means very considerable. As usual with the writers of his time, he imitates the ancient naturalists in mingling truth with fable, especially in his second book, in which he describes the chameleon. In some respects, however, he is very judicious. He notices the wonderful tenacity of life in reptiles, and particularly exemplifies it in the heart of the salamander.

About the same time with Gesner, viz in the middle of the 16th century, lived Rondelet, a native of Languedoc in France; who, in his work on fishes, has described some species of turtles as having been seen by him upon the coast of France.

That laborious collector and compiler, Aldrovandi, in that portion of his works which is dedicated to quadrupeds, describes many reptiles, especially the tortoise, the crocodile, the chameleon, and the salamander; but as his accounts are derived almost entirely from preceding authors, and abound with marvellous fictions, they are now rarely consulted.

In that part of Johnston's *Historia Animalium* which s dedicated to *quadrupeds*, we have also an account of several reptiles, among others the crocodile and the chameleon.

In the latter end of the 17th century, Blasius published his *Anatomia Animalium figuris variis illustrata*, which contains some useful observations on the structure of reptiles. He particularly remarks the imperfection of their secreting organs. He also describes the manners of a tame tortoise which he kept, and its remarkable abstinence.

About the same time appeared Sibbald's *Prodromus Historiæ naturalis Scotiæ*, in which he describes some species of *turtles* as being found on the western coast of Scotland.

In 1685, Francis Redi published his *Experimenta circa Varias res Naturales*, and about the same time his Italian work on the same subject. The experiments which Redi made on various species of tortoise are sufficiently cruel; but they illustrate, in an eminent degree, the surprising tenacity of life possessed by these animals. They will be particularly noticed hereafter.

Our learned and scientific countryman, Ray, was the first naturalist who gave any thing like a rational account of reptiles, in his *Synopsis Animalium*. He describes more species of tortoise than were known before; and, besides the crocodile, enumerates several rare species of lizards.

The immortal Swedish naturalist, in his *Systema Naturæ*, divided the class of amphibia into four orders,—reptiles having feet, serpents without feet, gliding reptiles, (*meantes*,) and swimming reptiles, (*nantes*). As the last order was afterwards removed to the class of fishes, and some other important emendations were introduced into subsequent editions of that laborious work, we shall defer any observations on Linnæus's method till we notice his last and best editor, Gmelin.

In Seba's *Thesaurus Naturæ*, published about the middle of last century, a considerable number of the most remarkable reptiles is figured; and though the engravings are not in the first style, they give a sufficiently just idea of the objects which they represent.

All the British species then known are described, and some of them figured in the *British Zoology* of Pennant, published in 1749, in 4 vols. He particularly describes the coriaceous, or *leathern turtle*, as having been found on the British coast.

Mr Pennant also contributed some of the very few papers on reptiles to be found in the *Philosophical Transactions*, especially a description and figure of the *Testudo ferox*, or soft tortoise, and the *T. coriacea*, or leathern turtle. Some species are also noticed in his *Arctic Zoology*.

In 1755, professor Klein of Leipsic published his *Tentamen Erpetologiæ;* but as that work is confined chiefly to serpents, we cannot properly do more than notice it here.

In 1768, appeared the *Specimen Medicum exhibens Synopsin Reptilium* of Laurenti, in which a new arrangement of these animals was attempted. He distributes all reptiles (except tortoises, which he unaccountably omits altogether) into three orders,—*leaping reptiles*, *walking reptiles*, and *serpents*. Of the first order, he characterizes five genera, *Pipa*, *Bufo*, *Rana*, *Hyla*, and *Proteus;* and in his second order, thirteen genera, viz. *Triton Salamandra*, *Caudiverbera*, *Gecko*, *Chameleo*, *Iguana Basiliscus*, *Draco*, *Cordylus*, *Crocodilus*, *Scincus*, *Stellio*, *Seps*. Among the serpents he places the *Chalcides*, which certainly belong to the second as properly as the *Seps*.

Nine years after the "Specimen" of Laurenti, Scopoli published his *Introductio ad Historiam Naturalem*, in which he divides the reptiles into legitimate or true, and bastard or spurious reptiles, the latter term being applied to the cartilaginous fishes. The true reptiles, including serpents, he divides into two classes; the first containing the serpents, and the second the subjects of our present inquiry. This latter he subdivides into two orders. The first order comprises those reptiles that have tails, viz. the siren, lizards, dragons, and tortoises, including under lizards the crocodiles, iguanas, cordyli, salamanders, chameleons, and skinks. The second order contains only one genus, *Rana;* but this comprehends toads and tree frogs. The chalcides he ranks among the serpents.

In 1789, Professor Gmelin published his edition of Linnæus's *Systema Naturæ*. In this work, which, though little more than a compilation, reflects much credit on the industry and abilities of its author, the *amphibia* are divided into two orders, reptiles and serpents. The reptiles are characterized as being furnished with feet, respiring by means of lungs or gills, and having a simple penis.

Of the reptiles, he forms only four principal genera, viz. *Testudo*, *Draco*, *Lacerta*, and *Rana;* but most of these are subdivided. Of the tortoises, there are three subdivisions, *sea tortoises*, *fresh water tortoises*, and *land tortoises*. Of the genus *Lacerta*, there are eleven subgenera; *crocodiles*, *cordyli*, *stelliones*, *iguanas*, *salamanders*, *geckos*, *chameleons*, *ameivas*, *lizards*, *skinks*, and *chalcides*. Of the genus *Rana*, there are three subdivisions: *bufones*, or land toads; *ranæ*, or frogs; and *hylæ*, or tree frogs.

The principal defects of this arrangement are, the ranking the salamanders among the *Lacertæ*, from which, as will appear hereafter, they are separated by well marked characters; and omitting the *siren*, which Gmelin has placed in the genus *Murena*, among the fishes. For the small number of his species Gmelin is scarcely accountable, as many have been discovered since his time; and for the small number of his *genera*, his numerous subdivisions in a great measure compensate. It is of little consequence whether we call these *genera*, or *sub-genera*. The effect of the subdivisions in ascertaining the species is much the same; and this, added to their scientific accuracy, is one great merit of the French naturalists, whose writings we are presently to notice.

That part of Gmelin's work which comprises the *Animal Kingdom* has been translated, with some additional matter, by Dr. Turton, and published in four thick volumes 8vo.

In 1788 and 1790, the Count de Lacepede published his *Histoire Naturelle des Quadrupedes Ovipaires et Serpens.* This work had been projected by Buffon as a sequel to his Natural History, general and particular, and he had collected considerable materials towards its composition; but finding himself unable to pursue the arduous task, he deputed Lacepede to supply his place, and caused the materials to be put into his hands. The result shewed how ably Buffon had selected his successor; for, though since this work was published much additional information has been obtained, and many scientific improvements introduced into systematic Herpetology, the work of Lacepede will long be regarded as one of the most classical and elegant publications on this part of natural history.

The whole work is divided into two nearly equal parts, which may be considered as distinct and independent treatises, each being prefaced by a preliminary discourse. The first part, with which we alone are at present concerned, treats of oviparous quadrupeds; and these are classed under four géneral heads, tortoises, lizards, oviparous quadrupeds without tails, and two-footed reptiles, each being more or less subdivided. The tortoises have only two subdivisions: 1st, *Sea tortoises*, of which six species are described; and 2d, *Fresh water* and *land tortoises*, of which there are twenty species noticed. The lizards are divided into, 1st, Those which have flat tails, and five toes before, including four species of crocodile, the dragon, tupinambis, and five other species; 2d, Those which have round tails, five toes before, and a crested back, comprehending the guana, the basilisk, the agama, and three other species; 3d, Those that have round tails, five toes before, and fillets on the belly, containing eight species, among which are the cordylus and ameiva; 4th, Those that have five toes before, but no transverse bands on the belly, including the chameleon, the skink, and twenty other species; 5th, Those having large imbricated scales on the under surface of the toes, containing the geckos and two other analogous species; 6th, Those that have only three or four toes, to which belong the seps and chalcides; 7th, Those that have membranous wings, the dragon or flying lizard; 8th, Those which have three or four toes on each fore foot, and four or five on each hind foot, including the salamander, ask, and four others.

Of the oviparous quadrupeds without tails, there are three subdivisions: 1st, Frogs having their heads and bodies angular and elongated, of which there are thirteen species; 2d, Tree frogs, having a small viscous pellet under each toe, comprehending seven species; 3d, Toads with compact rounded bodies, of which there are fourteen species, including the pipa, or Surinam toad. The last head, which is not subdivided, contains only two species.

This work of M. Lacepede was translated into English by Mr Kerr, and published at Edinburgh in 4 vols. 8vo. in 1802.

In 1792 was published at Erlang, the *Historia Testudinum* of J. D. Schoepff, an excellent work, left imperfect by the death of its ingenious author.

We must not here omit to notice two ingenious publications in Latin on the physiology of reptiles, by Dr Robert Townson: 1st, *De Amphibiis*, published at Gottingen in 1794: and 2d, *Observationes Physiologicæ de Respiratione Amphibiorum*, published at Vienna in 1796.

According to Daudin, the most natural classification of reptiles that has yet appeared is that of M. Alexandre Brongniart, published in 1799 in the *Magazin Encyclopedique*. As we shall fully explain this classification, after having noticed the principal naturalists who have adopted and modified it, we shall here merely give an outline of this author's subdivisions. He distributes all reptiles under four general orders: *Cheloniens*, or tortoises, of which he makes two genera, *Chelonia* and *Testudo*, corresponding exactly thus far with the division of Lacepede; 2d, *Sauriens*, of which there are nine genera, viz. *Crocodilus*, *Iguana*, *Draco*, *Stellio*, *Gecko*, *Chameleo*, *Lacerta*, *Scincus*, and *Chalcides*; 3d, *Ophidiens*, or serpents; and 4th, *Batraciens*, of which there are four genera, *Rana*, *Bufo*, *Hyla*, and *Salamandra*.

At the very commencement of the present century, M. Latreille published *L'Histoire Naturelle des Reptiles*, the arrangement of which differs little from that of Lacepede, except in placing the Salamander under the same head with the frogs and toads, and a species of Proteus, which appears to be a tadpole of the water salamander, and the Siren, among the serpents. His generic characters, however, are more precise than those of Lacepede; but his method, on the whole, is inferior to that of Brongniart. M. Latreille also published *L'Histoire Naturelle des Salamandres*.

Between the years 1800 and 1803, the celebrated anatomist and naturalist Cuvier, and his disciple and assistant Dumeril, published his *Leçons Anatomie Comparée*, in 5 vols. 8vo. with 52 plates at the end of the fifth volume. Cuvier had, in 1798, published an elementary work on natural history, under the title of *Tableau Elementaire de l'Histoire Naturelle des Animaux*, in which he gave a general description of reptiles.

Attached to the first volume of his Lectures, Cuvier has given a systematic arrangement of the various classes and orders of animals; and in the classification of reptiles, he has adopted an arrangement radically the same with that of Brongniart. In the first place, he divides reptiles into two sections; 1st, Those which have two auricles to the heart; 2d, Those that have but one. Each of these sections is subdivided into two orders. The first order consists of those reptiles that have a shell or carapace, and their jaws defended by horn. These are the *cheloniens*, or tortoises. The second order consists of those that have the body covered with scales, and are furnished with teeth, like the *sauriens*, or lizards, the genera of which are, with the addition of seps, the same with those of Brongniart. The first order of the second section contains the serpents. The second order comprehends those reptiles that have a naked skin, feet, and gills, at an early stage of their existence. Of this order (the Batraciens) there are three families; *Rana*, or frog, including the three subgenera of *Rana*, *Hyla*, and *Bufo*; *Salamandra*, including the sub-genera of *Salamandra* and *Triton*; and *Siren*.

These excellent Lectures contain a very full account of the anatomical structure and physiology of reptiles, and to them we are almost entirely indebted for our chapters on that subject. The first two volumes of this work were translated into English under the inspection of Mr Macartney, lecturer on comparative anatomy in London, and published there in 1801.

In 1800, Dr George Shaw began his *General Zoology*, which was intended to include all the genera and species of animals at present known. The third volume contains the reptiles and serpents. In giving our opinion of this extensive work, we are somewhat at a loss. As a systematic arrangement of animals, it is very defective, and the references to other authors are extremely few. As a popular descriptive work, it is scarcely deserving our attention; for, though almost all the species are described, as well as figured, there is scarcely any thing like a history of the species. The arrangement is that of Linnæus, and the characters are in general derived from Gmelin's edition of the *Systema Naturæ.* The work, however, abounds in excellent plates, the figures of which are in general well delineated, and beautifully engraved.

We need scarcely mention the *Naturalist's Miscellany* of the same author, as but few reptiles are there figured.

Perhaps the most complete account of reptiles, up to the present day, has been given by M. Daudin, who has long devoted most of his attention to this part of zoology, and has published several treatises on the subject. Besides his *Histoire Naturelle des Reptiles*, published separately, and the sequel of the same work, entitled *Histoire Naturelle des Rainettes des Grenouilles, et des Crapauds*, he has contributed eight volumes octavo, with numerous plates, to the voluminous and expensive collection of natural history published by Sonnini. These volumes were published at different times, from 1802 to 1805. The first volume contains some historical notices of several writers on Herpetology, and a copious introductory treatise on the structure and physiology of reptiles, illustrated by fifteen plates. The second volume contains the natural history of the Chelonian order, in which are described fifty-seven species of *tortoise;* and the same volume commences the history of the Saurian order, and describes seven species of *crocodile.* In the third and fourth volumes, the history of the Saurian order is completed, by a description of one species of *Dracæna*, fourteen of *Tupinambis*, thirty-two of *Lacerta*, two of *Takydromus*, three of *Iguano*, three of *Draco*, two of *Basiliscus*, twenty-five of *Agama*, nine of *Stellio*, eight of *Anolis*, fifteen of *Gecko*, four of *Chamæleo*, twenty-one of *Scincus*, six of *Seps*, and four of *Chalcides.* The fifth, sixth, and seventh volumes are occupied with the Ophidian order, or *serpents*, and the eighth completes the work with the history of the Batracian order, containing a description of twenty-seven species of *Hyla*, sixteen species of *Rana*, thirty-two of *Bufo*, fourteen of *Salamandra*, one of *Proteus*, and one of *Siren.* The specific characters in the body of the work are in Latin; but, at the end of the eighth volume, the whole genera and species are arranged together, with their characters in French, under the title of *Tableau Methodique des Reptiles.*

Daudin's Natural History of Reptiles has considerably increased the number of species, and has brought us acquainted with many that were either not known before, or whose place in the systematic arrangement had not been distinctly ascertained. Though the matter of this work is excellent, we cannot, however, say so much for the execution of the plates. The figures are in general so deeply shaded, as to render it difficult to observe the characteristic lines, scales, and dots, that distinguish the species.

Dumeril, whom we have already noticed as the assistant of Cuvier, has published two works on natural history, which contain, among other animals, the new systematic arrangement of reptiles. These are, *Zoologie Analytique*, published in 1806, and *Traité Elementaire d'Histoire Naturelle*, in two volumes, of which the second contains the animal kingdom. His arrangement is so near that of the other distinguished naturalists of the French school, that we need not detail it here, especially as we have already given a summary view of it under the article Amphibia.

We might have extended these historical notices to a much greater length; but we consider it unnecessary. We have given a succinct account of the principal writings on Herpetology, and shall now conclude this Part of our subject with a list of other works, to which the reader may refer for additional information.

On the anatomy, physiology, and classification of reptiles, see Swammerdam, *Biblia Naturæ;* Rœsel, *Historia Naturalis Ranarum;* Schneider, *Amphibiorum Physiologiæ Specimen;* and his *Historia Amphibiorum;* Caldesi, *Osservazioni Anatomiche intorno alle Tartarughe;* Spallanzani, *De Fenomini della Circolatione;* his *Tracts on the Natural History of Animals and Vegetables;* and his *Memoires sur la Respiration*, lately publisned by Sennebier; Blumenbach, *Abbildungen Natur Historischer gigenstande;* and his *Handbuch*, or manual of the same subject; Schmid, *Historia Testudinum;* Daubenton, *Dictionaire d'Erpetologie*, forming a part of *L'Encyclopedie Methodique;* Perault, *Memoires pour servir à l'Histoire Naturelle des Animaux;* Humboldt, *Recueil d'Observations de Zoologie et d'Anatomie comparée;* Walbaum, *Chelonographia;* the compendious System of Comparative Anatomy translated from Blumenbach, with much additional information from Cuvier, and lately published by Mr Lawrence; Ellis's *Inquiry into the changes produced in Atmospheric Air by Respiration, &c.;* several papers by Cuvier, Geoffroy, Daudin, Lacepede, &c. in the *Annales de Museum d'Histoire Naturelle*, more particularly in the 2d, 10th, 12th, and 14th volumes, and a single paper by Mr Revet Sheppard on the British lizards, in the seventh volume of the *Linnean Transactions.*

On the history and manners of the species, much interesting information may be derived from Sloane's *Natural History of Jamaica, Barbadoes, &c.;* Brown's *Natural and Civil History of Jamaica;* Catesby's *Natural history of Carolina;* Russel's *Natural History of Aleppo;* White's *Natural History of Selborne;* Cetti, *Storia Naturale della Sardegna*, or his *Historia Amphibiorum et Piscium Sardiniæ;* Bingley's *Animal Biography*, vol. iii.; Forskal, *Fauna Arabica*; and the Voyages or Travels of Hasselquist, Bruce, Sonnini, Olivier, Cook, Stedman, Bartram, Denon, Barrow, Marchand, &c.

Before commencing our account of the structure and economy of reptiles, it is necessary, in order to render that account intelligible, that we should here give a comprehensive view of the arrangement which we mean to follow in the Second Part of this article.

On carefully comparing the various arrangements of reptiles which have been adopted by modern naturalists, we are disposed to prefer that of the French school, though we think it unnecessary to carry the subdivision of the genera so far as has been done by Dumeril and some of his associates.

Exclusive then of the serpents, which, as we have seen, constitute the third order in this new arrangement, the reptile tribes are distributed into three orders, Chelonians, Saurians, and Batracians.

The Chelonians have a short, thick, oval body, covered with a horny shell or membranaceous coat. The upper or *dorsal* part of this is called the *shield*, and is formed of the vertebræ and ribs, cemented together within or beneath the outer covering; and the lower or *sternal* part is called the *breastplate.* The head is supported by a pretty long neck, and the mouth is furnished with two mandibles, generally resembling the bill of a bird. These tribes are in general slow in motion, possess little sensibility, and have a languid circulation and slow respiration. They live chiefly on vegetables. They generate by copulation, in which act they remain for several days. Their eggs are covered with a shell, and are deposited by the female in the sand, or among loose earth or gravel. The young are hatched in the form which they are to preserve through life.

The Chelonian order is divided by Dumeril into four genera, *Chelonia*, *Emys*, *Chelys*, and *Testudo;* but as the third of these comprehends only one species, and the second is distinguished from the fourth only by a few minute differences, we shall continue the division of Cuvier into two genera, *Chelonia* and *Testudo;* the former comprehending the sea tortoises, or turtles, which have the articulated members in the form rather of swimming paws than feet; and the latter, or the tortoises, having feet more or less digitated, and furnished with distinct claws.

The Saurians, or lizards, have a lengthened scaly body, feet armed with claws; a tail that is often of considerable length, and the jaws beset with teeth. Their legs are in general short; and consequently their pace, though quicker than that of the former order, is slower than that of most quadrupeds; and as their legs are set wide from the body, their progress is unsteady and oblique. The reptiles of this order also copulate, and deposit their eggs to be hatched by chance. The young are extruded in a perfect state.

Of the Saurian order, Daudin reckons sixteen genera, which we shall divide, with Dumeril, into two Sections, *Plani caudata*, or flat tailed, and *Tereticaudata*, or round tailed. Of the flat-tailed Saurians we have four genera: *Crocodilus*, having a flattened head, the scales on the back of unequal size, and the hind feet palmated; *Dracæna*, having a square head, and toes distinct; *Basiliscus*, having equal dorsal scales and a crested ridge along the back, supported by bony rays; and *Tupinambis*, having equal scales but no dorsal ridge. Of the round-tailed section there are twelve genera, viz. *Iguana*, having a crest on the back, and a serrated crest on the throat; *Draco*, having the sides furnished with membranes resembling wings; *Agama*, having an oblong scaly body and tail, an inflated throat, and the feet long and thin, each furnished with five slender separate toes; *Stellio*, having a spinous tail covered with carinated scales; *Chameleo*, having feet formed for climbing; *Gecko*, having a thick body, and a throat capable of being dilated by inflation; *Anolis*, having a long thin body, and dilatable throat; *Lacerta*, having a plated head, but no inflation of the throat; *Takydromus*, having the body long and thin, and a row of very small granular pores along each thigh; *Scincus*, having a long scaly body and tail, and distinct legs; *Seps* and *Chalcides*, agreeing in having a very long and slender body, with either two or four very small short feet, and differing in some minute particulars, which will be noticed hereafter.

In the third order, Batracians, the body is naked, *i. e.* covered neither with shell nor scales; the feet are always distinct and without claws; the two sexes do not enter into perfect copulation, and the young undergo a metamorphosis.

This order is subdivided into two sections, those without tails, and those with tails, and in each of these sections are reckoned three genera.

The genera of the Batracians without tails are *Hyla*, or tree-frog, having a long body a little compressed; a short fleshy tongue; four toes on the fore feet, terminated by lenticular knobs; *Rana*, or frog, differing from the former in having the toes pointed and not knobbed; and *Bufo*, or toad, having a thick broad body beset with warty tubercles, especially two upon the neck. The genera belonging to the second section are *Salamandra*, having a long body terminated by a tail that is generally cylindrical, three or four toes on the fore feet, and five on the hind; *Proteus*, having a long body terminated by a compressed fin-like tail, three toes on the fore feet, and two on the hind, with persistent branchiæ; and *Siren*, having a lengthened body, a compressed fin-like tail, fore feet furnished with claws, but no hind feet and persistent branchiæ.

## Part I. ON THE ANATOMY AND PHYSIOLOGY OF REPTILES.

Having now given a general description of reptiles, and explained the classification which we intend to follow in the subsequent pages; we shall proceed to exhibit a comprehensive view of their anatomy and physiology, pursuing the same order which we have observed in the comparative part of our Anatomy.

### CHAP. I.

#### *Of the Motions of Reptiles.*

The organs of motion in reptiles, do not differ so much from those of quadrupeds as some other parts of their organical structure, though there is considerable variety in the several tribes of this class.

The bones of most species are as firm as those of quadrupeds; but in the smaller reptiles, as the frogs, they are more cartilaginous. It is asserted by some naturalists, that the bones of tortoises have no medullary cavities; but in the larger lizards, these are sufficiently apparent. The skeleton of a Saurian reptile is figured in Plate CCXCV. Fig. 1.

The skull of reptiles is generally very small in proportion to the body; but in many species, the jaws are proportionally very large. The cavity of the skull is either exceedingly small, or not half filled by the brain. A remarkable change takes place in the head of the crocodile, in proportion as the animal advances in growth after its extrusion from the shell. When first hatched, the skull is thick and rounded, and the forehead prominent, and the eyes are nearly at an equal distance between the fore and back parts of the head. In proportion as the animal grows, the frontal prominence gradually disappears, and the jaws lengthen forwards; and in the adult state, the head is quite flat, and the eyes three times as far distant from the snout as they are from the back of the head.

The skull of the crocodile resembles a truncated pyramid, of which the cavity for the brain forms the base; that of frogs and salamanders is of a form between the cylindrical and the prismatic; that of tortoises considerably resembles that of the crocodile. The cavity of the skull, in reptiles, is of an oblong form, and nearly of an equal breadth. Of the jaws and teeth, we shall speak under the organs of digestion.

With respect to the vertebral column, we may remark, that the number and proportions of its component vertebræ vary more in this class than in all the other vertebral animals. The tortoises have generally seven vertebræ in the neck, from eight to eleven in the back, and generally three or four in the sacrum. In this genus all the vertebræ, except those of the neck and tail, are immoveably fixed with what is analogous to ribs, in the horny shield with which they are covered. The crocodile has seven cervical, twelve dorsal, five lumbar, two sacral, and thirty-four caudal vertebræ; but in the other saurians, the proportional numbers vary in almost every species. Frogs and toads having no ribs, the ordinary division of the vertebral column cannot be distinctly made. The common frog has in all ten vertebræ, and the pipa, or Surinam toad, has in all eight.

The muscles attached to the spine also vary considerably. In tortoises, where only the head and tail are moveable, the spinal muscles are confined chiefly to these two organs, and those of the neck possess many peculiarities. The chief motions of the neck in this genus are those by which the head is thrust out from the shell, and drawn back within it. The spinal muscles of frogs and salamanders are few in number, except that, in the latter, the crocodiles, and other saurians, the muscles of the tail are proportionally numerous and powerful.

The thorax is very differently formed in the different orders. In the tortoises, the sternum or breast bone is lost in the breast plate or lower shell, while the ribs are, as we have said, firmly cemented in the shield. Of the saurians, the crocodile has the anterior part of the sternum bony and prolonged, so as to receive the clavicles; while the rest is cartilaginous, and extends backward to the pubis, furnishing eight cylindrical cartilages that surround the belly. The ribs of this animal are twelve in number; but the two most atlantal or forward, and the two most sacral or backward, are not united to the sternum. In the guana and tupinambis, only six of the ribs are united to the sternum. The chameleon has a small sternum, but all the ribs are made to meet round the thorax, by means of intermediate cartilages. In the salamanders the ribs are extremely short, so as to appear like appendages of the vertebræ. The frogs have a sternum, though no ribs.

In most of the reptiles, there is little peculiar in the muscles of the thorax and abdomen. In the tortoises, however, where the ribs are immoveable, and where the place of abdominal muscles is supplied by the breast plate, the muscles which would be attached to the sternum are inserted into the pelvis, upon which they act; and in frogs, which have no ribs, the muscles are united to the sternum by strong membranes.

The superficial or glenoid cavity, in which the humerus or large bone of the atlantal or anterior extremity moves, is in reptiles formed partly by the scapula, and partly by the clavicle. The scapula has no spine; it is elongated, and retracts and becomes thicker towards its neck. The clavicle is simple, short, and flat. In tortoises, the disposition of the bones that form the shoulder is most remarkable, and is thus described by Cuvier. Besides the scapula and the clavicle, there is a bone which he calls the *fork;* one of the bones stretches from the base of the rudiment of the first rib, to which it is attached by a ligament as high as the glenoid cavity, where it is intimately united with the other two. The second bone, which appears like the continuation of the former, is attached by its other exteremity to the breast plate, and this extremity is bound by strong ligaments to that of the bone behind it. These bones thus united are slightly curved outward, so as to leave between them and those on the opposite side an oval space, for the passage of the gullet, the windpipe, and numerous muscles. Lastly, the third bone is placed below the abdominal and thoracic viscera, nearest the breast plate, and is extended from the glenoid cavity as far as the abdomen. It gives attachment to numerous muscles, and resembles the scapula in every thing but situation. See Cuvier, *Leçons d'Anat. Comparée*, Sec. IV.

The humerus presents nothing remarkable, except in the tortoises, where it is united, somewhat in the manner of birds, with the scapula, the clavicle, and the fork.

In the tortoise tribes, numerous and strong muscles are attached to the humerus; while in frogs many of the muscles which are found in this region in quadrupeds are wanting.

The distal part of the atlantal extremity, or what comparative anatomists chuse to call the fore-arm, consists, as in quadrupeds, of two bones, except in the frog and toad. These are analogous to the radius and ulna, but have several peculiarities of structure. In particular, the tortoises have them so fixed in a state of pronation, as to confine the action of these extremities to swimming.

What is called the hand or paw is in reptiles considerably varied. In the sea turtles or chelonians, it is whole without, though consisting within of many separate bones. In the saurians it is digitated, and consists in some species of five divisions, in others of four, three, and even one: these toes are generally furnished with claws. These digitated paws, according to the number, length, and armour of their divisions, are adapted to the various actions of walking, climbing, grasping, and seizing, or tearing prey.

The pelvis, and especially that part of it which corresponds to the pubis, is of considerable size, and it is extraordinary, that in these animals the pelvis is moveable on the vertebral column.

The thigh bone of reptiles is similar to that of other animals, except that it has a double curvature, more or less remarkable, presenting a convexity forward towards the tibial or distal extremity, and a concavity towards the pelvis. In the tortoises it has well marked trochanters; but these are wanting in lizards and frogs. It is generally round, except in the Surinam toad, in which it is much flattened. There are few peculiarities in the muscles of this region.

The leg is composed of a tibia and fibula, distinct throughout their whole length, except in frogs, in which they are united. When separate, they are nearly of equal size, and in general are articulated immediately with the thigh bone. The muscles of the leg are most remarkable in the turtles and frogs. In the former, they are adapted to the act of swimming; in the latter, they form a prominence behind, resembling the calf of the leg in man. The bones and muscles of the hinder feet are in most cases similar to those of the paws.*

From the very different form and position of the limbs of reptiles, their progressive motions, and even their mode of standing, vary considerably in the different tribes and species. In standing, turtles rest as much on their breast-plate as on their paws, while the land tortoises stand with their belly a little above the ground. The *batracians*, and especially frogs, rest in a kind of sitting posture, with the fore part of their body elevated on the fore legs. Those lizards, whose bodies resemble those of serpents, as the *chalcides*, are coiled up in a state of rest.

The turtles rather scramble than walk, like seals; but tortoises walk well, though slowly. Some saurians move along with great agility, while others, as the crocodile, have a comparatively slow progression. Few reptiles climb well, if we except the chameleon, which is much assisted by its prehensile tail. The guanas and tupinambes are the best leapers among the saurians; and frogs and toads, though they cannot walk well, are excellent jumpers.

A great variety of reptiles swim well, especially turtles, crocodiles, and frogs. The only species that can be said to fly is the dragon, whose motion through the air resembles that of the flying squirrels.

* In the twelfth volume of the *Annales de Museum*, is an elaborate Memoir by Cuvier on the Osteology of the crocodile, to which we refer the reader for details, which it would be inconsistent with our plan to introduce in this place.

## CHAP. II.

### *Of Sensation in Reptiles.*

As the cavity of the cranium in reptiles is very small, and not nearly filled by the brain, it follows that the size of this organ is very inconsiderable. It is calculated that, in the turtle, the brain is little larger than $\frac{1}{5000}$ part of the whole body, though in the frog it is proportionally much larger, being as 1 to 172. It consists chiefly of five rounded eminences, without convolutions, and with a smooth base. There is no *corpus callosum*, *fornix*, *pons varioli*, or *arbor vitæ*; and what are called the *thalami* of the optic nerves, are situated behind the hemispheres. The distribution of the nerves in the head has no remarkable peculiarities.

The number of spinal nerves in the different orders and tribes of reptiles, is proportional to the number of vertebræ of which the spinal column is composed, and their distribution is so little different from that in man and quadrupeds, that it need not be here described. The nerves of the atlantal, or fore legs, are derived from the cervical nerves, and sometimes the dorsal, uniting to form a brachial plexus or net-work. Those of tortoises are extremely complex; those of lizards more simple; and those of frogs proceed from a very thick cord coming from between the second and third vertebræ, and forming the largest nerve in the body.

The nerves of the sacral extremity in lizards, after emerging from the pelvis, form a single cord, which runs down the inside of the thigh, and thence supplies the leg and toes. In frogs this large cord passes to the posterior part of the thigh, like the sciatic nerve in man.

It appears that reptiles possess all the five senses found in the other vertebral animals, though in very different proportions and degrees. Their sight appears to be very acute, and their eyes are in general large and prominent. The sense of hearing, if we may judge from their want of external ears, is much less perfect than that of sight. Their smelling is supposed, for a similar reason, and from the little use they appear to make of this sense in seeking their food, to be still less acute; and it is doubted whether many of them possess the faculty of tasting at all. With respect to touch, it is probable that those which have soft skins and digitated feet possess considerable acuteness in that sense; while those which have scaly, shelly, or coriaceous coverings, and more especially the turtles, are capable of exercising touch in a very slight degree, if at all. We shall examine the organs of all these senses in the order which we have laid down in the article ANATOMY, and exemplified in CETOLOGY, except that we shall defer the organs of feeling, if they deserve that name, to the head of *Integumation*.

All reptiles appear to possess a tongue, but it varies much in substance and degree of mobility. In the tortoises, it is covered on the upper part with long soft close papillæ, giving it the appearance of velvet. In crocodiles, these papillæ are extremely short, and more like wrinkles. In these animals it is entirely fleshy, but is so completely attached by the point and edges to the basilar or lower jaw, as to admit of scarcely any motion; and it was long doubted whether crocodiles had a tongue. In stelliones, again, it is very moveable; and in the common lizards, and the tupinambes, it it considerably extensile. In these latter reptiles, the tongue terminates in two long flexible cartilaginous points; and in the skinks and geckos it is notched at the tip.

The tongue of salamanders is rough with papillæ, but that of frogs and toads has a smooth slimy surface. The chameleon has the tongue of a cylindrical form, covered on its surface with deep regular transverse furrows; and it is so constructed, as to be easily thrust out of the mouth, to collect the proper food of the animal.

The organs of smelling are imperfect, and consist chiefly of cavities opening in front of the snout, and communicating backward with the mouth, lined, like the nostrils of *mammalia*, with a pituitary membrane, for the ramification of the nerves. This membrane is in several species divided into several folds, supported by bony plates. Tortoises have three of these. The external nostrils are furnished with muscular fibres, by which they may be occasionally contracted and dilated. The nostrils are very close together in crocodiles, while in some of the other saurians, as the tupinambes, stelliones, and chameleons, they are more apart and lateral. In the tortoises, they are very small and close together; and they are also extremely small in salamanders. In short, from the small extent of the nasal cavities in reptiles, compared with those in quadrupeds, it appears that they are rather organs of respiration than of smelling.

These animals have, as we before hinted, no auricles or external ears, though their internal organs of hearing are sufficiently apparent. These consist of a tympanum, (except in the salamander,) and a labyrinth, with their attending bones and cavities. In turtles the membrane of the tympanum is cartilaginous, and covered externally by the integuments. The tympanum contains only a single little bone, and from it proceeds a Eustachian tube. In this order there are semicircular canals. The saurians, with the exception of the salamander, have the same parts, and several little bones, besides several soft stony substances in the vestibule. The crocodile is the only instance among reptiles, in which there is any appearance of external passage to the organ of hearing. The batracians, especially frogs, have a large membrane of the tympanum, level with the surface of the body. The tympanum contains two cartilaginous ossicles, and has a wide opening of the Eustachian tube next the throat. The vestibule contains rudiments of those soft stony substances just mentioned as occurring in the saurians. In the salamander, the vestibule contains one of these stony bodies, and the oval hole leading to the labyrinth is closed by cartilage. In general, the vestibule and membranous canals in these animals are much smaller than the bony or cartilaginous cavities in which they are contained.

There is, we believe, only one instance in reptiles where the eyes appear of little use. This is in that singular species, the *proteus*, in which the eyeballs are so covered with the integuments, as not to be visible till these have been removed.

In the tortoise tribes there is a bony ring, composed of thin plates at the anterior part of the sclerotic coat; and a similar structure occurs in frogs, chameleons, the guana, and some other saurians. The iris is variously coloured, but generally yellow, red, or brown. The pupil varies in figure. In the crocodile it resembles that of the cat, being vertically oblong; in frogs and geckos it is rhomboidal; and in tortoises, the chameleon, and common lizards, it is round. The crystalline lens resembles that of fishes in its spheroidal figure.

Besides the two eye-lids common to reptiles, and the superior classes of animals, the former have, like birds, a third, or nictitating membrane, which is vertical in tortoises and crocodiles, but horizontal in frogs. In the crocodile there is a bony substance in the upper eye-lid. In the common lizards, instead of eye-lids, there is a kind of circular veil extended before the eye, with a sphincter muscle, by which it may be closed.

There is considerable variety among reptiles with respect to the lachrymal gland. Turtles have it very large, and situated at the lateral or posterior angle. In the fresh water tortoises again, as well as in frogs and toads, there are two small, blackish glands.

Thus it appears that the eyes of reptiles are well adapted to perfect vision, and provided with ample defence against the too stimulating power of the rays of light. It is well known that many of them are very quick in perceiving their prey; and some species, as the green lizard and green frog, appear extremely fond of the brightest light. Some few, however, shun the day-light, and seek their prey chiefly by night, having for this purpose the power of contracting or dilating the pupil in a very considerable degree. It is said that the chameleon can move both eyes at once, in different directions, a circumstance scarcely noticed in any other animal.

The general phenomena respecting the nervous system of reptiles, and the influence of the brain on the other organic functions, cannot properly be considered till these functions shall have been examined. The remarkable tenacity of life in reptiles, their great reproductive power, and the phenomena of the torpid state which they undergo, all of which are more or less connected with the nervous system, must also be deferred till we have treated of the functions of circulation and respiration.

## CHAP. III.

### *Of Digestion in Reptiles.*

Digestion in reptiles is divisible into what we may call prehension, deglutition, and digestion, properly so called.* We shall here consider the organs and phenomena of these functions, in the order in which we have named them.

We have seen that the mouth of the *chelonians* is furnished with mandibles. These close over each other somewhat like the parts of a box, and frequently have their edges so deeply indented, as to have led to the mistake that some tortoises have teeth. The horny part of the mandibles is connected with the bony jaw, nearly in the same manner in which the hoof of the horse is united to the coffin bone. (See Mammalia and Veterinary Medicine.) In the upper jaw there is an intermaxillary bone. The lower jaw is articulated with the skull, by means of a bony eminence of the latter. The lower jaw only is moveable, and its motion consists of little more than opening and shutting the mouth. Many of this order possess great strength in the jaws.

The jaws, in many of the *Saurians*, especially in the crocodile tribe, are of very considerable length, and, in most instances, beset with numerous strong and sharp teeth. In most of the species, the lower jaw is moveable on the upper, in the usual manner; but in the crocodile there is a peculiarity in this articulation which merits particular notice, especially as it has been made a subject of dispute among naturalists from the earliest ages.

Herodotus was, we believe, the first to assert, that the upper jaw of the crocodile was moveable on the lower, which he supposed to be fixed. This opinion was followed by Aristotle and Pliny, and of course by the earlier modern naturalists, who copied from them. Of late, this general ancient opinion of the mobility of the upper jaw has been warmly called in question; and some of the French academicians believed they had demonstrated its absurdity. The more recent observations of M. Geoffroy, however, shew that the ancient supposition was wrong only so far as respects the lower jaw, as, in fact, both the jaws are moveable on each other. This peculiar articulation is well illustrated by Fig. 3. of Plate CCXCV. from which it appears, that the posterior extremities of the lateral branches of the upper jaw-bone are received into hollows in the lower, so as to admit of free and extensive motion. See *Annales du Muséum*, tom. ii. p. 39.

We are not, however, to suppose, that the upper jaw of the crocodile moves upon the cranium. The fact is, that the cranium is very small, and is so fixed within the branches of the upper jaw-bone, as to move along with this latter: the articulation of the two jaws being behind the cranium. None of the other *Saurians* have the maxillary articulation similar to that in the crocodile; but in many the length of the jaws, and consequently the opening of the mouth, is very considerable. The lower jaw in most of these animals is very complex, consisting of from eight to twelve pieces. In the *Batracian* order it is also complex, consisting generally of six pieces.

That part of the jaws which corresponds to the snout, has a very different degree of rotundity in the several orders of reptiles. It is most obtuse in the *Batracians;* less so, though still considerably rounded, in the *Chelonians;* while in the *Saurians*, the angle formed by the meeting of the branches of the jaw is generally very acute.

The muscles attached to the jaws are most powerful in the *Chelonians* and *Saurians*. In the former, the temporal muscles are the strongest; while in the latter, the digastric and the masseter appear most prominent. The force with which some turtles close the jaws is astonishing. It is even asserted, that when once closed with violence, it is impossible to open them; and that even when the head is cut off, the contraction of the muscles continues to act for many hours. A turtle has been known to tear asunder a large rope, by means of the indentations in its mandibles.

All the *Saurians* have teeth in both jaws, and in the *Guana* there are besides teeth set in the palate. All these teeth resemble the cutting and pointed teeth of the predacious quadrupeds, and seem entirely adapted to seizing and retaining prey. The number of teeth is seldom constant in the same species, and evidently depends on the age of the animal.

Among the *Batracians*, the frogs have teeth only in the upper jaw; salamanders have them in both; but toads have teeth in neither jaw. All these tribes, however, have them in the palate. The siren has teeth attached to the inner surface of the jaws.

*The organs of deglutition* in reptiles have a considerable variety in point of structure. We have already briefly noticed the tongue under the organs of sensation, but must here treat of that organ and its appendages at greater length.

In the *Chelonians*, the tongue is small and pyramidal, with the base turned backwards, and the point forwards. The *os hyoides*, or bone of the tongue, varies in different species. It is more or less cartilaginous.

The mechanism of the tongue in the Chameleon is extremely curious. The tongue itself is not larger than a goose quill, but is five or six inches long, growing broader towards its extremity, where it is covered with a glutinous matter. In the usual state of the animal, this organ lies within a sheath at the bottom of the mouth, and is so contracted as to appear not more than an inch in length; but when the animal is in search of prey, the tongue is, by peculiar muscles, darted out to the length we have de-

* Properly speaking there is no mastication in reptiles, and the jaws and teeth are used entirely for seizing and holding their prey. We have therefore taken the liberty of borrowing a word from the Latin, and have called this action *prehension*.

scribed, and catching the insects on which the chameleon feeds, by means of its glutinous secretion, is again withdrawn into the mouth.

In many of the reptiles, the tongue is composed chiefly of a thick glandular mass, formed of a great number of small pipes, united towards the base, and diverging towards the surface of the tongue. In fact, in these cases the tongue forms a salivary gland, and the same saliva prepared in it is poured out by numerous orifices along the sides of the organ. This is particularly the case in the *Chelonians*, and many of the *Saurians*; and a similar structure, though to a less extent, prevails in the *Batracians*.

In those reptiles that have a scaly tongue, there are two oblong sub-maxillary glands.

What is called the *pharynx*, or swallow, is in reptiles not easily distinguished from the gullet, to which it forms the opening, its diameter being nearly the same with that of the gullet.

The gullet in reptiles is nearly of equal diameter through its whole length, and this diameter is greater in proportion to the stomach than in quadrupeds. In the *Chelonians*, its internal surface is sometimes beset with hard long conical papillæ, with their points directed backwards, apparently for the purpose of preventing the return of the food from the stomach. In this order, swallowing is also facilitated by the action of muscles placed along the neck, and inserted into the gullet, as well as by the bone of the tongue and its muscles. The same mechanism is evident in the *Batracians*, especially in the frogs and toads; and in all this class there are usually in the gullet numerous longitudinal folds, which, by admitting a considerable degree of expansion in the tube, as the food passes through it, greatly facilitate deglutition.

The *stomach* of reptiles is of very various figure and dimensions, in the different orders, tribes, and species. In the *Chelonians* this organ appears as if doubled back upon itself; and that portion which is opposite the principal curvature, has its sides thicker than the rest, and is internally plated with longitudinal folds. The insertion of the gullet in these animals is distinguished by the sudden dilatation formed by the stomach. Among the *Saurians*, the crocodile has the stomach of a globular figure, divided, however, into two unequal portions. See Plate CCXCV. fig. 4. The stomach of the *Guana* is oval, and very long, without curvature, and not easily distinguished from the gullet, fig. 5. In the Tupinambis, the stomach forms a long tube, bent nearly into a circle, fig. 6. The stomach of the Chameleon begins by an inflated portion, then takes the form of a long cylinder, and bends back upon itself, fig. 7. In the Dragon, this organ is strait, and has nearly the shape of a pear. In the *Batracians*, the form of the stomach resembles that in tortoises, but is proportionally more dilated. In *Salamanders*, it is long, not much expanded, and strait, except near its farthest extremity.

The intestinal canal of reptiles is not easily to be divided into small and large by any particular appendage, like the *cæcum* of quadrupeds; though the distinction in point of diameter, holds in most species. All the *Chelonians*, most of the *Saurians*, and all the *Batracians* except the *Siren*, have a long small intestine inserted into one extremity of a short great gut, into which it is usually prolonged, so as to form a valve. In the *Iguana* only, is there any thing like a *cæcum*.

The intestines of reptiles in general are very short.

In the *Chelonians*, what may be called the small intestine is largest at its juncture with the stomach, and gradually diminishes in diameter till it terminates in the great intestine, where its diameter is only about one-fourth of that of the latter. The coats of the intestines in this order are thicker than in those of most other reptiles. See Fig. 8.

In the *nilotic crocodile*, the small intestine is divided into two portions, of which one is of greater diameter, and has thinner coats than the other. This intestine is remarkable for a thin layer of a pulpy glandular substance, between the muscular and the villous coats. The large intestine of the *nilotic crocodile* is cylindrical; but in another species, the *gavial*, it is pear-shaped, fig. 9. In the *lizard tribe*, the large intestine is cylindrical, and of much greater diameter than the rest of the canal, fig. 10. In the *chameleon*, the whole intestinal canal is nearly of equal diameter, except at one part, where it forms a sort of valve. In the *dragon*, the intestines make about two circumvolutions and a half, before terminating in the anus. In most of the *smaller saurians* the coats of the intestines are thin and transparent.

The most remarkable differences in the intestinal canal of the *Batracians*, are those which take place in the same species at different periods of its existence. In the *tadpole*, or young animal, the intestines are very long, small, and nearly of equal diameter, without any valvular distinction, and have numerous circumvolutions. In the perfect animal, the whole intestinal canal is much shorter, the distinction into small and large intestines very evident, and the circumvolutions much fewer. In frogs, the large intestine is cylindrical; in toads, it is more or less conical. The difference of diameter between the large and small intestines is most evident in *salamanders*, whereas in the *siren* this distinction is scarcely to be noticed. See Fig. 11.

The food of most reptiles consists of worms, insects, and other small animals, which they swallow whole. Of course the process of digestion takes place almost entirely in the stomach, where the gastric juice is evidently possessed of considerable solvent power. Some of the Chelonian order, indeed, feed partly on sea-plants, thence called turtle grass, which they bite off with their horny mandibles, and swallow whole.

Many of these animals are extremely voracious, and will gorge themselves with living worms or insects, till they become nearly incapable of motion, and till the animals they have swallowed crawl again out of their mouths.

The process of *deglutition*, in most reptiles, is effected by repeated contractions and dilatations of the throat and gullet, which are very evident to an observer. It is supposed by some physiologists, that part of the prey in some species undergoes a degree of solution in the gullet; but this seems to us not very probable.

Though the solvent power of the gastric juice in reptiles is undoubted, its action is sometimes very slow, especially on living animals, these having been found undissolved, and sometimes even still alive, at the end of several days.

Notwithstanding the voracity of some reptiles, it is astonishing how long almost all these tribes can support the want of food. Turtles and tortoises, even when not in a torpid state, have lived for 10, or even 18 months, without taking any kind of food. Newts have lived for two months, a chameleon for eight, salamanders for an equal period, protei for two years, and toads for a much longer time, under the most perfect abstinence. It is most extraordinary, and the circumstance forms a strange anomaly in animal physiology, that although these reptiles gradually lose their vitality from the want of food, they do not lose weight in proportion, and in some instances suffer no sensible diminution or flaccidity of muscle.

## CHAP. IV.

### *Of Circulation and Absorption in Reptiles.*

There are several peculiarities in the circulation of reptiles, and the organs vary considerably in the different orders. In some they are similar to those of the higher classes of animals, except that the principal cavities of the heart communicate more or less freely with each other; in others, the circulating system is entirely different from that of *Mammalia*, and much more simple.

In the Chelonian tribes, the heart is very broad in proportion to its length, but differs in figure in the two genera, being nearly hemispherical in the proper *Cheloniæ*, and of an oblong square form in the *Testudines*. In both it has two auricles, and a ventricle divided into compartments. It is situated below the lungs, and between the lobes of the liver. The auricles are very large, forming each about one-third of the whole heart, and spread wide at the base of the ventricle. Their sides are thin, and their cavities do not communicate. The ventricle is strong and fleshy; and its cavity, which is naturally small, is still more diminished by numerous fleshy bundles that proceed from its sides, and are separated from each other in such a manner as to leave spaces between them. The auricles communicate with the ventricle by large apertures, guarded by membranous valves; and on each side of the ventricle are orifices, also furnished with valves, that lead to the great arterial trunks. The pericardium is large, and closely attached to the contiguous membrane, as to the diaphragm in quadrupeds.

In the *Saurians*, the heart is also provided with two auricles; and in one tribe, the crocodiles, is even more complicated than that of the first order. It is in the crocodiles, indeed, that its structure has been most accurately examined, and to this tribe we shall here confine ourselves.

The heart of the crocodile is situated partly between the lungs, and partly between the lobes of the liver. Its auricles are proportionally less than in the *Chelonians*, but their sides are thicker, and strengthened by fleshy bundles, diverging in various directions. The ventricle is of an oval form, and has very thick sides. Its cavity is divided into three compartments, communicating with each other by numerous orifices. One of these is below, and towards the right, and communicates with the right auricle by a large opening, contracted by two valves that direct the blood through its upper part. On the left side of this cavity is the passage to a large artery on the left, that distributes blood to the sacral or hind parts of the body; and behind this an orifice leads to the smallest of the three compartments, situated at the middle of the base of the heart; and from this arises the common trunk of the pulmonary arteries. (See Plate CCXCV. Figs. 12, 13, 14.)

Hence the blood that is poured by the right auricle into the compartment on that side flows chiefly in two directions; 1*st*, Into what may be called the *right systemic* compartment of the ventricle, which throws it into the left *sacral aorta;* 2*dly*, Into the *pulmonic* compartment, which impels it into the pulmonary artery, though some of it probably oozes into the left systemic compartment. The left auricle receives the blood from the pulmonary veins, and pours it into the left compartment; and from this latter it is thrown into the left systemic artery, the carotids, and axillary arteries.

The *Batracian* order have a heart extremely simple, consisting of a single auricle, and a single undivided ventricle, of a conical form, from which arises one arterial trunk, that by its branches transmits the blood to all parts of the body.

We cannot here enter into an examination of the number and course of the principal blood-vessels in the reptile tribes; but must refer the reader to Cuvier's *Anatomie Comparée*, Leçon xxv. Art. 3. vol. iv. where they are minutely described.

There is not that well marked distinction between the arterial and venous blood in reptiles, which is found in *mammalia cetacea*, and birds; but in some species there is a manifest difference, as Caldesi has observed in tortoises. It is said that reptiles which have fasted long, have the blood of a paler colour than the same species regularly fed.

The absolute quantity of blood in the circulating system of reptiles is proportionally much smaller than in *mammalia* and birds; hence their muscles are whiter, and their lungs of a paler colour, than in those classes. The circulation in these animals, though not so complicated as in the higher classes of animals, is yet a perfect circulation; and, as in the higher classes, though not in the same degree, the blood takes a double course, some of it passing through the lungs before it be distributed to the rest of the body. We shall see, in the succeeding chapter, that although the lungs of reptiles are larger in proportion than those of *mammalia* and birds, they are less vascular, and therefore contain a smaller quantity of blood. It is this imperfection of what has been called the lesser circulation, and the slight difference between the *systemic* and *pulmonic* blood, that lay the foundation for some of the most remarkable circumstances in the physiology of these animals. We are now prepared to consider two of these circumstances—the remarkable faculty of reproduction of parts that have been mutilated or destroyed, and the great tenacity of life, at which we have already hinted.

It is chiefly in the lizard tribe and salamander, that experiments and observations on the reproduction of parts have been made; but it is reasonable, from analogy, to infer, that similar phenomena may take place in other tribes. The lizards are peculiarly liable, from their smallness and the numerous enemies to which they are exposed, to partial injury or destruction of their members. This is particularly the case with respect to the tail, which is long and slender, and in many species so brittle as to break short on being handled. In these cases it has been repeatedly observed, that the part lost has been in no long time reproduced, generally similar to the original, but sometimes a double tail has appeared.

The reproduction of lost parts in reptiles, has been made the subject of numerous and satisfactory experiments, especially by Spallanzani, Bonnet, and Blumenbach. From these it appears, that when part of either extremity, or of the tail, is cut off, from two species of lizard, the *lacerta agilis*, and *lacustris*, or water newt, the wound is followed, for two or three minutes, by an effusion of blood, after which the stump gradually heals, and in the course of a few days the rudiments of a new limb or tail begin to make their appearance; that these rudiments are gradually developed, till in a few months, or sometimes little more than a year, there is formed a perfect member, similar in size and proportions to that which had been cut off, only retaining for some time a delicacy of structure and transparency of appearance, not found in the original organ. It is further proved, that these regenerated parts may be again repeatedly removed and reproduced. The most surprising of these experiments, however, are those of Bonnet and Blumenbach, on the reproduction of the whole eye in the water newt. These have taught us, that when the eye of that animal is dissected from the orbit, so as to leave about a fifth of the membranes in contact with the optic nerve, the vacant orbit is first closed by the eye-lids, and gradually the vacuity is filled up with a growth of new parts, which in about a year acquire the perfect structure of an eye, with its investing membranes, contained humours, transparent cornea, and coloured iris.

We have already remarked the great power of abstinence possessed by reptiles, and have now to notice some other unfavourable circumstances, under which they continue to live and perform most of their functions.

Most reptiles possess the faculty of resisting extremes of heat and cold, and the effect of chemical agents, better than other animals. Though nobody now believes the ridiculous stories of salamanders living in the fire, it is still a curious fact, that lizards and alligators live with ease and apparent satisfaction in the waters of hot springs, heated to a degree very considerably higher than the hottest temperature of the torrid zone. Frogs and newts are often exposed to a degree of cold far below the freezing point, while in a state of torpidity, and they have even been known to remain imbedded in a block of ice for many hours, without having their vitality extinguished. Some of these animals, that have been put alive into spirit of wine, for the purpose of preserving them as specimens, have remained alive for several hours; and other instances are recorded of their existing for a considerable time in the exhausted receiver of an air-pump. Frogs and water-lizards have lived, and moved with agility, many hours after having been deprived of their hearts; and Redi, by a curious but cruel experiment, proved that a land-tortoise, after having the cavity of the skull laid open, and the brain dissected out, walked away with apparent unconcern; and, except that its eyes closed, and never afterwards opened, it appeared for several months to enjoy life, and exercise its functions nearly as before the loss of the brain. Frogs, which were subjected to a similar experiment by Spallanzani, lived for five days. Nay, a turtle has been known to live and move its limbs for thirteen days after its head had been cut off.

Not only is the body in general of reptiles thus tenacious of life, but the parts and organs that have been cut off shew signs of vitality and irritability, for hours and even days together. The tails of water newts have exhited very lively motions for more than ten hours; the heart of a frog has continued to palpitate, when irritated, for several hours after being taken from the body: the head of a turtle has not only opened and closed its jaws, but has closed upon a stick with considerable force, two days after having been amputated.

The *absorbent system* of reptiles has been very little examined, and the investigation has scarcely extended beyond the Chelonian order. We find that the thoracic duct of turtles is double, and that the mesentery in these animals abounds with lacteals. Numerous lymphatics are seen running in a longitudinal direction, both on the superficial and central coats of the intestines; but it is not certain that these animals possess lymphatic glands.

If we may judge from the little waste that takes place in the body of reptiles during a long abstinence, and while in the torpid state, it would seem that their absorbent system possesses less activity than that of most other animals.

## CHAP. V.

### *Of Respiration and Voice in Reptiles.*

The lungs of reptiles are proportionally much larger than those of quadrupeds and birds, and they are also of a much looser texture; their structure is most complicated in the Chelonian order, in which they are of a uniform texture, but the air vesicles are very large. In the *Saurian* order, the lungs form two large vesicular bags, one on each side the heart, and have their internal substance divided by membranous plates into numerous polygonal cells, which are again subdivided into smaller. All the *Batracian* order have lungs, which resemble those of most of the Saurians in largeness and simplicity; but in the tadpole state they have also gills, which disappear in the perfect animal, except in two tribes, in which they are permanent.

In all, the lungs float loose with the other viscera in the same cavity, and appear to have no innate contractile power.

The windpipe, except in one or two instances, divides into branches or *bronchi*, before it reaches the lungs; but this division takes place nearer the head in some tribes than in others. In the Chelonians, it commences very early, while in the crocodile the trachea continues undivided for a considerable extent. In general, however, the bronchi are very short, and in most instances they terminate abruptly in the lungs.

The extent of the lungs is greatest in the Chelonians, in whom they reach along the whole length of the back. The lungs of reptiles are supplied with blood by the pulmonary arteries, there being in general no bronchial vessels.

The gills or branchiæ of tadpoles, and of the proteus and siren, resemble the gills of fishes in their general structure, but are not, like them, inclosed within a particular covering, but hang loose and floating on each side of the neck. They form three or four rows of small tufts or fringes, supported by small cartilaginous arches; and these arches are articulated on one side behind the cranium, while on the other they are united to a bone resembling the os hyoides. They have between the rows intervals, by which the water in which the animal floats is freely admitted to the mouth. The branches of the siren consist of three tufts.

The spongy texture, and little vascularity of the lungs in reptiles, enable them to take in a greater quantity of air than other animals at a single inspiration, and this capacity appears to be increased by the expansive power of the air cells. It is remarkable, that reptiles not only receive air into the lungs in the ordinary way of inspiration, but swallow it by the mouth, in which action they are assisted by the muscles of the throat. In fact, it is only by deglutition that the Chelonians inspire, and in expiration the animals of this order employ chiefly two pairs of muscles, situated in two layers near the tail, between the shield and breast plate. In the Saurians, the mechanism of respiration is executed chiefly by the abdominal muscles, and by those which move the ribs.

From the large quantity of air which reptiles can inspire at once, there is the less occasion for frequent respiration; and, accordingly, in these animals, the breathing is remarkably slow. It is least slow in the Chelonian tribes, and it appears to be slowest when the animals are asleep. What is most remarkable, however, in the respiration of reptiles, is the power they possess of suspending respiration. Tortoises have been known to live more than a month with their jaws closely tied, and their nostrils stopped with wax; and there seems little reason to doubt the remarkable instances that are on record, of toads being found alive in the trunks of trees and blocks of solid stone, where the function of respiration must have been suspended for years together. It also appears that reptiles can live for a longer time uninjured in deoxygenated or impure air than other animals; a circumstance that is explained on similar principles. This continued vitality in vitiated air has its limits however; for it is found, that when these animals are confined in atmospheric air, they cease to exist when the oxygenous portion is expended.

The changes produced on atmospheric air by the respiration of reptiles, are similar to those produced by the breathing of other animals, viz. the consumption of oxygen and formation of carbonic acid. On this subject we may refer our readers to Mr Ellis's *Inquiry into the changes produced on Atmospheric Air*, published in 1807, and *Further Inquiry* in 1811, in which the experiments and observations made by the ingenious author, and collected by him from former writers, are fully and satisfactorily detailed.

Intimately connected with the function of respiration, is the vital heat of animals. We have already seen that this in reptiles is very low. It appears, however, that, under the ordinary temperature of the atmosphere, the heat of these animals is generally a few degrees above that of the surrounding medium; and while life continues, they have the power of preserving a moderate temperature, and of resisting, to a certain degree, considerably inferior indeed to man and quadrupeds, the extremes of either heat or cold. See Chap. IV.

Almost all reptiles utter sounds more or less loud; the salamander and the green lizard being almost the only known exceptions; and it is even not certain whether the former should be entirely excluded. Turtles and tortoises hiss or sigh; crocodiles low or roar, sometimes in so loud a tone as to resemble distant thunder, while the young of these animals are said to make a noise like a cat, (but whether *mewing* or *purring* we are not told,) and to utter piercing cries if attacked, when first extruded from the egg. Iguanas make a sort of whistling sound as they run along the trees, and the croaking of frogs and toads is sufficiently known.

The organs of voice in these animals are very simple, consisting of a single *larynx*, without *epiglottis*, but including ligamentous chords of the *glottis*, moved by appropriate muscles. In some species of frogs, especially the males, there are also membranous bags connected with the glottis, or pouches in the cheeks, which, when inflated, serve to increase or modify the sound.

## CHAP. VI.

### *Of Secretion and Excretion in Reptiles.*

The most important of the secreting organs, which we are to notice in reptiles, are the liver, pancreas, spleen, and urinary organs.

The liver of these animals is always large; and in some instances, as in the salamander, its proportional magnitude is very considerable. In the Chelonians it is divided into two rounded irregular lobes, the one occupying the right hypochondrium, and the other connected to the stomach at its small curvature. It is also divided into two lobes in the crocodile and the chameleon; but in the other Saurians, it forms only one lobe, differing in size and figure in the several tribes. In all the Batracians, except the salamander, the liver is composed of two lobes.

All reptiles have a gall bladder, which is more intimately connected with the liver, but is proportionally smaller than in quadrupeds and birds. In the Chelonians, it is almost wholly concealed in the right lobe of the liver, and is found in a similar situation in crocodiles. There are generally two ducts leading to the intestines; one from the liver, the hepatic duct; and the other, the cystic, from the gall-bladder; and these, in most instances, run separate from each other.

The position and size of the pancreas are very various. In most of the Chelonians it is triangular, and generally entire. In the crocodile it is divided into lobes. In some of the Batracians, as the frog, it is lodged in the arch of the stomach towards the sternal part of the body; in others, as the salamander, it is situated in the first curve of the intestines. The pancreatic duct is commonly single, but in some instances, as in the Nilotic crocodile, it is double.

The spleen exists in all reptiles, but its structure, form, and situation, in these animals, has been very imperfectly investigated. In the Chelonians, it is shaped like the kidney; in the Saurians, it is elongated; in most of the Batracians, as frogs and toads, it is small and spherical, and in the former tribe is situated in the mesentery; while in salamanders it is of an oblong form.

All reptiles appear to have kidneys; but the structure of these organs is extremely simple and uniform, as they have no distinction of cortical and medullary substance, and no parts corresponding to the *infundibula* and *pelvis* in mammalia. In figure and situation, however, they vary in the several orders. In the Chelonians they are short and thick, and lie far back in the cavity of the abdomen. In the Saurians they are of an oval form, more or less flattened and elongated, and in general they lie far back under the sacrum, or near the tail. It is uncertain whether their form varies with age in all these animals; but it appears that in young crocodiles they are entire, while in full grown individuals of the same tribe they are divided into several lobes. In the Batracians they are situated pretty far forward and very near each other, and resemble those of the Saurians in form.

All the reptile tribes have not an urinary bladder. It is found in the Chelonians, in whom it is very large, and is more or less divided into two portions. Of the Saurians, only the tupinambis, iguanas, stellios, chameleons, and dragons, have an urinary bladder. It is found in the Batracians, in some of whom it consists of two membranous bags, while in others it is single.

In reptiles there is a common receptacle or passage for the urine and *fæces*, called *cloaca*; and in those tribes that have no urinary bladder, the ureters, or pipes from the kidneys, open immediately into this receptacle.

Several secretions of a peculiar nature take place in reptiles. Thus, in the crocodile, there is a gland situated on each side of the lower jaw, just beneath the skin, having a duct opening externally, and secreting a substance that smells like musk; while glands of a similar nature are found in the cayman, near the anus. In several of these animals, as in toads and salamanders, an acrid fluid exudes through numerous pores of the skin when they are irritated. This fluid is not, however, poisonous, as has been supposed; but among the Saurians, the geckos secrete from between their toes a matter, which is really of a venomous nature. See Gecko in the subsequent Part.

## CHAP. VII.

### *Of Integumation in Reptiles.*

A considerable variety is found among the reptiles with respect to their integuments; and as these varieties constitute many of the generic and specific characters, it is necessary to examine them with some minuteness.

In all these animals there is the usual distinction of cuticle, true skin, and *rete mucosum*. The structure of the skin and *rete mucosum* differs but little from that of other animals, except in the frog and toad, where there is this peculiarity, that the skin adheres to the parts beneath only at a few points, so that it forms a sort of loose bag about the animal, susceptible of occasional inflation. The cuticle is extremely various in the different orders and tribes. In the Chelonians, though only the head, tail, and extremities, appear to be covered with skin, yet in reality the whole body within the shell is enveloped with a thin transparent cuticle, capable of being detached in plates. In most of these animals, the cuticle, when exposed, is covered with scales of a horny texture, and differing very much in number, situation, and figure. A thin membrane resembling cuticle, also covers the shell of the Chelonians; and in several species, the upper shell, or shield, is covered with a dense and strong membrane resembling leather or parchment. Among the Saurians there is first a cuticle enveloping the true skin, then scales, plates, or tubercles, and over these again another cuticle, as in the Chelonians. In the crocodiles and *Dracæna*, there are strong and broad plates differently shaped and arranged, as we shall see hereafter; in the tupinambes, the scales are disposed in circular rows or transverse bands; in the basilisks, they are diffused over the whole body, while in the lizards again, they are arranged in transverse bands. The Batracians have the epidermis smooth, and in general slimy.

The Saurians have generally very strong and numerous subcutaneous muscles, especially in the tail; and in most cases, there is an intimate connection or adhesion between these muscles and the skin.

We have already seen that the Chelonians are covered, both on the upper and lower parts of the body, with a strong and hard shell, of which the upper part may be termed the shield, and the lower the breast plate. Each of these is divided into a considerable number of separate plates, united together by their edges, sometimes in a smooth and even manner, at others overlapping each other. A row of these plates lies along the middle of the back over the vertebræ, and these are surrounded on each side by several others, which, together with the vertebral plates, constitute what is called the *disc*. The other plates of the shield, lying between the disc and the breast plate, are called *marginal*, and are generally from twenty-one to twenty-five in number. They are of a more irregular figure than those of the disc, and generally of an oblong form. The shield is more or less convex. The shield and breast plate are united only at their sides, leaving a space at the fore and back parts for the head, tail, and extremities. This shelly covering, in general, resembles the hoofs of quadrupeds in its texture, though in some instances, as in what is called tortoise-shell, it is purer and more transparent than the finest horn.

The Saurians and Batracians occasionally change the cuticle, throwing off the old, and acquiring a new one. This is particularly the case while they are young, and after leaving their winter quarters. In these animals, the change is not made at once, as in serpents, (see Ophiology,) but the cuticle is detached in scales or plates, till the whole is thrown off.

## CHAP. VIII.

### *Of Generation in Reptiles.*

There is no part of the economy of reptiles more curious, none more interesting to the naturalist, than that function by which these animals generate their like. The differences, with respect both to organs and pnenomena, which are found in this class, admirably illustrate the observation of a celebrated naturalist, that a systematic arrangement of animals, as well as plants, might be composed merely from a comparison of their generative organs.

A difference of sexes prevails in all reptiles, and the distinction of male and female organs is in most instances very manifest. There is one part of the structure, however, found in both sexes. The *cloaca*, which has been already noticed as forming the common outlet for the urine and fæces, also forms, as in birds, the common receptacle of the external organs, and the outlet for the ova.

All male reptiles have *testes*, but these organs differ in form and situation. In the Chelonians, they lie within the abdominal cavity, (as is the case in all these animals,) contiguous to the kidneys, and united to their inferior or sacral surface. In the Saurians, they lie in front, or on the sternal side of the kidneys, on each side of the vertebral column; and in the Batracians they are situated immediately below the anterior surface of those organs. In the first order, the *testes* are composed of large vascular bundles, disposed in various directions; and the *epididymis* is formed in the usual way, by the convolutions of the vessels, particularly of the seminal duct, or *vas deferens*. It is not certain whether these animals have seminal vesicles. The *testes* of the crocodile are long and narrow, and communicate with two organs that are supposed by some anatomists to be seminal vesicles; and if so, form the only instance of these organs among the reptile tribe. In salamanders, each of the *testes* is divided into two spherical bodies, placed one before the other: and their texture consists, as in all the Batracians, of an agglomeration of small whitish granular bodies, interspersed with blood-vessels.

The *penis* is single in all the Chelonians, and in most of the Saurians. The Batracians have no organ of this kind; but, in some of that order, its place appears to be supplied by a small *papilla* within the *cloaca*. This organ is most remarkable in the Chelonians, in some of whom it is of very considerable length. It is cylindrical, terminates in a point, and has a deep furrow along the whole extent of its upper surface. It is furnished with two retractor muscles, by which it is withdrawn within the cloaca, where it usually lies concealed, and from which it is thrust out in preparing for copulation. In the Saurians, this organ is short, cylindrical, and beset with numerous spiny processes, resembling the bristles of the hedgehog. In the usual state, it is drawn up under the skin of the tail, and, when erected, appears externally at the slit of the *cloaca*.

We must here notice a peculiarity of structure in the males of those reptiles which do not immediately copulate with the female. There are found in these males, during the copulating season, hard brown or blackish *papillæ* or tubercles, attached to the thumb and palm of the fore feet, which assist in grasping the female. These tubercles are found chiefly in the frog and toad. Salamanders have, during the same season, a crest with divided edge upon the back and tail, which afterwards disappears.

The female reptiles have ovaries, and most of them a *uterus*, or an expansion of the oviducts, which answers a similar purpose. The ovaries of the Chelonians resemble those of birds, (see Ornithology.) They are two in number, and have each a duct opening into a *uterus*. The *uteri* are thick and fleshy, and have openings by which they communicate with the *cloaca*. The ovaries of the Saurians and Batracians are much alike; but the former contain fewer eggs, and have larger and shorter oviducts. Those of frogs lie below the liver.

A curious structure prevails in the female of the Surinam toad, or *Bufo dorsiger*. The skin of the back in this animal is hollowed out into a great number of cells, in which the ova, after being extruded by the female, and fecundated by the male, are placed by the latter; and here they remain enveloped in the skin, which contracts round them till they are hatched, and ready for enjoying a separate existence.

Only the Chelonians and Saurians enter into actual copulation, and this act is different in the two orders. It is not certainly known in what manner the male and female turtles and tortoises perform this act. It is supposed, and even asserted by some, that they unite breast plate to breast plate, while others affirm, that the union takes place in the manner of quadrupeds. We are not disposed to enter into the minutiæ of these reptilian amours, as we do not think them calculated for a work addressed to general readers. Those who wish to gratify their curiosity on this part of comparative physiology, may consult the dissertations of Spallanzani, and the works of Reësel, Swammerdam, and Daudin, already mentioned in our historical notices.

The season of copulation commences early in spring, or as soon as the animals are roused from their winter state of torpor, and seems to return only once a year: it continues for a longer or shorter time in different orders and tribes, generally longest among the frogs and toads.

All reptiles are properly oviparous, though in one instance, the salamander, the ova are hatched in the oviduct. In most of the tribes, the eggs, though numerous, are laid distinct from each other; and, in that case, they are enveloped either by a calcareous shell, or a membrane resembling parchment. Frogs and toads, however, lay eggs that are connected together in a kind of bunch, and are of a gelatinous consistence, each egg containing in its centre a dark spot, which is the rudiment of the future young, (see Plate CCXCV. Fig. 15.) These connected eggs are extruded gradually by the female, and each is fecundated by the male as it escapes from the cloaca. What may be considered as perfect eggs, which are those of the Chelonians and Saurians, are very similar to those of birds, except that the transparent fluid, which corresponds to the *albumen* in the latter, does not coagulate by heat. The eggs of the Chelonians, and, according to some authors, those of the crocodile, afford good and wholesome nourishment to man.

We have said, that the young of the Batracians undergo a *metamorphosis;* and this is not the least interesting part in the physiology of generation in these animals. M. Reësel, in his *Historia Ranarum Nostratium*, has given a minute account, illustrated by figures, of the progress of the common frog, from the time when the egg is first fecundated to the completion of the perfect animal. We shall here present our readers with an abstract of this account.

Two days after the ovum is excluded, the central spot is somewhat enlarged, but still spherical, and is enveloped by an immediate albuminous covering, very distinct from the exterior mucilage. In four days, the central germ has assumed the shape of a kidney bean, and its albuminous covering is enlarged. In five days, the kidney-shaped embryo has changed its form to that of a half crescent, though still scarcely increased in size; but the following day it has become longer, thicker, and straighter, and the distinction between the outer and inner mucilage is no longer visible. The head, eyes, and mouth are also now obscurely visible, and there is some appearance of a tail. By the seventh day, the size of the tadpole is increased, and the distinction of head and tail more evident; and there are also visible the rudiments of the fore feet, and of the gills. It has now quitted the egg. At the end of nine days, the head and body are enlarged, and the tail considerably lengthened. Soon after this, the *branchiæ* are so much increased as to be distinctly observed; but, about the twentieth day, these appendages are withdrawn below the skin, as no longer necessary; and about four days after, the fore legs, which till now had been almost entirely concealed below the skin, appear externally. The body of the tadpole is still transparent, and its long intestines are seen extending from head to tail, (see Plate CCXCV. Fig. 16.) In a few days after this, the tail gradually disappears; the hind legs are developed; and in about two months from the first exclusion of the ovum, the animal becomes a perfect frog.

The metamorphosis of all the Batracians does not proceed exactly in the manner above described. In particular, the tadpole of the *Rana paradoxa* undergoes such remarkable changes, as to have been mistaken for an animal of a very different class. These will be noticed in a subsequent part of this article. The young of salamanders also differ from the tadpoles of frogs, and have been denominated *larvæ.* They remain four months in the tadpole state.

## CHAP. IX.

### *On Hybernation in Reptiles.*

Having, in the preceding chapters, described the organization of Reptiles, and given a comprehensive view of their organic functions, we have only to consider the phenomena that take place in these animals at that season when they begin to lose sense and motion, and sink into a state of torpor.

If we except the insect tribes, there are no animals to whom heat appears more necessary for enabling them to exercise their functions with vigour and activity, than reptiles. We shall find presently, that by far the greater number of the species are natives of the torrid zone, and indeed the few which inhabit these colder regions are comparatively lifeless and inactive. The heat of the sun seems to increase not only their vivacity and agility, but their sensibility. Cold produces the contrary effects; and when this takes place in any considerable degree, they become listless and inactive, and would probably perish, if they did not seek for refuge in some situation where they are in some measure sheltered from the cold in its extreme degree. Accordingly, we find that, on the approach of winter, these animals betake themselves to some retreat corresponding to their natural situation. Turtles and fresh water tortoises imbed themselves in the muddy or the sandy bottoms of lakes and rivers, while land tortoises make an excavation in the earth, and there find a temporary grave. Crocodiles, and those other Saurians which resemble them in their usual habitation, find retreats in sandbanks; while others, especially the Batracians, retire to crevices of walls, cavities of stones, clefts of trees, and caverns of mountains; while a few seek a precarious continuance of warmth by creeping into dunghills. In these retreats, where they can no longer find their accustomed prey, they gradually sink into a state of insensibility, and appear in a profound sleep, scarcely to be distinguished from actual death.

As this torpidity approaches, their circulation becomes languid, their respiration is extremely slow, their appetite for food appears to cease, and their temperature sinks below its natural standard. So complete is their want of sensation, that they may be cut, torn, and in some cases broken to pieces, without expressing the least degree of pain, or showing any signs of motion.

In this state they continue generally during the whole winter; and, as the genial heat of the spring returns, or in those climates where the changes of season are not so remarkable, when the analogous revolution of the season takes place, the animal begins to shew signs of returning life, gradually recovers sense and motion, its heart beats with a gradually increased velocity, its respiration becomes more frequent and regular, its temperature increases, it quits its retreat, resumes its ordinary functions, searches after prey, and seeks a mate.

It is remarkable that this hybernation of reptiles is not confined to those species which inhabit a cold or temperate region, but seems to extend even to the hotter climates of Barbary, Egypt, and South America. It is also worthy of remark, that this continued state of torpor, unlike the winter sleep of bears, marmots, and other hybernating quadrupeds, does not produce any very evident emaciation or loss of weight in the torpid animal. Land tortoises have been repeatedly weighed just before retiring to their winter quarters, and after emerging from them, and were found in some cases not to have lost above two ounces.

It is found that when some of these animals, as tortoises, in a state of domestication, are taken from their winter retreat, and exposed to a more elevated temperature, they recover, in some degree, their sense and motion, though they scarcely ever take food during this period. We have known a land tortoise, kept in a room where there was almost a constant fire, lie for several weeks together in the box that formed its retreat, without making any attempt to come out, and though when taken from the box, it opened its eyes, moved its head, and sometimes walked a little, it could not be prevailed upon to eat till its usual period of hybernation was completed. The person with whom it lived, with officious kindness, would sometimes force a little broth or soup into its mouth; but the animal never showed any desire to eat of its own accord. See Hybernation.

## Part II. CLASSIFICATION AND NATURAL HISTORY OF THE SPECIES.

### ORDER I. CHELONIAN REPTILES.

We have seen that most of this order, comprehending the animals called turtles and tortoises, are enclosed within a horny covering, consisting of two parts, one covering the back, and usually called the *shield;* the other supplying the place of a sternum, and called the *breastplate.* Each of these is composed of numerous *plates;* those of the shield being most numerous, and divided into those of the *disc*, or middle part, and those of the margin. The plates of the *disc* are generally thirteen in number; and those which are ranged along the back from head to tail, are denominated *vertebral* plates. The plates of the margin vary in the different species from 21 to 25. There are several terms applicable to these plates, which occur in the following characters, and therefore require explanation here. When the plates rise in a ridge in the middle, they are said to be *carinated;* when they have depressions in the contrary direction, they are *furrowed;* when they are uniformly highest in the centre, they are *convex*, or *subconvex*, according to the degree of elevation; when they lie upon each other like tiles or slates upon a roof, they are *imbricated;* when they are notched about the edge like the teeth of a saw, they are *serrated.*

The shield and breast plate of these animals are more or less firmly united together at the edges, leaving openings for the head, legs, and tail. Some species have the power of withdrawing all these parts within the shell, where they lie as if shut up in a box, safe from the attacks of almost every animal but man.

The legs of these animals are very short, but so strong, that one of the larger turtles has been known to walk with apparent ease, while several men stood on its back. In their motions they are slow and awkward, and, with very few exceptions, they are inoffensive, and submit, without resistance, to the most cruel treatment. They pass the winter in a torpid state.

### Genus I. Chelonia. TURTLES.

The feet flattened, so as to resemble the broad part of an oar; the toes of unequal length, united together so as to form a broad expanded surface, with flat nails inserted into its margin.

The *Cheloniæ* comprise the largest species of this order; some having been found that weighed seven or eight hundred pounds. They are inhabitants of the ocean, and feed partly on fuci or sea-weeds, and partly on the mollusca and other small sea animals that harbour among these submarine plants. The eggs of all the species, and the flesh of most of them, afford a delicious repast even to the epicure.

Of this genus only six species are distinctly marked by naturalists, though it is understood that Schoepff, the Prussian naturalist, was acquainted with eight. These six species may be thus distinguished.

Species 1. *Chelonia mydas.* Green turtle. Plates of the shield neither imbricated nor carinated, in number thirty; four feet, furnished with two nails. See Plate CCXCVI. Fig. 1.

*La tortue Franche.* Daudin, *Hist. Nat. des Reptiles*, par Sonnini, i. p. 10. Lacepede, *Hist. Nat. des Quad.* Ovip. i. Art. 1. (Translation by Kerr.)

*Testudo mydas*, Linn. *Syst. Nat.* a Gmelin, p. 1037. Schoepff, *Hist. Nat. Testudinum*, p. 73 pl. xvii. fig. 2.

*Green turtle*, Shaw, *General Zoology*, iii. pl. xxii.

2. *C. rugosa.* Wrinkled T Plates marked with three transverse black furrows; body of the shield chesnut-coloured, with a yellow margin.

*T. ridée.* Daudin, i. p 37.

3. *C. caretta.* Caret, or Hawksbill T. Shell elliptical, subcarinated, serrated; dorsal plates thirty, imbricated.

*T caret*, Daudin, i. p. 39. Lacepede, i. Art. 5.

*T. imbricata*, Linn. a Gmelin, p. 1036. Schoepff, p. 83. pl. xviii.

*Imbricated turtle*, Shaw, iii, 89. pl. 26. xxvi.

4 *C. cepediana.* Cepedian T. Feet thin shaped, furnished with one nail; plates of the breast plate 14.

*T. cépédienne*, Daudin, i. p. 49.

6. *C. caouanna.* Loggerhead T. Shell ovato-cordate, serrated; plates of the disc 15; vertebral plates gibbous behind.

*T caouane*, Daudin, i. p. 54. Lacepede, i. art. 3.

*T. caretta*, Linn. a Gmelin, 1038. Schoepff, p. 67. pl. xvi.

*Loggerhead turtle*, Shaw, iii. pl. 23, 24, 25.

6. *C. Coriacea.* Coriaceous T. Body not shelled, but covered with a leathery coat plaited longitudinally; feet fin-shaped.

*T. luth*, Daudin, i. p. 62. Lacepede, i. art. 6.

*T. ferox*, Linn. a Gmelin, 1036.
*Soft-shelled turtle*, Pennant, *Phil. Trans.* lxi. 275.
*Spinous tortoise?* *British Zoology*, vol. iv. p. 1.
*Coriaceous turtle*. Shaw, iii. p. 77. pl. 21.

Of these six species, we shall notice the first, third, fifth, and sixth more particularly.

*Species* 1. *Chelonia mydas*. Esculent, or green turtle.

Of all the Chelonian reptiles, this is deservedly held in the highest esteem, from the very nourishing and palatable food which it affords to the human race. It is also one of the largest of these tribes, and is not less interesting from its habits and manners, than from its utility as an article of diet.

A full grown turtle often measures six or seven feet in length from the nose to the tip of its short tail, three or four feet in breadth, and nearly as much in thickness at the middle of the body. It sometimes weighs eight hundred pounds. The body appears of an oval form, and the head is of considerable size in proportion to the body. The tail is short and thick. The feet are long, and much better adapted to the action of swimming than that of walking. The head, feet, and tail, are covered with scales. The breast plate is shorter than the shield, and has twenty-three or twenty-four plates disposed in four rows. The prevailing colour of this turtle's shell, when in its usual situation, is bright brown, with spots of a yellow colour; and when the shell becomes dry, the brown assumes a darker hue.

This species frequents the coasts both of the islands and continents of the intra-tropical regions, and is found in great abundance both in the East and West Indies. It sometimes enters the mouths of large rivers, and occasionally goes to some distance from the shore into the sheltered woody parts of the country. It swims with great facility, keeping its head and part of its shell above the surface of the water; but when it fears the approach of danger, or seeks its prey among the rocks, it dives to the bottom, and may be seen browsing at its ease among the weeds. It is said, however, that it does not dive very readily, as the specific gravity of its body but little exceeds that of the salt water. When it quits the water, its motion on the land is rather a scramble than a walk, and resembles that of seals and walrusses among quadrupeds, except that it is much slower.

The great purpose for which turtles go on shore, is to deposit their eggs in the sand. This process is generally begun in the month of April, and takes up several weeks, as the eggs are laid at intervals of about fourteen days. When preparing to lay her eggs, the female turtle digs a hole about two feet deep, a little above high water mark, and into this cavity she drops about a hundred eggs at one time. While thus employed, her attention is so completely taken up with the business for which she has come ashore, that a person may easily approach her from behind, and catch the eggs as they are let fall; but if disturbed before she begins to lay, she quits the place, and seeks a more secluded spot. After having deposited all the eggs which she is to lay at one time, she scratches the sand over them, and leaves them to be hatched by the heat of the sun. The eggs of this species are round, about the size of a tennis ball, and covered with a white skin resembling parchment. It is said that that part of turtles' eggs which is analogous to the albumen or white in the eggs of birds, does not coagulate by the heat of boiling water.

As the female turtle lays her eggs at three or four times, with intervals of about a fortnight, the young are of course hatched at different periods, the eggs of each laying requiring about three weeks before the young are ready for extrusion. The little animals are of the same shape with their parent, but have only a soft covering instead of a shell. As soon as they are released from their confinement, they make directly for the water; and though this be sometimes at a considerable distance, they shape their course towards it in a straight direction. But a small proportion of them, however, in general reach their natural habitation. Great numbers of them are seized by various predacious animals, especially cormorants and other large birds, which hover about the shore from May to September, for the purpose of seizing such a desirable prize.

The individuals of this species are often found collected into numerous groups, though it does not appear that they have much enjoyment of a social intercourse, but are rather attracted to the same place by the abundance of their natural food which it affords. During the coupling season, the male and female seem warmly attached to each other, and are said to continue their connubial embraces for near a fortnight together.

To what age the green turtle is capable of living, were it to remain unmolested, cannot be ascertained; but it is conjectured by those naturalists who suppose the age of an animal to depend on its size, and the number of years required for attaining its full growth, that this species must live for at least a century. We shall see hereafter that this is no uncommon age for species of a much more diminutive size.

Even in the time of Pliny, the taking of turtles for the tables of the great was practised in the East Indies; and if we may credit the accounts of Ælian and Diodorus Siculus, the barbarous nations of the East were accustomed to employ the shields of the largest individuals as canoes. It is believed that it is only within these hundred years that turtles have been imported into Europe for the purposes of food.

Various methods are resorted to in different countries for catching turtles. A very common mode is, to watch them as they go on shore, or return, during the season of laying their eggs, when they are easily arrested; and, by the united force of several persons, are turned on their backs, a position from which they find it extremely difficult to escape. Several individuals are thus turned, and when a sufficient number has been thus partly secured, they are dragged away by ropes, and carried in boats to their place of destination. This is the method practised by the inhabitants of the Bahama islands, and is often employed with success by sailors, while touching at the islands between the tropics during their long voyages. Turtles are also taken while swimming in the sea. Some fishers of great dexterity dive for such as they see at the bottom, in the shallows, and getting on their backs, press down the hind part, and raise the fore part of their body, so as to compel them to rise to the surface, where an assistant is ready to slip a noose over the head, and thus secure the captured animal. The most common mode, however, of catching turtles out at sea, is by means of a kind of spear, or harpoon, with a long wooden shaft, to which the head of the spear is but loosely attached. This kind of fishing, as it is termed, is generally carried on by two men in a small light boat or canoe. One of those persons manages the boat, while the other stands ready to dart the spear into the back of his destined victim. It is not long before a turtle is seen either swimming at the surface, or, what is more usual, feeding at the bottom, where the water is about a fathom deep. Sometimes the animal discovers the approach of his enemies, and endeavours to escape; but the men paddle after him, and generally contrive to tire him out in about half an hour's chace. The spearman then hurls his weapon, the head of which, from the peculiar construction of the instrument, generally sticks fast in the shell, while its attachment to the shaft is secured by a long string. The animal thus wounded again makes off, unless he has been so much fatigued in the chace, as to be incapable of further exertion. In either case, he soon becomes an easy prey to his pursuers.

It is only for its flesh that this species is so much esteemed, its shell being of no use. In many of the West India islands, turtles are exposed in the open market, and a turtle-steak is there as common as a beef steak in Britain. The flesh of the turtle is extremely nutritious, and is considered an excellent restorative in cases of debility and emaciation.

*Sp.* 3. *Chelonia caretta.* The imbricated or hawksbill turtle.

This species, though of considerable size, is much less than the preceding, the largest individuals seldom weighing more than three or four hundred pounds. The shield is of an oval and almost heart-shaped form, slightly sinuated before, and narrowest behind. The disc is covered with thirteen plates, that are two or three lines thick, of a smooth surface, nearly transparent, lying over each other like tiles upon a roof. The five vertebral plates are of unequal size and figure, though each is ridged longitudinally in the middle. That nearest the head is very large and quadrangular, with a semicircular margin anteriorly. The three next plates are hexagonal, and have their greatest length across the body. The fifth is pentagonal, with one angle directed backwards, and a little prolonged towards the tail. The eight lateral plates are very large, and of an irregular pentagonal figure. There are twenty-five marginal plates, which are so much imbricated as to give the sides of the animal a serrated appearance. The colour of all these plates is generally black, with irregular transparent shades of red or yellow; all of them together sometimes weigh from four to eight pounds.

We have been thus particular in describing the plates of this species, because they constitute its most valuable product. They form what in Europe is denominated *tortoise-shell*, which, by the inhabitants of the West Indies, is more properly called *turtle-shell*. The head and neck of the caret turtle are considerably longer than those of the green turtle; and the upper mandible projects so much over the lower, as to give the snout a distant resemblance to the bill of a bird of prey, whence English sailors have given it the name of hawksbill.

This species is found in the Asiatic seas, and on the Atlantic coasts of America; but is said not to be met with in the South Sea.

Though so much smaller than the green turtle, the hawksbill possesses considerable strength; and when attacked, defends itself with much ferocity, giving very severe and painful bites. It is also more difficult to secure, as its shield is more convex, and its feet longer than those of the first species; so that when turned on its back, it more readily regains its natural position. The female begins to lay her eggs in May, and continues with intervals till July. She is said not to deposit them in fine sand, but in gravel mixed with shells. The young of this species very nearly resemble those of the former.

The eggs of the hawksbill turtle are esteemed very delicious; but its flesh is unwholesome, and affects those who eat of it with fever and dysentery. It is almost entirely for the plates of tortoise-shell that it is made an object of search.

The use of tortoise-shell was known to the ancients, but it is only in modern times that the manufacture of it has been brought to perfection. In selecting the plates, those are preferred which are thick, clear, and transparent, and variegated with dark-brown, golden-yellow, red, and white. In preparing them for use, the plates are softened in warm water, and then reduced to the desired shape, by pressing them in warm iron moulds. After they are cooled, they are taken from the mould, smoothed and polished. For the purposes of inlaying in cabinet work, the moistened plates are pressed perfectly flat, and kept in that state till cool and dry. It is usual to place below them metallic leaves, of such a colour as it is wished should appear through the transparent part of the shell.

*Sp.* 5. *Chelonia caouanna.* Loggerhead, or Mediterranean turtle.

This has been sometimes confounded with the last species, under the name of *caret*, but Lacepede restricted this name to the hawksbill, in which he has been followed by succeeding naturalists.

This is a very large species of turtle, and is said by Lacepede even to exceed the green turtle in size. Its head is much larger in proportion than that of either of the former species. The mouth, and especially the upper mandible, is also of considerable size. The neck is thick, and covered with a loose wrinkled skin, thinly beset with horny scales. The shield is of an oval form, narrowest behind. It is of a yellow colour, with black spots. The legs, especially the fore legs, are proportionally longer than in many other species; and both the fore and hind feet are furnished with two sharp claws.

The individuals of this species are most abundant in the tropical seas, especially about the West India islands; but they are also found in the Mediterranean, particularly on the coasts of Sicily and Sardinia.

In its manners, this is one of the fiercest of the Chelonian tribe; it defends itself with great courage and activity, both with its mouth and claws, and has been known to snap a moderate sized walking-stick with a single stroke of its jaws. It appears to be the most predacious of all the turtles, not only feeding on shell-fish of considerable size, the habitations of which it easily breaks with its strong mandibles, but attacking the young crocodiles, seizing them by the tail as they retire backwards into the water. Thus these animals instinctively perform an act of retributive justice. The older crocodiles make a prey of the eggs and young of those turtles which inhabit the shores to which they resort, and the turtles in return seize on the young crocodiles while they are too weak to defend themselves.

The loggerhead turtle wanders very far from land. It has been seen apparently sleeping on the surface of the ocean, about midway between the Azores and Bahama islands, at a distance of many hundred miles from land. The female lays her eggs in the sand.

The flesh of this species is coarse and rank, and eaten only by the lowest classes of the people. Its body, however, affords a considerable quantity of oil, which is used for burning in lamps, and dressing leather. The plates of its shell are too thin for most purposes, but have been employed in cabinet-work.

An individual of this species, which was caught on the coast of Provence in France, was kept by Rondelet. It emitted a confused kind of noise resembling sighing.

M. Daudin reckons as varieties of this species, the *Nasicorne* of Lacepede, the Box tortoise of Catesby, the Thick-headed tortoise of Dampier, and the *Testudo macropus* of Walbaume.

*Sp.* 6. *Chelonia coriacea*, coriaceous turtle.

We notice this species here, only for the purpose of remarking, that it is sometimes confounded with the first species of the next tribe. The distinguishing characters of both will be considered more properly in a subsequent page.

## Genus II. Testudo. TORTOISES.

The *Tortoises*, under which we include the *Emydes*, *Chelydes*, and *Testudines* of Dumeril, have all the toes furnished with claws, but not distinct in all species, some having them separate, while in others the distinction is marked only by the projecting claws. The shell is generally hard and horny, but in a few species it is of a soft consistence. The tortoises feed partly on vegetables, and partly on insects, worms, snails, and similar small animals. Some of them reside on the borders of lakes and rivers; others live entirely on land. There are about 52 species, which may be divided into two Sections, according as they live most commonly on water or on land.

### Sect. I. *Fresh-water Tortoises.*

These have the toes distinct, and generally terminated by crooked claws. In some species the toes are entirely separate; in others they are more or less connected by membranes, or the feet are palmated. They live in or near fresh water, but walk easily on land. Of this Section there are about 36 species, distinguished by the following names and characters.

Species I. *Testudo Ferox.* Fierce or soft tortoise. Shell ovate, brown, leathery, tuberculated before and behind; three toes, furnished with nails; muzzle prominent, cylindrical.

*T. Ferox*, Pennant, *Phil. Trans.* vol. lxi. p. 266. Linn. a Gmelin, p. 1039. Schoepff, *Hist. Testud.* p. 88 pl. xix.

*La Tortue de Pennant*, Daudin, i. p. 69. pl. xviii. fig. 2.

*Fierce T.* Shaw, iii. p. 64. pl. xvii.

*La Tortue Molle*, Lacepede, i. art. xiv.

*Le Trionyx de Georgie*, Geoffroy, *Ann. de Mus.* xiv. p. 17.*

2. *T. Euphratica*, Euphratian T. Shield of an obscure green, leathery, not tuberculated; breastplate white and smooth.

*La T. de l'Euphrate*, Daud. i. p. 305.

*Le Trionyx de l'Euphrate*, Geoff. *Ann.* xiv. p. 17.

3. *T. bartrami.* Cirrhated T. Shell soft; feet five-toed, all the toes nailed; nose elongated, and furnished with retractile cirrhi.

*La Tortue de Bartram*, Daud. i. p. 74.

*Testudo Verrucosa Bartrami*, Schoepff, p. 90.

4. *T. rostrata.* Beaked T. Shell orbiculo-ovate, leathery, carinated, rough, streaked with oblique furrows from elevated points; nose cylindrical; three toes, furnished with claws.

*La tortue a bec*, Daud. i. p. 77.

*T. rostrata*, Schoepff, p. 93. pl. xx.

*T. membranacea*, Linn. a Gmelin.

*Le trionyx de carène*, Geoff. *Ann.* xiv. p. 14.

5. *T. granulata.* Shagreen T. Plates of the shield granulated, naked, hard; breastplate and margin of the shield cartilaginous.

*La tortue chagrinée*, Daud. i. p. 81. Lacepede, i. art. xxiv.

*Le trionyx de Coromandel*, Geoff. *Ann.* xiv. p. 16.

6. *T. matamata.* Matamata T. Shell oval, subconvex, triply carinated; feet subdigitated; nose cylindrical, lengthened into a proboscis; neck fimbriated on each side.

*La tortue matamata*, Daud. i. p. 86. pl. xx fig. 1.

*T. fimbriata*, Schoepff, p. 97. pl. xxi. Linn. a Gmelin.

*Fimbriated T.* Shaw, iii. p. 70. pl. xviii.

*Chelys fimbriata*,† Dumeril, *Zoolog. Analyt.*

7. *T. bispinosa.* Two-spined T. Dorsal plates 13, elongated, posteriorly subimbricated, wrinkled, acutely carinated; two of the marginal plates above the tail acutely two-forked.

*La tortue double-epine*, Daud. i. p. 94.

8. *T. serpentina.* Serpentine T. Dorsal plates subcarinated behind; shield marked behind with five or six tooth-like processes; feet digitated.

*La tortue serpentine*, Daud. i. p. 98. pl. xx. fig. 2. Lacepede, i. art. x.

*T. serpentina*, Linn. a Gmelin, p. 1042. Schoepff, p. 28. pl. vi.

*Snake tortoise*, Shaw, iii. pl. xix.

9. *T. spengleri.* Spenglerian T. Shield yellow, subcarinated, posteriorly six-toothed; scales imbricated.

*La tortue spenglerienne*, Daud. i. p. 103.

*Testudo spengleri*, Linn. a Gmelin, p. 1043.

10. *T. flava.* Yellow T. Shield of a blackish-brown colour, with yellow dots and lines radiated on each plate.

*La tortue jaune*, Daud. i p. 107. Lacepede, i. art. xiii.

*T. orbicularis*, Linn. a Gmelin, p. 1039.

*T. Europæa*. Schoepff, p. i. pl. i.

*Speckled T.* Shaw, iii. p. 30.

11. *T. lutaria.* Mud tortoise. Shield of a uniform dark brown colour; fibular or outermost toe of the hind feet without claw.

*La tortue bourbeuse*, Daud. i. p. 115. Lacepede, i. art. vii.

*T. lutaria*, Linn. a Gmelin, p. 1040.

*Mud tortoise*, Shaw, iii. p. 32. pl. 6.

12. *T. caspica*, Caspian T. Shell orbicular; five nails on the fore-feet, and four on the hind; head scaly; no tail.

*La tortue caspienne*, Daud. i. p. 124.

*T. caspica*, Linn. a Gmel. p. 1041.

13. *T. melanocephala.* Blackheaded T. Shell chesnut-coloured; head and feet black; tail short.

*La tortue a tête noire*, Daud. i. p. 128.

14. *T. scabra.* Rough T. Upper part of the shield rough, yellowish, irregularly spotted and striped with brown; marginal plates 25; feet palmated; one hind toe without claw.

*La tortue rabouteuse*, Daud. i. p. 129. Lacepede, i. art. xviii.

*T. scabra*, Linn. a Gmel. p. 1040.

15. *T. subrufa.* Reddish or brown T. Shell chesnut-

* This and the other Testudines, which agree in having the shield more or less coriaceous or cartilaginous, have been lately arranged under a new genus by M. Geoffroy St Hilaire, under the name of *Trionyx*, so called from their having but three claws on each foot. Of this tribe he characterizes eight species, four of which we have noticed in the list as synonymes. The rest are as follow:

1. *Tr. subplanus.* Le Tryonix Aplati. *Ann. de Mus.* xiv. p. 11.
2. *Tr. Egyptiacus.* Le Tr. d'Egypte, p. 12.
   The same with the *Testudo triunguis* of Gmelin.
3. *Tr stellatus.* Le Tr. etoilé, p. 13.
   The *Tr. cartilaginea* of Gmelin.
4. *Tr. Javanicus.* Le Tr. de Java, p. 15.

† This singular animal has occasioned the introduction of a new genus (*Chelys*) in the modern French arrangement; a nicety of distinction which we have not at present ventured to adopt. Of this genus M. Geoffroy reckons two species, and thinks there may be three. See *Ann. de Mus.* xiv. p. 18.

coloured; plates of the disc flattened, smooth in the middle, streaked on the margin; plates of the breastplate 13; all the feet five-clawed.

*La tortue roussâtre*, Daud. i. p. 132. Lacepede, i. art. xxv.

16. *T. verrucosa*. Warty T. Shell covered with warty prominences; notched round the margin; all the feet four-clawed.

*La tortue a verrues*, Daud. i. p. 134.

*T. verrucosa*, Walbaum, *Chelonograph*, p. 116.

*T. scabra*. Linn. a Gmelin, p. 1040.

17. *T. Galeata*. Helmeted tortoise. Shell oval, depressed; three dorsal intermediate plates, acutely carinated; marginal plates 24; head plated; lower mandible furnished with filiform cirrhi.

*La tortue a casque*, Daud. i. p. 136.

*T. galeata*, Schoeffp, p. 12. pl. iii. fig. 1.

*Galeated T.* Shaw, iii. p. 57. pl. xii.

18. *T. scripta*. Manuscript T. Shell orbicular, depressed; plates marked above with characters; marginal plates 25, spotted on the lower part.

*La tortue ecrite*, Daud. i. p. 140.

*T. scripta*, Schoeffp, p. 16. pl. iii. fig. 4. and 5.

*Lettered T* Shaw, iii. p. 57. pl. xii.

19. *T. porphyrea*. Porphyry T. Shell of an ochry red colour, scantily spotted with obscure green and brown; four squamous tubercles at the anus.

*La tortue porphyrée*, Daud. i. p. 142.

20. *T. reticulata*. Reticulated T. Shield streaked and reticulated with black and brown, with yellowish lines in the middle of the plates; marginal plates not toothed, three spotted at the juncture with the breastplate.

*La tortue reticulaire*, Daud. i. p. 144. pl. xxi. fig. 3.

21. *T. serrata*. Serrated T. Shell marked above with transverse brown and yellow bands; posterior marginal plates not toothed; lateral margin at the juncture of the breastplate five-spotted.

*La tortue a bord en scie*, Daud. i. p. 148. pl. xxi. fig. 1, 2.

22. *T. centrata*. Concentric T. Dorsal and marginal plates marked with two or four black concentric circles; breastplate yellow, without spots, notched behind.

*La tortue a lignes concentriques*, Daud. i. p. 153.

*Concentric tortoise*, Shaw, p. 43. pl. ix.

23. *T. punctata*. Dotted T. Shell oval, moderately convex; dorsal plates and head smooth and black, dotted with yellow.

*La tortue ponctuée*, Daud. i. p. 159. pl. xxii.

*T. punctata*, Schoepff, p. 25. pl. v.

*Spotted T.* Shaw, iii. p. 47. pl. x.

24. *T. picta*. Painted T. Shield oblong, convex, very smooth; plates nearly square, brown, bordered with yellow; breastplate as long as the shield.

*La tortue peinte*, Daud. i. p. 164.

*T. picta*, Linn. a Gmelin, p. 1045. Schoepff, p. 20. pl. iv.

*Painted tortoise*, Shaw, iii. p. 45. pl. x.

25. *T. martinella*. Martinella T. Shell a little flattened, oval, marked on the back with two longitudinal ridges; plates of the breastplate 13.

*La tortue martinelle*, Daud. viii. p. 344.

26. *T. tricarinata*. Three-ridged T. Shell orbicular; three-ridged, vertebral plates transverse.

*La tortue retzienne*, Daud. i. p. 174.

*T. tricarinata retzii*, Schoepff, p. 9. pl. ii.

*Tortue a trois carênes*, Latreille, *Hist. des Rep.* i. p. 118.

*Tricarinated T.* Shaw, iii. p. 54. pl. xi.

27. *T. scorpioides*. Scorpion T. Shell oval, longitudinally three ridged; vertebral plates oblong, posteriorly imbricated.

*La tortue a trois carênes*, Daud. i. p. 178.

*La tortue scorpion*, Lacepede, i. art. xii.

*T. scorpioides*, Linn. a Gmelin, p. 1041.

28. *T. amboinensis*. Amboyna T. Shield convex, smooth, brown, both it and breastplate bordered with yellow; head compressed, brown, cheeks and beak radiated with yellow; feet palmated.

*La tortue d'amboine*, Daud. viii. p. 345.

29. *T. Pennsylvanica*. Pennsylvanian T. Upper part of the shield smooth, uniformly reddish, flattish in the middle; three of the vertebral plates hexagonal, oblong, imbricated behind, the first and fifth being elongated, and nearly triangular; marginal plates 25; tail tipped with a claw.

*T. rougeatre*, Daud. i. 182. pl. xxiv. Lacepede, i. art. 2.

*T. Pennsylvanica*, Linn. a Gmel. i. 1042. Schoepff, pl. xxiv. fig. A.

*Pennsylvanian T.* Shaw, iii. p. 60. pl. xiv.

30. *T. odorata*. Odorous T. Shield smooth, uniformly brownish, flattish in the middle; marginal plates 23; breastplate moveable only in front; tail tipped with a claw.

*T. odorante*, Daud i. 189.

3. *T. glutinata*. *T. a batans soudées*, Daud. i. 194. This, which is marked by Daudin as a distinct species, seems to be only a variety of the preceding, differing in the immobility of the breastplate.

32. *T. subnigra*. Blackish T. Shield rounded, convex; plates streaked at the margin, smooth in the middle; vertebral plates carinated; plates of breast plate 13.

*T. noiratre*, Daud. i. 197. Lacep. i. art. 28.

33. *T. virgulata*. Striped T. Shell dark brown, with numerous yellow spots; vertebral plates longitudinally carinated.

*T. a goutellettes*, Daud. i. 201.

34. *T. clausa*. Close T. Shell brownish, striped on the back with yellow; vertebral plates longitudinally subcarinated; middle of the breastplate a little compressed.

*T. a baite*, Daud. i. 207.

*Close tortoise*, Shaw, iii. p. 36. pl. vii.

35. *T. carolineana*. Carolina T. Shell brown bay, marked above with yellow lines and spots; dorsal plates striated; vertebral plates longitudinally carinated, lateral subgibbous.

*T. courte-queue*, Daud. i. 207. Lacep. i. art. xxv.

*T. carolina*, Linn. a Gmel. 1041, 1042.

*T. clausa*, Schoepff, p. 32. pl. vii.

36. *T. squamata*. Scaly T. Shell ovate; body, neck, tail and feet scaly above, smooth and soft below.

*T. ecailleuse de Bontius*, Daud. i. 216.

*T. squamata*, Linn. a Gmel. 1040. No. 2.

### Sect. II. *Land Tortoises.*

In the species that belong to this section, the toes are not distinct from each other, but are united below the skin into one broad expansion, from the margin of which appear the claws. They however walk, though with a very slow pace, on the ground; and live chiefly on worms and insects. There are 16 species, viz.

*Species* 37. *T. græca*. Common land T. Shield hemispherical; plates of the disc subconvex, vertebral plates subgibbous; marginal 25, obtuse at the sides; the whole shield black and yellow. See Plate CCXCVI. Fig. 2.

*La T. grecque*, Daud. i. 218. Lacepede, v. i. p. 1. art. xvi. pl. 8.

*Testudo græca*, Linn. a Gmelin, p. 1043. Schoepff, p. 38. pl. viii.

*Common tortoise*, Shaw, iii. p. 9.

38. *T. marginata*. Bordered T. Shield oblong, convex, gibbous; dorsal plates blackish-brown, with a shade of

yellow in the middle; marginal 23 or 24, obliquely marked with black and yellow.

*T. bordée*, Daud. i. 233.

*T. marginata*, Schoepff, p. 52. pl. ii.

*Marginated tortoise*, Shaw, iii. p. 17.

39. *T. tabulata*. Inlaid T. Shield oblong, gibbous; plates of the disc rectangular, subgibbous, furrowed, black, with yellow lines; marginal plates 23, black with yellow below.

*T a masqueterie*, Daud. i. 242.

*T. tabulata*. Linn. a Gmel. 1045.

*Tabular tortoise*, Shaw, iii. p. 41. pl. viii.

40. *T. punctularia*. Spotted T. Shell a little flattened, broad, subcarinated; breast plate nearly of the same length with the shield; head black above, spotted with yellow, entirely yellow below. Daud. i. 249.

41. *T. polyphemus*. Gopher T. Snout slender and sharp; plates thin, of a greyish ash colour; claws flat and roundish. Daud. i. 256.

*T. gopher*, Bartram's *Travels*.

42. *T. geometrica*. Geometrical T. Shell ovate; all the plates elevated, but flat on the top, marked with yellow streaks radiating from a centre in each plate.

*T. geometrique*, Daud. i. 260 Lacepede, i. art. xvii.

*T. geometrica*, Linn. a Gmelin. p. 1044. Schoepff, p. 49. pl. x.

*Geometrical tortoise*, Shaw, iii. p. 20.

43. *T. elegans*. Elegant T. Shell hemispherical; plates furrowed, convex, four-striped, with flat areolæ broader than long.

*T. elegante*, Daud. i. 266.

*T. elegans*, Shoepff, p. 111. pl. xxv.

44. *T. coui*. Shield round, highly convex; plates furrowed, flattened, with prominent red areolæ; three middle vertebral plates radiated of a deep yellow laterally; lateral plates radiated below.

*La tortue coui*, Daud. i. 271. pl. xxvi

45. *T. luteola*. Yellowish T. Shield rounded, gibbous, yellow, with subgibbous plates.

*T. luteole*, Daud. i. 277.

46. *T. indica*. Indian T. Shield convex; anterior marginal plates reflected upwards.

*La tortue indienne*, Daud. i. 280.

*T. indica*, Linn. a Gmelin. Schoepff, p. 101. pl. xxii.

*Indian tortoise*, Shaw, iii. p. 25.

47. *T. areolata*. Areolated T. Shield ovato-oblong, moderately convex; plates nearly square, elevated, deeply furrowed, with rough depressed areolæ.

*La T. areolée*, Daud. i 287.

*T. areolata*, Schoepff, p. 104. pl. xxiii.

48. *T. cafra*. Cafre T. Shield flattish, broad; plates flat, except the last vertebral, which is gibbous; yellow, elegantly sprinkled with black dots; marginal plates of the shield 27.

*La T cafre*, Daud. i. 291.

49. *T. juvencula*. Juvencula T. Shield square, oblong, little gibbous, with concave grained areolæ: plates of the disc 13, yellow, with black radiated points; marginal plates 26.

*La T. juvencule*, Daud. viii. p. 348.

50. *T. fasciata*. Banded T. Shield brown-bay, with a white transverse band in the plates of the disc; first vertebral plate carinated; marginal plates 27.

*La T. a fasciés blanches a Ceilon*, Daud. i. p. 294.

51. *T. pusilla*. Dwarf T. Plates of the shield variegated with black, white, purple, green, and yellow; breast-plate white; a red tubercle on the neck.

*La T. vermillon*, Daud. i. 299. Lacepede i. art. xxii.

*T. pusilla*. Linn. a Gmelin, p. 1044.

*African land tortoise*, Edwards' *Gleanings*.

52. *T. denticulata*. Denticulated T. Shield orbiculate cordate, denticulated at the margin; plates hexagonal; feet four-clawed.

*La T. dentilé*. Daud. i. p. 303. Lacepede, i. art. xix.

*T. denticulata* Linn. a Gmelin, p. 1043.

*Denticulated T.* Shaw, p. 59. pl. xiii.

Species I. *Testudo ferox* Fierce tortoise.

There are several species of the Chelonian order which have the shield softer than the ordinary shell of most species. This is the case with the 6th species of the former tribe, and with at least four of the present. The coriaceous turtle, or *Luth* of the French writers, and the soft-shelled tortoise of Pennant, though agreeing in the comparative softness of their external covering, differ very materially in general form, habitation and manners. The coriaceous turtle has an oblong body, covered immediately with a bony shell: but that shell is invested with a tough membranous coat resembling leather, plaited longitudinally, and the shield terminates behind in an acute point, overhanging the tail. The body of the fierce tortoise is rounder and more convex, and the middle part of the shield is hard; but its margin, especially towards the tail, is soft and pliable, resembling thin sole-leather, and the hind part is rounded. The tail of the first species is long, and very thick at the root; that of the second very short and small. The head of the former is small, round, and terminates in a beak, resembling the bill of a bird; that of the latter is proportionally larger and longer, with a long tapering cylindrical snout, having some resemblance to that of the mole. The coriaceous turtle is an inhabitant of the sea, is frequently found in the Mediterranean, and has been seen even on the coast of Britain. The fierce tortoise has yet been found only in the rivers and fresh water lakes of America, especially in Florida and Carolina. The former is a large species, often measuring above seven feet in length; the latter seldom weighs above seventy pounds.

The fierce tortoise frequents lakes and muddy rivers, and hides itself among the water plants that grow at the bottom, from which it is said to spring suddenly on its prey. This consists of small water animals, and, in some places, more particularly of young crocodiles, of which this species is extremely fond. They seize their prey by suddenly darting forward their long and strong neck, which they do with great celerity.

This species is among the strongest and most active of its tribe, and, as its trivial name implies, is possessed of ferocity and courage. When attacked, it boldly defends itself, rising on its hind legs, and leaping forward to seize on its assailant; and if once it fixes with its jaws on any part, it is scarcely made to let go its hold without cutting off its head.

The fierce tortoise forms an excellent article of food, at least not inferior to the green turtle.

Sp. 11. *T. lutaria*. The mud tortoise.

This is one of the smallest of the fresh water tortoises; its whole length, from the snout to the tip of the tail, seldom exceeding eight inches, while in breadth it is not more than three or four. It is of a blackish or dark brown colour. Its tail is nearly half the length of the shield, and is stretched out when the animal walks. Hence the mud tortoise has been sometimes called by the ancients, *mus aquatilis*, or water rat.

This is a very frequent inhabitant of lakes and muddy rivers in the south of Europe, and in many parts of Asia. It is very plentiful in France, especially in the provinces of Languedoc and Provence. It lives almost entirely in the water, only going on land to lay its eggs, which it covers with mould. It moves with a quicker pace on land than many of this tribe; when disturbed, it utters a kind of interrupted hissing sound. It feeds on fish, snails, and worms, and often proves a troublesome inmate in fish-ponds, killing many of the fish, and biting others till they are nearly exhausted from loss of blood.

It has been proposed to employ the mud tortoise for destroying vermin in gardens; but it is necessary to have a pond or large vessel of water for its ordinary residence. With such a convenience, it may be rendered tame and domestic.

The young of this species, when first hatched, are not an inch in diameter. They continue to grow for a long time, and are known to live for at least twenty-four years.

Sp. 36. *T. Græca.* Common land tortoise.

Several varieties of tortoise, known both to ancient and modern naturalists, have been described under the name of *Greek;* and, according to Daudin, Schoepff was the first to remedy this confusion, and to mark each by its distinctive characters. The species of which we are now treating seldom exceeds ten inches in length; is of an oval form, with a very convex shield, broader behind than before. The breastplate is nearly of equal size with the shield, and is of a pale yellow colour, with a broad dark stripe down each side, while the middle part of the shield is of a blackish brown, mixed with yellow. The head is small, and covered on its upper part with irregular scales; the mouth is small, the legs short, and the feet pretty broad, and covered with strong ovate scales. The tail is very short, scaly, and terminated at its extremity with a curved horny process. It seldom weighs above three pounds.

This species is entirely confined to the land, and prefers elevated woody situations. It is found in Europe, Asia, and Africa, and is very common on all the coasts of the Mediterranean Sea, especially in Sardinia, Barbary, and probably in Egypt. It is not a little curious, that, even in the warmer climates, this species regularly retires to its subterranean quarters during the winter months; thus proving what we have before remarked, that the hybernation of these animals does not depend solely on the degree of cold. It begins to bury itself in October, and usually makes a hole about two feet below the surface, where it continues till April.

The males of this species are in summer tolerably active, and very fierce towards each other. The female lays her eggs towards the end of June, depositing them in a hole, and covering them with sand or mould. They seldom exceed five in number at one time, and are of a white colour, and about the size of those of a pigeon. They are hatched towards the end of September; and the young, when first extruded, are scarcely bigger than walnut-shells.

The individuals of this species live on roots, fruits, worms, and insects, the shells of which latter they easily break with their strong jaws.*

The land tortoise is often domesticated, especially in gardens. We shall select the account of a tame tortoise, given by the Rev. Mr. White of Selborne, as a pleasing specimen of the manners of these animals in a state of captivity. This individual had been in possessien of a lady for upwards of thirty years. It regularly retired below ground about the middle of November, and did not emerge till the middle of April. Its appetite was voracious in the middle of summer, but it ate very little in spring and autumn. It seemed greatly alarmed if surprised by a shower of rain during its peregrinations in search of food; and though its shell was so thick that it could scarcely have been injured by the wheel of a loaded cart, it discovered as much solicitude to avoid rain, as a fine lady in her gayest attire, shuffling away on the first sprinklings, and making for some shelter. Whenever the old lady, its mistress, who usually waited on it, came in sight, it always hobbled, with awkward alacrity, towards its benefactress, though to strangers it appeared quite inattentive. It never stirred out after dark; often appeared abroad only for a few hours in the middle of the day; and in wet days never came from its retreat. Though it loved warm weather, it carefully avoided the hot sun, and passed the more sultry hours under the shelter of a large cabbage leaf, or amid the friendly shades of an asparagus bed. Towards autumn, however, he appeared anxious to improve the effect of the faint sunbeams, by getting under the reflection of a wall, and inclining its shell towards the sun. In scraping the ground to form its winter retreat, it dug with its fore feet, and threw up the earth over its back with its hinder feet; but the motion of its legs was so slow, as scarcely to be observed; and though it worked with the greatest assiduity both night and day, it was more than a fortnight before it had completed its inhumation.

How long an animal of this species may live, we cannot determine; but it is known at least, that their age may exceed a century. One of them was introduced into the garden of Lambeth palace in the time of Archbishop Laud, was living a hundred and twenty years afterwards, and died at last rather from the neglect of the gardener than from excessive age.

The land tortoise forms an excellent article of food, though it is scarcely employed for that purpose except in Greece. The eggs, however, are eaten very commonly in Italy.

Daudin enumerates eight varieties of the Greek tortoise, all of which are of a very diminutive size, and differ chiefly in the surface and variegations of the shield.

Among the numerous fossil remains of an ancient world that have lately been discovered, are several that belong to the tortoise tribes. These have been found at Malta; in the environs of Berlin; in the forest of Leipsic; at Aix in the south of France; in the neighbourhood of Brussels; in the mountains of St Pierre near Maestricht; and in the plaster quarries near Paris. These remains have been described by Faujas de St Fond, in his account of the mountain of St Pierre, and by Cuvier in the 14th vol. of the *Annales de Muscum*, p. 229. From these accounts we gather, that, besides many species either now extinct, or to us unknown, remains have been found of the *green turtle*, of the *imbricated*, *caretta*, and *coriaceous* turtles; and of at least one species (*T. flava*, or *Europea*) of fresh water tortoises.

* We do not remember to have seen, in any author with which we are acquainted, that land tortoises are accustomed to drink. The writer of this article has lately, however, ascertained the fact, that although they can live without drink for years, they swallow liquids with pleasure and avidity when offered to them in the spring. A land tortoise, which has been in the possession of a carpenter at Portobello, near Edinburgh, for above six years, was never known to drink of its own accord till the spring of this year (1816), when it has repeatedly drunk water set before it. Its mode of drinking is peculiar. It puts down its head deep into the fluid, so as to cover even its eyes, and then gradually, and almost imperceptibly, sucks it up, so as to drink some ounces in the course of a quarter of an hour.

## Order II. SAURIAN REPTILES.

Besides what we have said respecting this order, in our general arrangement, p. 5. we may remark, that, in most of the species, there is no sensible neck, or remarkable contraction between the head and body; that they have all a lengthened thorax, protected by the ribs; that their tail is most commonly rounded, though in some tribes it is compressed laterally, then serving the purpose of a fin, being very seldom prehensile. The limbs, which are always short, are in a few instances only two in number. The number of the toes and of their component joints, as well as their form and respective situation, differ considerably. All the species change their skin every spring. Their jaws, though they commonly expand very considerably, never separate from each other at the articulation, as we shall hereafter find to be the case with serpents. They all feed on living animals. Their voice is weak, and resembles a dull hiss or whistle. They copulate, lay eggs covered with a calcareous or membranous shell, which they deposit in the earth or sand, but do not assist in hatching them. They are in general very active and voracious. Most of the species are inhabitants of the warmer climates, few of them being found in the northern countries. It has been remarked, that in this order are found nearly the largest and the smallest of the perfect animals.

### Family I. *Sauri Planicaudati.* Flat-tailed Saurians.

### Genus I. Crocodilus. CROCODILES.

In this tribe, the back and belly are covered with large plates; the head is broad and flat; the tongue short, fleshy, and adhering to the lower jaw; the tail very much compressed, and armed above with a serrated crest, at first double, but single towards the tip. They have four strong feet, of which the hinder have five toes, more or less palmated, only three being furnished with nails. All the species are capable of living both in water and on land; they generally inhabit the former, but move with ease upon the latter.

Daudin has enumerated seven species, which he arranges under three Sections, as follows:

#### Sect. I. *Crocodiles properly so called.*

Snout long and flat; one tooth on each side of the lower jaw, prolonged outwards, and shutting into a groove in the upper jaw.

Species 1. *Crocodilus niloticus.* Nilotic crocodile. Muzzle flat and oblong; fourth tooth of the lower jaw resting against the edge of the upper jaw; six large carinated plates upon the neck. Plate CCXCVI. Fig. 3.

*Le crocodile de Nil*, Daud. ii. p. 367, pl. xxvii. fig. 1.

*Le crocodile*, Lacepede, i. part ii. art. 1.

*Lacerta crocodilus*, Linn. a Gmelin, p. 1057.

*Common crocodile*, Shaw iii. pl. lv. lvi. lvii.

Under this species, Daudin ranks, as varieties, the crocodile of Senegal, the black crocodile, and the Indian crocodile.

#### Sect. II. *Gavials.*

Muzzle lengthened, narrow, nearly cylindrical; two teeth at least on each side of the lower jaw, prolonged upwards beside the upper jaw.

*Sp.* 2. *C. longirostris.* Long-beaked crocodile. Muzzle double the length of the head; both jaws furnished with 27 teeth on each side; four carinated plates, disposed in a square upon the neck.

*Le crocodile à long bec*, ou *le petit gavial*, Daud. i. 389.

*Sp.* 3. *C. Arctirostris.* Narrow-beaked C. Gangetic C. Muzzle narrow, as long as the head; upper jaw furnished with 28 teeth on each side; lower jaw with only 25 on each side; two carinated plates upon the neck.

*Le crocodile à bec etroit*, ou *le grand gavial*, Daud. i. 393. pl. xxvii. fig. 2.

*Le gavial*, Lacepede, vol. i. part ii. art. 3. pl. xii. fig. 2.

*Lacerta gangetica*, Linn. a Gmel. p. 1057.

*Long-nosed crocodile*, Edwards, *Phil. Trans.* xlix. p. 639. pl. xix.

*Gangetic crocodile*, Shaw, iii. p. 197. pl. lx.

#### Sect. III. *Caïmans.*

Muzzle broad, flat, and obtuse; the fourth tooth of the lower jaw received into a particular cavity of the upper jaw, by which it is concealed.

*Sp.* 4. *C. caïman.* Caïman crocodile. Beak flat, a little narrower than the head; jaws furnished with 19 teeth on each side; 14 carinated plates, disposed in five rows upon the neck.

*Le crocodile caïman*, Daud. i. p. 399.

*Lacerta alligator*, Linn. a Gmel. p. 1058. No. li.

*Alligator*, Shaw, iii. p. 192. pl. lix.

*Sp.* 5. *C. yacare.* Yacare C. Muzzle blunt, a little elevated; jaws furnished with 19 teeth on each side; two fore teeth of the lower jaw elongated, and passing through the upper jaw. Daud. i. p. 407.

*Sp.* 6. *C. Mississippiensis.* Mississippi C. or alligator. Muzzle broad and flattened; four carinated scales, disposed in a square upon the neck.

*Le crocodile du Mississippi*, Daud. i. p. 412.

*Alligator*, or *Florida crocodile*, Bartram's *Travels in South America.*

*Sp.* 7. *C. latirostris.* Broad-beaked crocodile. Muzzle broad and flattened; jaws furnished with 19 teeth on each side; eight scales, disposed in four pairs upon the neck.

*Le crocodile a large museau*, Daud. i. p. 417.

Perhaps this may be considered as a variety of the alligator, from which it appears to differ only in the number and disposition of the plates on the neck.

Such is the arrangement of Daudin. We must now notice the classification of Cuvier, as given in the 10th volume of the *Annales de Museum.*

#### *Essential Characters of the Genus.*

Tail flattened at the sides; hind feet palmated or semipalmated; tongue fleshy, attached to the floor of the mouth, except at its edge; teeth sharp, simple, ranged in a single row; penis single.

#### *Subgenera and Species, with their essential Characters.*

#### Subgenus I. *Alligators.* (Sect. III. Daudin.)

Species 1. *Cr. lucius.* Muzzle parabolic, depressed; scales on the neck four. Native of North America.

2. *Cr. sclerops.* A transverse ridge between the orbits;

neck furnished with four bony bands. Native of Guiana and Brasil.

3. *Cr. palpebrosus.* Bony palpebræ; neck furnished with four bony bands.

4. *Cr. trigonatus.* Bony palpebræ; neck furnished with irregular triangular carinated scales.

SUBGENUS II. *Crocodiles.* (Sect. I. Daudin.)

5. *Cr. vulgaris.* Muzzle equal; scales of the neck six; those of the back in sixes, square. Native of Africa.

6. *Cr. biporcatus.* Muzzle furnished with two ridges nearly parallel; plates of the neck six; scales of the back in eights, oval. Native of the Indian islands.

7. *Cr. rhombifer.* Muzzle sub-convex, with two converging ridges; plates of the neck six; scales of the back in sixes, square, those of the limbs thick and carinated.

8. *Cr. galeatus.* Top of the head furnished with a two-toothed elevated crest; plates of the neck six. Native of India beyond the Ganges.

9. *Cr. biscutatus.* Intermediate scales of the back square; outer ones irregular both in form and situation; plates of the neck two.

10. *Cr. acutus.* Intermediate scales of the back square; outer ones irregular; plates of the neck six; muzzle elongated and convex at the base. Native of the Antilles.

SUBGENUS III. *Longirostres, or Gavials.* (Sect. II. Daud.)

11. *Cr. gangeticus.* Top of the head and orbits transverse; two small plates on the neck.

12. *Cr. tenuirostris.* Top of the head and orbits contracted; four small plates on the neck.

M. Geoffroy St Hilaire, in a second Memoir on Crocodiles, in the tenth volume of the *Annales de Museum*, has formed another species of Nilotic crocodile, under the trivial name *Suchos*; but his account of it is not sufficiently precise to determine its specific differences.

As we have already, under the article CROCODILE, given a comprehensive account of the three principal species of this tribe, viz. the crocodile of the Nile, the alligator, and the Gangetic crocodile, or *caïman*, we shall at present dispense with any thing more on the natural history of these animals.

GENUS II. DRACÆNA. DRAGON.

In this genus the body is covered with large rounded scales, (those upon the back being carinated,) disposed in transverse bands, and separated by numerous other very small scales that are round and carinated. The head is thick, compressed laterally, and covered at the top with several smooth scales. Some of the teeth in the fore part of the jaws are sharp-pointed, and those behind are broad and flat like the molares of quadrupeds. The tongue is forked at its distal extremity; and the tympanum of the ear is apparent externally of a round form. The lower part of the body is covered with smooth scales, disposed in transverse bands. The tail is covered on that half next the body with plates, which form on its upper part first four, and then two toothed ridges, while the remaining half is covered with rough rhomboidal scales, carinated and imbricated. The four feet are each furnished with five long toes, completely separated from each other, and terminated by claws.

There is only one species, viz.

SPECIES 1. *Dracæna guianensis.* Guiana dragon.

*La Dragone de la Guian*, Daud. i. p. 423. pl. xxviii.

*La Dragone*, Lacepede, vol. i. part. ii. art. 5. pl. xiii.

*Lacerta dracæna*, Linn. a Gmelin, p. 1059.

*Dracæna lizard.* Shaw, iii. p. 218. pl. 67.

See Plate CCXCVI. Fig. 4.

This animal in many respects resembles the smaller crocodiles, differing from them chiefly in its forked tongue and distinct toes. It is of a reddish-brown colour, shaded with green. It is from two to four feet in length, of which the tail is about one half. This latter organ is very thick at its proximal extremity, tapering gradually towards the point, and is strong and flexible.

The dragon has hitherto been found only in South America, and chiefly in Guiana. It is a land animal, frequents the savannahs and marshy plains; readily climbs trees, and hides itself when in danger from crocodiles or other enemies. Both its flesh and eggs are used as articles of food.

GENUS III. BASILISCUS. BASILISK.

The body in this tribe is thicker in proportion to its length than many of the order; and its whole surface, as well as that of the head, neck, tail, and limbs, is covered with small scales, that are generally rhomboidal and a little carinated. The head is short and pretty thick, especially towards the back part; the tongue broad, thick, flat, rounded at its tip, not extensile, and almost wholly attached within the lower jaw. The throat is susceptible of inflation. The tail is long, very much compressed laterally, and surmounted, at least along its anterior half, with a high vertical crest that is radiated, capable of being folded together, and scaly. The feet are rather thick and long, and furnished each with five toes, terminating in claws.

There are two species, viz.

*Species* 1. *Basiliscus mitratus.* Mitred basilisk. Tail long and pointed; back of the head surmounted with a very high mitre-shaped membrane. See Plate CCXCVI. Fig. 5.

*Le Basilic proprement dit*, ou *a capuchon*, Daud. iii. p. 310. pl. xlii.

*Le Basilic*, Lacepede, vol. i. part ii. art. 14.

*Lacerta basiliscus*, Linn. a Gmelin, 1062.

2. *B. amboinensis.* Amboina B. Tail long; head naked, dorsal crest pectinated.

*Le B. porte-crète d'Amboine*, Daud. iii. p. 322.

*Le porte-crète*, Lacepede, vol. i. part ii. art. 15.

*Lacerta amboinensis*, Linn. a Gmelin, p. 1064.

The animals above characterised, though singular in their external appearance, have nothing of the terrible aspect and deadly properties of the basilisk, so renowned among the writers of antiquity. See BASILISK. They are harmless inoffensive creatures, enlivening the woods of America and Asia with their active motions. Assisted by the crest on their back and tail, they leap with agility from branch to branch, though they have no pretensions to flying, as was supposed by Seba. It is not certain whether they frequent the water, but if they do, their crested membranes must act as fins.

GENUS IV. TUPINAMBIS.

The animals of this tribe have the back and belly covered with small scales disposed in transverse lines. The head is covered with numerous small scales, and, as well as the neck, is long and thin. The tongue is long, extensile, and forked. The body is long and slender, but of a robust make. The tail is very long, and taper; rounded at its base, slightly verticillated, or ringed, furnished with a very small double ridge in some species, but smooth in others. The feet are strong, and have each five toes separated and furnished with claws.

The tupinambes are very active, live both on land and in the water, feed on insects, snails, and worms, and sometimes on wood mice, fruits, and fishes. The larger species seek greedily after the eggs of crocodiles, although they carefully avoid the young of those animals, which, in their turn, prey on the tupinambes. They are all natives of warm climates, and are found chiefly in South America, Egypt, and the East Indies.

Daudin has characterised fourteen species, which he distributes under two Sections as follows:

Sect. I. *Tupinambes with the Tail compressed and simple.*

*Species* 1. *Tupinambis monitor.* Safeguard tupinambis. Head covered with pretty large scales; back black, with four longitudinal lines and transverse white bands, irregularly disposed; belly whitish, with black shades; tail very little compressed.

*Le Tupinambis proprement dit*, ou *Sauvegard*, Daud. iii. p. 20.

*Le Tupinambis*, Lacep. i. part ii. art. 6. pl. xiii. fig. 2.

*Lacerta monitor*, Linn. a Gmelin, p. 1059.

*Monitory lizard*, Shaw, iii. p. 214. pl. lxvi.

2. *T. elegans.* Elegant T. Brownish with white concentric lines above the head and neck, nine transverse bands of round white spots upon the back; the belly white with interrupted transverse brown lines; tail very much compressed.

*Le T. elegans*, Daud. iii. p. 36.

3. *T. cepedianus.* Cepedian T. Brownish above, with from 23 to 24 transverse rows of spots; white on the fore part of the body, and black on the hinder; whitish below, with interrupted transverse brown lines.

*Le T. cepedian*, Daud. iii. p. 43. pl. xxix.

4. *T. indicus.* Indian T. Black above, with confusedly scattered white dots.

*Le T. indien*, Daud. iii. p. 46. pl. xxx.

5. *T. maculatus.* Spotted T. Black above, irregularly marked with transverse bands, and seven longitudinal rows of greenish spots on the upper part; neck plaited below; tail half the length of the body.

*Le T. a taches vertes*, Daud. iii. p. 48.

6. *T. griseus.* Gray T. Yellowish-gray without spots, paler below; scales nearly hexagonal, granulated on their margin; tail nearly cylindrical, and as long as the body.

*Le T. gris d'Egypte*, Daud. viii. p. 352.

Sect. II. *Tupinambes having the Tail surmounted with a small double Crest, slightly serrated.*

7. *T. stellatus.* Stellated T. Blackish-brown above, with transverse bands of small whitish circular spots, interspersed with whitish dots; tail long.

*Le T. etoilé d'Afrique*, Daud. iii. p. 59. pl. xxxi.

8. *T. niloticus.* T. of the Nile. Differs from the former in having the acellated spots and dots irregularly disposed. Probably a variety. See Daud. viii. p. 353.

9. *T. bengalensis.* Bengal T. Ash-coloured above, spotted with white and black; black bands across the cheeks; throat dotted with black; whitish below; tail long.

*Le T. piqueté de Bengale*, Daud. iii. p. 67.

10. *T. ornatus.* Ornamented T. Body black; throat white, radiated with nine transverse black bands; with seven transverse rows of round white spots upon the back; and from twelve to eighteen whitish rings round the tail. See Plate CCXCVI. Fig. 6.

*Le T. orné*, Daud. viii. p. 307. *Ann. de Mus. de Hist. Natur.* tom. ii. p. 240. pl. xlviii.

11. *T. albigularis.* White-throated T. Lower part and sides of the head and neck whitish, spotted with brown; two whitish lines extending from the eyes to the neck; tail long.

*Le T. a gorge blanche*, Daud. iii. p. 72. pl. xxxii.

12. *T. variegatus.* Variegated T. Blackish above, variegated with double transverse rows of round yellow lines and shades; tail twice as long as the body.

*Le T bigarré*, Daud. iii. p. 76.

*Variegated lizard*, White, *Voyage to N. S. Wales*, p. 253.

13. *T. exanthematicus.* Pimply T. Black-coloured, with roundish white spots irregularly disposed; belly marked with brown bands; two black lines behind the eyes; head scaly above; tail of moderate length.

*Le T. exanthematique de Senegal*, Daud. iii. p. 80.

14. *T. lacertinus.* Lizard T. Some carinated scales along the back; eight longitudinal rows of smooth plates below the belly; tail long, with a small double crest at its base.

*Le T. lizardet*, Daud. iii. p. 85.

*Le Silonné.* Lacepede, i. part ii. art. 11.

*Lacerta bicarinata*, Linn. a Gmelin, p. 1060.

Genus V. Iguana. GUANAS.

The individuals of this tribe resemble those of the last, in having the body and tail surrounded with numerous small rings of minute scales that are nearly of a square figure, and in sometimes having the tail a little compressed at the sides, though this is in a small degree. A high crest composed of numerous pointed scales, resembling the teeth of a comb, extends along the *vertebræ* from the neck to near the tip of the tail. The head is somewhat pyramidal, and has four sides; the tongue is broad, flat, fleshy, but little extensile, and a little notched at its tip; and below the throat is a pendulous inflated skin, compressed laterally, and furnished at its fore part with a crest resembling that on the back and tail. The feet are strong, each having five toes ending in claws, and under each thigh is a row of small porous tubercles. The Guanas are found both in the E. and W. Indies; and chiefly inhabit the woods, sporting among the trees. There are three species. viz.

*Species* 1. *Iguana delicatissima.* Common guana. Swelling of the throat pectinated anteriorly; dorsal and caudal crest pectinated; forehead and muzzle covered with smooth plates. Plate CCXCVI. Fig. 7.

*L'Iguane ordinaire*, Daud. iii. 263. pl. xl.

*L'Iguane*, Lacepede, vol. i. part ii. art. 12.

*Lacerta iguana*, Linn. a Gmelin. p. 1062.

*Common guana*, Shaw, iii. pl. lxi.

2. *I. cornuta.* Horned G. Swelling of the throat anteriorly pectinated; forehead beset with tubercles, especially one resembling a horn.

*L'Iguane cornu*, Daud. iii. 282.

*Le lezard cornu*, Lacepede, vol. i. part ii. art. 13.

3. *I. cærulea.* Blue G. Bluish-black, without spots; a longitudinal row of pointed scales on each side of the neck.

*L'Iguane ardoisé.* Daud. iii. p. 286.

*Species* 1. *Iguana delicatissima.* Common guana.

This animal, after the crocodile and the dragon, is one of the largest of the Saurian order, being not unfrequently found from four to six feet long from the muzzle to the tip of the tail. In its general appearance, exclusive of its colours, it is clumsy and unsightly, and occasionally even assumes a terrific aspect. Its head is large and thick; its belly protuberant; its tail very long, thick at its commencement, and tapering gradually towards a sharp point. Its serrated back, tail, and throat, its long toes armed with sharp crooked claws, and its jaws with numerous sharp teeth, are sufficient to alarm an observer who is unacquainted with its history. To counterbalance these deformities, however, its whole surface is covered with numerous shining scales, of the most brilliant appearance, reflecting various colours when viewed in the sunshine, though the prevailing tint is a brownish green.

The guana is found both in South America and the West Indies, where it inhabits the forests, especially near the borders of lakes or the banks of rivers. It sometimes ascends the highest trees in quest of insects; at others, seeks its prey among the grass and underwood. It is a harmless, inoffensive animal, and soon becomes familiar with mankind. Its flesh forms a delicious article of food, and is either roasted fresh, or salted and barrelled up for exportation, by the inhabitants of those islands where it is most frequent. It is said that the negroes are very expert in catching this animal, amusing it by whistling, and, when it suffers them to approach, tickling it with the end of a rod, having attached to it a cord with a running noose, which they gradually slip over the head of the animal, and thus secure their prey.

### Genus VI. Draco. FLYING DRAGONS.

The extraordinary reptiles comprehended under this name, differ from all the other oviparous quadrupeds, in having a membranous expansion resembling a wing, supported by bony rays, and capable of being folded and unfolded, extending from the flanks along each side of the body to the shoulders. In other respects they resemble the guanas, having, like them, a crest along the back and part of the tail, and an inflated membrane below the throat. Their tail is, however, proportionally longer, smaller, and more cylindrical, and their limbs more delicately formed. Naturalists of the present day reckon three species, which Daudin has distinguished by the following names and characters:

*Species* 1. *Draco lineatus.* Radiated flying dragon. Body beautifully variegated with blue and grey above; wings brown, longitudinally streaked with white.

*Le Dragon rayé*, Daud. iii. p. 298.

2. *D. viridis.* Green flying D. Body green, rather scaly; wings grey, transversely marked with four brown bands, and connected with the thighs. See Plate CCXCVI. Fig. 8.

*Le D. verd*, Daud. iii. p. 301. pl. xli.

*Draco volans*, Linn. a Gmel. p. 1056.

*Le Dragon*, Lacepede, vol. ii. part ii. art. 53.

3. *D. fuscus.* Brown dragon. Body brown, paler beneath, scarcely scaly; wings brown.

*Le D. brun*, Daud. iii. p. 307.

These animals so far resemble each other in habits, manners, and habitation, that it is unnecessary to describe each species. They are usually of small size, seldom exceeding eight inches in length.

From this small size, and the membranous wings with which they are furnished, they readily support themselves for some time in the air, though their flight seldom extends beyond thirty paces, darting from tree to tree in the manner of the flying squirrels; animals which they much resemble, as well in their motions as in their manner of life. They are supported chiefly by insects, which they sometimes take while on their flight. Flying dragons are found in Asia, Africa, and America, especially in the island of Java.

We need scarcely remark, that the fantastic animals described by the older writers of natural history, under the name of dragons, are mere creatures of the imagination; though it may be proper to observe, that specimens are not unfrequently met with, in cabinets of animals, that nearly resemble the figures given by those writers. It is now known that these specimens are artificial, and are formed by designing people, who make a trade of selling natural curiosities, by dressing up small ray fish, so as to resemble the fabulous dragons.

### Genus VII. Agama. AGAMAS.

The species now ranked under this name had generally been regarded as guanas, or stellios, from which Daudin distinguishes them by the following characters: Body oblong, more or less thick, entirely covered with small rhomboidal scales, that are almost always carinated and reticulated together; tail in most instances cylindrical, but in a few compressed; throat capable of being inflated; tongue short, thick, a little cleft at its tip; head thick, callous, generally set with spines at the back part, and covered with numerous small rhomboidal scales; feet long and thin, having each five slender toes furnished with claws. There are twenty-five species, arranged under five Sections.

#### Sect. 1. *Agamas having a compressed Tail.*

*Species* 1. *Agama superciliosa.* Supercilious Agama. Body of a pitchy black; back and tail crested above; occiput callous and spinous; scales of the body rhomboid and carinated.

*L'Agame sourcilleux*, Daud. iii. p. 336.

*Lacerta superciliosa*, Linn. a Gmel. p. 1063.

*Le Sourcilleux*, Lacepede, vol. i. part ii. art. 7.

*Fringed lizard*, Shaw.

2. *A scutata.* Fork-headed A. Tail a little compressed, of the length of the body; a serrated crest on the back and tail; occiput callous and two forked.

*L'A. occiput fourchu*, Daud. iii. p. 345.

*Lacerta scutata*, Linn. a Gmel. p. 1063.

*Shielded lizard*, Shaw.

*La tete fourchue*, Lacepede, vol. i. part ii. art. 8.

3. *A. atra.* Black A. Occiput very spinous; body of a blackish squalid brown above, with a longitudinal yellowish band along the back; belly and throat bluish; tail a little compressed.

*L'Agame sombre*, Daud. iii. p. 349.

4. *A. fasciata.* Banded A. Tail compressed, thrice as long as the body; colour blue, paler below, with pale spots on the neck, and four transverse pale blue bands, of which the second is the shortest, on the back.

*L'A. à bandes de l'Inde*, Daud. iii. p. 352.

#### Section II. *Agamas properly so called.*

Body slender, without tubercles; tail cylindrical.

5 *A. colonorum.* Common Agama. Tail long; upper part of the neck and back part of the head spinous, with the scales of the occiput reversed; a small dorsal pectinated crest; colour a pale greenish blue.

*L'A. des colons*, Daud. iii. p. 356.

*Lacerta agama*, Linn. a Gmel. p. 1064.

*L'Agame*, Lacep. i. part ii. art. 17.

6. *A. calotes.* Galeot A. Blue; tail long; fore part

of the back and back part of the head furnished with a small crest. See Plate CCXCVII. Fig. 9.

*L'A. galeote*, Daud. iii. p. 361. pl. xliii.
*Lacerta calotes*, Linn. a Gmelin, p. 1063.
*Galeot lizard*, Shaw.
*L'A. galeote*, Lacepede, i. part ii. art. 15.

7. *A. Umbra.* Clouded A. Tail long; occiput callous and spinous; back five streaked; a black spot on the throat.

*L'A. umbre*, Daud. iii. p. 375.
*Lacerta umbra*, Linn. a Gmel. p. 1064.
*Clouded lizard*, Shaw.
*L'Umbre*, Lacepede, ii. part ii. art. 30.

8. *A. undulata.* Undulated A. Ash brown above, irregularly marked with transverse bands or waves; bluish below, with a large whitish cross.

*L'A. ondulé*, Daud. p. 384.

9. *A. angulata.* Angled A. Head wrinkled above, and almost naked; scales of the back rhomboidal and carinated, those of the belly smooth; two large round scales below the throat; tail long and hexagonal.

*L'A. hexagone*, Daud. iii. p. 389.
*Lacerta angulata*, Linn. a Gmel. 1061.
*Angulated lizard*, Shaw.
*L'Hexagone*, Lacepede, i. part ii. art. 22.

10. *A. muricata.* Muricated A. Body longitudinally streaked with pointed carinated scales; tail striated, barred, twice as long as the body; occiput callous and spinous.

*L'A. hérissé de la Nouvelle Hollande*, Daud. iii. p. 391.
*Muricated lizard.* White's *Voyage to New South Wales*, p. 244.

11. *A. versicolor.* Harlequin A. Back marked on each side with a longitudinal white line; body of a clear blue, with transverse brown bands upon the back; tail twice as long as the body.

*L'A. Arlequiné*, Daud. iii. p. 395, plate xliv.

12. *A. flavigularis.* Yellow-throated A. Grey, reddish above, with a yellow throat; tail once and a half as long as the body, a short longitudinal white line upon each flank.

*L'A. a gorge safranée*, Daud. iii. p. 398.

13. *A. rosacauda.* Rose-tailed A. Grey, pale below; tail of a rose colour, $1\frac{1}{2}$ the length of the body.

*L'A. rose-queue*, Daud. iii. p. 400.

14. *A. aspera.* Rough A. Head smooth and reddish above; body and tail beset with pointed scales, marbled with transverse shades of reddish-brown and white.

*L'A. rude*, Daud. iii. p. 402.

15. *A. stellaris.* Starred A. Body and tail furnished above with a toothed crest, with numerous white starry points on the back and on each side.

*L'A. etoilé*, Daud. iii. p. 404.

### Section III. *Orbicular Agamas or Tapays.*

Body a little depressed, and beset here and there with small rounded or pointed tubercles.

16. *A. orbicularis.* Orbicular A. Body orbicular and rough, variegated above with brown; head like that of a toad; feet yellow below; tail of moderate length.

*L'A. orbiculaire*, Daud. iii. p. 406. plate xlv. fig. 1.
*Lacerta orbicularis*, Linn. a Gmel. p. 1061.
*Le Tapaye*, Lacepede, vol. ii. part ii. art. 37.
*Orbicular lizard*, Shaw.

17. *A. Gemmata.* Gemmed A. Body marked with six longitudinal rows of four-sided pointed scales, with brownish transverse angular bands upon the back.

*L'A. à pierreries*, Daud. iii. p. 410.

18. *A. plica.* Plated A. Tail long; occiput callous, palpebræ excoriated above; neck tuberculated at the sides, and plated below.

*L'A. plissé*, Daud. iii. p. 412.
*Lacerta plica*, Linn. a Gmel. p. 1074.
*Le plissé*, Lacepede, ii. part ii. art 31.

19. *A. paraguensis.* Paraguay A. Tongue round and thick; head obtuse; a longitudinal brown band upon the back, with a triangular brown spot on each side of the tail.

*L'A. du Paraguay*, Daud. iii. p. 414.

20. *A. helioscopa.* Stargazing A. Tail imbricated, thick at the base, and sharp at the tip; head thick and callous, spinous at the back part; neck contracted, marked with a transverse fold below; tail scarlet below.

*L'A helioscopa*, Daud. iii. p. 419.
*Lacerta helioscopa*, Linn. a Gmel. p. 1074.

21. *A. uralensis.* Uralian A. Head roundish, neck plated below; back of a livid ash-colour, wrinkled, and a little rough; tail the length of the body, black at the tip, and six-banded.

*L'A. raboteux de l'oural.* Daud. iii. p. 422.
*Lacerta uralensis*, Linn. a Gmel. p. 1073.

22. *A. guttata.* Dotted A. Head roundish; body smooth, blue above, with round white dots; belly whitish; tail longer than the body, black at its tip, with four black opposite spots towards its base.

*L'A. a goutelettes*, Daud. iii. p. 426.
*Lacerta guttata*, Linn. a Gmel. p. 1078.

23. *A. aurita.* Eared A. Angles of the mouth dilated on each side into a semi-orbicular dentated crest.

*L'A. a oreilles*, Daud. iii. p. 429. plate xlv. fig. 2.
*Lacerta aurita*, Linn. a Gmel. p. 1073.

### Sect. IV. *Lizard Agamas.*

Plates on the head, and a row of granular pores under each thigh.

24. *A. marmorata.* Marbled A. Throat inflated; head covered with numerous plates, colour brownish-bay, with transverse dark bands and green shades; tail very long.

*L'A. marbré de Surinam*, Daud. iii. p. 433.
*Lacerta marmorata*, Linn. a Gmel. p. 1065.
*Marbled lizard*, Shaw.
*Le marbré*, Lacepede, ii. part ii. art. 39. plate ii.

### Sect. V. *Agamas with prehensile Tails.*

25. *A. prehensilis.* Prehensile A. Four transverse black bands on each flank; belly brown, with black and white shades; three black bands upon the cheeks; tail prehensile, scarcely longer than the body.

*L'A. a queue prenante*, Daud. iii. p. 440.

## Genus VIII. Stellio. STELLIOS.

Body oblong, thick, entirely covered with small scales, regularly disposed transversely; tongue thick, short, and a little cleft at the tip; head broad, rather short, covered above with numerous scales or plates; throat capable of slight inflation; tail compressed, surrounded with transverse rows of large carinated pointed scales; feet strong, furnished each with five separate toes, tipt with claws.

This singular tribe of reptiles, which, in the form of their bodies and the tubercles with which they are often covered, bear some resemblance to the toads. are found only in the hottest parts of Africa and America. They hide themselves during the day below stones, and in the crevices of old buildings, and leave these retreats at the approach of night. They prefer dry situations, and live chiefly on insects.

Daudin has characterised nine species, which he arranges under three Sections, as follows.

Sect. I. *Cordyli.*

Plates upon the head, body, and tail, versicillated and spinous.

*Species* 1. *Stellio cordylus.* Cordyle S. Head plated above, body and tail covered with pointed carinated scales, disposed in whirls.

*Le Stellion Cordyle*, Daud. iv. p. 8.

*Lacerta Cordylus*, Linn. a Gmel. p. 1060.

*Le Cordyle*, Lacepede, i. part ii. art. 21.

Sect. II. *True Stellios.*

Head covered above with small scales, with some scattered transverse bands of large scales upon the body.

2. *S. Vulgaris.* Common S. Body covered with small scales, with a few transverse bands of larger scales upon the back; scales of the tail a little elongated.

*Le S. proprement dit*, Daud. iv. p. 16.

*Lacerta Stellio*, Linn. a Gmel. p. 1060.

*Le Stellion*, Lacepede, ii. part ii. art. 33.

*Rough lizard*, Shaw.

3. *S. Platurus.* Broad tailed S. Tail flat, broadest in the middle, spinous at its edges; occiput and back tuberculated and spinous; muzzle slender; colour brownish-grey.

*Le S. a queue plate de la Nouvelle Hollande*, Daud. iv. p. 24.

*Broad tailed lizard.* White's *Voy. to New South Wales*, p. 246.

Sect. III. *Bastard Stellios.*

Numerous very small scales on the upper part of the head and body.

4. *S. quetz-paleo.* Quetz-paleo S. Pale grey; body a little scaly and granulated; tail the length of the body, with elongated scales, each thigh furnished below with a row of fifteen pores.

*Le S. quetz-paleo.* Daud. iv. p. 26.

5. *S. Spinipes.* Spinefooted S. Body of a bright green, covered with minute scales, spinous at the sides; upper part of the feet covered with round sharp scales; pores below the thighs; tail a little elongated.

*Le S. Spinipède*, Daud. iv. p. 31.

6. *S. azureus.* Azure S. Body of a light azure colour, without spots, and slender; tail elongated, and surrounded with 35 or 36 spinous whirls.

*Le S. Azuré de l'Amérique meridionale*, Daud. iv. p. 36. pl. xlvi.

7. *S. brevicauda.* Short tailed S. Colour light blue, with transverse bands of a darker blue, and a star-like spot upon the forehead; tail a little depressed and short. See Plate CCXCVII. Fig. 10.

*Le S. courte queue*, Daud. iv. p. 40. pl. xlvii.

8. *S. Pelluma.* Pelluma S. Upper part of the body variegated with green, yellow, blue, and black; lower part with green and yellow; tail the length of the body.

*Le S. pelluma du Chili*, Daud. iv. p. 46.

*Lacerta pelluma*, Linn. a Gmel. p. 1060.

*Pelluma lizard.* Shaw.

9. *S. niger.* Black S. Colour black, with a double broad white spot on each side of the neck.

*Le S. négre*, Daud. iv. p. 48.

Genus IX. Chameleo. CHAMELEONS.

The head short and pretty thick, covered on its surface with smooth five-sided or six-sided scales; nose generally obtuse; eyes covered with a granular membrane perforated in the middle; tongue long and cylindrical, terminating in a glutinous tubercle, and very extensile; tympanum of the ear very apparent; throat capable of inflation into a compressed pouch; body elongated, compressed, capable of considerable inflation, covered with small scaly tubercles, irregularly disposed at a distance from each other; back sharp, and often furnished with a crest formed by small prominent or pointed scales; tail at least as long as the body, covered with a granular scaly skin, capable of being rolled in a spiral form round an object; feet furnished each with five toes, terminating in claws, and united two together and three together.

*Species* 1. *Chameleo vulgaris.* Common chameleon, brownish-grey, with a spiny crest upon the back and throat; occiput pyramidal, four-sided, with prominent tubercles under the skin of the back. See Plate CCXCVII. Fig. 11.

*Le Chaméléon ordinaire*, Daud. iv. p. 181.

*Lacerta chamæleon.* Linn. a Gmel. p. 1069. See Shaw's *Gen. Zool.* iii. pl. lxxvi.

*Le Caméléon*, Lacepede, ii. part ii. art. 26.

2. *C. Senegalensis.* Senegal C. Yellowish ash colour, shaded above with blackish; an acute slender crest upon the back, and a serrated crest upon the belly; occiput furnished with a triangular eminence.

*Le C. à ventre dentelée en scie du Senegal*, Daud. iv. p. 203.

3. *C. pumilus.* Dwarf C. Light blue, with two yellowish longitudinal lines on each side of the body; throat fringed below.

*Le C. nain du Cap de bonne Esperance*, Daud. iv. p. 212. pl. liii.

*Lacerta pumila.* Linn. a Gmel. p. 1069.

4. *C. bifidus.* Two-forked C. Fore part of the muzzle prominent and two-forked, with each division long and compressed.

*Le C. nez fourchu de l'Inde*, Daud. iv. p. 217. pl. liv. See *Phil. Trans.* vol. lviii.

The chameleons are remarkable both for peculiarity of structure and singularity of manners; and the first and best known species has long been celebrated, both in ancient and modern times, for the variety of colours which it assumes on different occasions. Their skin is remarkably thin and delicate, and is so loose and dilatable, especially about the belly, as to admit of considerable inflation when the animals expand their ample lungs by a long and deep inspiration. Their eyes are remarkable, both for the membrane that covers them, and for the ease with which they are directed at the same time towards different objects. The peculiar structure of their feet, and their prehensile tails, serve to give them a surer hold of the branches of trees in which they generally live, and thus secure them against the attacks of serpents, by whom they are eagerly sought after, while their long extensile and glutinous tongue enables them more easily to catch the insects which form their natural food. From the smallness of these insects, and the long abstinence which the chameleons are able to sustain, it was long believed that these animals lived upon air: a vulgar error, which has given birth to many a pretty expression among our poets. It has also been supposed, that chameleons assume the colour of any object on which they are laid. This is so far true, that if the object be green of any shade, as green is the prevailing colour of the chameleon, and as it passes through various shades of this colour, when pleased or angry, hungry or satiated, it acquires, in the course of the experiment, a shade very near that of the grass or cloth on which it is laid. It never becomes quite blue or quite white, though it often verges upon these colours; and sometimes the shade of green is so dark, that a hasty observer might call it black.

Attempts have been made to account for the changes of colour in the chameleon, by the remark, that the blood of this animal is of a violet blue, while the natural colour of the skin is yellow; hence, when the skin is most transparent, and the animal in greatest vigour, the shade of green is darkest, or assumes most of the blue tinge, while, when the skin is least stretched, and the circulation languid, the colour becomes paler, and verges towards yellow-white, or even brown.

Chameleons are found chiefly in the tropical climates of the old continent, especially in Egypt and other parts of Africa. They are generally of diminutive size, the largest not exceeding two feet, from the muzzle to the tip of the tail; of which the tail occupies one-half.

### Genus X. Gecko. GECKOS.

The animals of this tribe are not so unsightly in their external appearance as they are disgusting in their manners, and the noxious fluid which they secrete. Their head is pretty thick, especially at the articulation of the jaws, where it is bordered with small plates, while the surface of the head is covered with small rounded prominent scales; the muzzle is taper; the tongue thick, flat, slightly cleft at its tip, and glutinous, but not extensile; the eyes resemble those of the chameleons, but the external opening of the ears is less apparent, and the throat is susceptible of slight inflation. The body is long and thin, a little depressed, and covered with very small prominent scales; the tail is generally cylindrical, but in a few species flattened; the feet have each five broad toes, flattened along their margins, covered on their inferior surface with small transverse imbricated scales, concealing glandular pores, from which exudes a very corrosive fluid. Each toe is tipped with a small crooked claw.

The geckos are found in South America, in Africa, and the East Indies. They live about walls and in trees, feed chiefly on insects, and have so little dread of mankind, as familiarly to enter their houses.

There are 15 species, arranged under three Sections.

#### Section I. *Geckos.*

Geckos, properly so called, having the five toes distinct, or a little palmated at their base, the tail cylindrical, and the body smooth.

*Species* 1. *Gecko Ægyptiacus.* Egyptian or common gecko. Light ash-grey; tail for the most part having six broad rings at its base; body rather swollen, and a little flattened. See Plate CCXCVII. Fig. 12.

*Le Gecko ordinaire*, Daud. iv. p. 107.

*Lacerta gecko*, Linn. a Gmel. p. 1068.

*Common gecko, lizard*, Shaw.

*Le Gecko*, Lacepede, ii. part ii. art. 48.

A very curious structure has lately been detected in the foot of this animal by Sir Everard Home, Bart. Sir Joseph Banks had often observed at Batavia, that the Gecko comes out in the evening from the roofs of the houses, and walks down the smooth hard polished chunam walls in search of flies; and it occurred to Sir Everard Home, that this must be done by a contrivance like that of the *Echineis remora*, or sucking fish. Having procured from Sir Joseph a large specimen weighing 5¾ oz. he was enabled to ascertain the peculiar mechanism by which the feet of the animal can keep hold of a smooth surface. Plate CCXCV. Figs. 18, 19. The Gecko has five toes, and at the end of each, except the thumb, is a very sharp curved claw. On the under surface of each toe are 16 transverse slits, leading to as many cavities, or pockets, whose depth is nearly equal to the length of the slit which forms the orifice: they all open forwards, and the external edge of each opening is serrated like a small-toothed comb. The cavities, pockets, and serrated edges, are covered with a cuticle. A large oval muscle moves the claw of each toe; and from the tendons of these large muscles, two sets of smaller muscles originate, one pair of which is lost upon the posterior surface of each of the cavities that lie immediately over them. The large muscles draw down the claws, and necessarily stretch the small muscles. When the small muscles contract, they open the orifices of the cavities, and turn down their serrated edge upon the surface on which the animal stands. By this means vacua are formed, and the animal adheres to the surface by the pressure of the atmosphere. See *Phil. Trans.* 1816, p. 149. and page 404, col. 2. of this article.

2. *G. lævis.* Smooth G. Ash grey, all the scales very minute, inside of the thighs not porous; tail of moderate length, simple at the base; tips of the toes triangular.

*Le G. lisse d'Amérique*, Daud. iv. p. 112.

3. *G. spinicauda.* Spine-tailed G. Body smooth; tail nearly the same length as the body, thick, and ringed at the base; rings beset with spines on each side.

*Le G. a queue épineuse*, Daud. iv. p. 115.

4. *G. guttatus.* Dotted G. Pale red above, with small round whitish spots disposed in rows; numerous square scales upon the tail.

*Le G. a gouttelettes blanches*, Daud. iv. p. 122. pl. xlix.

5. *G. Surinamensis.* Surinam G. Tail as long as the body, with brown bands, a yellowish band bordered with brown running from the eyes to the thighs; back marbled with little brown spots.

*Le G. de Surinam*, Daud. iv. p. 126.

6. *G. porphyreus.* Porphyry G. Pale red-brownish above, with numerous small round spots of a paler hue.

*Le G. porphyré*, Daud. iv. p. 130.

7. *G. squalidus.* Squalid G. Tail short; toes carinated above, lamellated below; scales very minute, unequal, and dotted.

*Le G. chagriné*, Daud. iv. p. 134.

8. *G. vittatus.* Banded G. Reddish, with a longitudinal white band running from the occiput, where it is forked, along the back; tail long, marked with white bands.

*Le G. a bandeblanche de l'Inde*, Daud. iv. p. 136. plate l.

*Lacerta vittata*, Linn. a Gmel. p. 1067.

*Forked lizard*, Shaw.

9. *G. rapicauda.* Turnip-tailed G. Dirty brown, with a whitish band, bordered with brown, behind the eyes; tail short, thick, and turbinated at the base, constricted at the anus, pointed at the tip.

*Le G. a queue turbinée*, Daud. iv. p. 141. plate li.

*Lacerta rapicauda*, Linn. a Gmel. p. 1068.

*Turnip-tailed lizard*, Shaw.

#### Sect. II. *Geckots.*

Tail cylindrical; body covered with pointed scales.

10. *G. fascicularis.* Common geckot. Twelve longitudinal rows of acute fasciculated scales on the body; tail short, with two broad rings at its base.

*Le G. fasciculaire*, Daud. iv. p. 144.

*Lacerta mauritanica*, Linn. a Gmel. p. 160.
*Moorish lizard*, Shaw.
*Le Geckotte*, Lacepede, ii. part ii. art. 49.

11. *G. triedrus.* Triangular G. Body covered above with eighteen longitudinal rows of triangular pointed scales; lower part of the tail covered with small transverse plates.
*Le G. a ecailles triédres*, Daud. iv. p. 155.

12. *G. Tuberculosus.* Tuberculated G. Brownish, covered above with scattered, sharp, tuberculated scales, with brown spots upon the back, disposed in pairs.
*Le G. tuberculeux*, Daud. iv. p. 158.

Sect. III. *Flat-tailed Geckots.*

13. *G. fimbriatus.* Fimbriated G. Head, body, and legs flattened at the sides, and bordered with a membranous fringe; tail broad and compressed, with a simple membrane on each side.
*Le G. a tete plâte*, Daud. iv. p. 160. pl. lii.
*La tete plâte*, Lacepede, ii. part ii. art. 50.

14. *G. cristatus.* Crested G. Tail furnished with a pinnatifid membranous crest; feet palmated.
*Le G. a queue cretée*, Daud. iv. p. 167.
*Lacerta caudiverbera*, Linn. a Gmel. p. 1058.
*Flat-tailed lizard*, Shaw.
*Le fouette queue*, Lacepede, i. part ii. art. 4.

15. *G. sarroubea.* Sarroube G. Yellow, spotted with green; fore feet four-toed.
*Le G sarroubé de Madagascar*, Daud. iv. p. 176.
*Le salamandre sarroubé*, Lacep. ii. part ii. art. 58.

## Genus XI. Anolis. ANOLES.

The animals of this genus are nearly allied to those of the last, in the form of their bodies and the structure of their feet, except that, in the latter, only the first joint of the toes are scaly below. The body is covered with fine granular scales; the tongue is not cleft, and is attached to the floor of the mouth; the tail is cylindrical in some species, and compressed in others.

The anoles are inhabitants of America, where they live in dry places much exposed to the sun. Daudin reckons eight species, arranged under two Sections.

Sect. I. *Anoles having the Tail compressed, carinated, and serrated.*

*Species* 1. *Anolis bimaculatus.* Two-spotted A. Bluish green, with a black spot upon each shoulder; back flattened and serrated. See Plate CCXCVII. Fig. 13.
*L'Anolis bimaculé*, Daud. iv. p. 55.
*Lacerta bimaculata*, Linn. a Gmel. p. 1059.
*Le Bimaculé*, Lacepede, i. part ii. art. 10.
*Pennsylvanian lizard*, Shaw.

2. *A. carbonarius.* Charcoal coloured A. Deep black, with shades of blue; throat yellow; toes broadest at their tips.
*L'A. charbonnier*, Daud. iv. p. 64.

3. *A. lineatus.* Striped A. Body marked on each side with two longitudinal rows of oblong black linear spots.
*L'A. rayé*, Daud. iv. p. 66. plate. xlviii. fig. 1.

Sect. II. *Anoles having a cylindrical Tail, articulated, but not carinated.*

4. *A. Bullaris.* Red-throated A. Greenish or reddish, with a black spot on the temple.
*L'A. roquet*, Daud. iv. p. 69.
*Lacerta bullaris*, Linn. a Gmel. p. 1075.
*Le roquet*, Lacepede, ii. part ii. art. 40. pl. iv. fig. 1.

5. *A. punctatus.* Dotted A. Blue above, with white dots, and a black longitudinal line upon the back; sides dotted with black.
*L'A. a points blancs de l'Amerique meridionale*, Daud. iv. p. 84. pl. xlviii. fig. 2.
*Lacerta punctata*, Linn. a Gmel. p. 1076.
*Dotted lizard*, Shaw, *Gen. Zool.* vol. iii.

6. *A. podagricus.* Gouty A. Greenish above, yellowish below, with marginated nostrils, and the joints of the toes flattened.
*L'A. goutteux*, Daud. iv. p. 87.

7. *A. auratus.* Gilded A. A longitudinal white line edged with brown, running from the eyes along each side of the body; toes slender.
*L'A doré*, Daud. iv. p. 89.

8. *A. sputator.* Spitting A. Tail round, and of moderate length, covered below with a longitudinal row of plates; toes truncated; body ash colour, with transverse white bands, bordered with liver colour.
*L'A. sputateur*, Daud. iv. p. 99.
*Lacerta sputator*, Linn. a Gmel. p. 1076.
*Spitting lizard*, Shaw, *Gen. Zool.* vol. iii.

## Genus XII. Lacerta. LIZARDS.

In the numerous tribe of lizards, properly so called, the body is covered on its upper part with very small hexagonal or rounded scales, disposed in numerous transverse bands, and below with small smooth square plates, disposed in longitudinal rows. The head resembles an oblong pyramid, with four sides covered above and on the sides with smooth plates. The tongue is forked, and capable of being thrust far out of the mouth. The opening to the ear is oval or oblong, and very apparent. The tail is at least as long as the body, quite cylindrical, composed of jointed rings, and has no upper crest. All the feet are nearly of equal length, and under each thigh there is a row of small, rough, porous, scaly tubercles. Each foot has five toes, completely separate, thin, and terminated by small crooked claws. Many of the species inhabit woody situations, and seek their food among the foliage, or in the underwood. This food consists chiefly of insects. Others live about ruinous buildings, or even approach the dwellings of mankind, and feed partly on insects, and partly on fruits and vegetables. A few have their natural habitation in marshes, ponds, or lakes, and prey upon the small animals which inhabit them.

The lizards are in general lively and active, and, on the whole, form the most pleasing of all the Saurian tribes. They are innocent in their manners; cheerful in their movements; and many of them, from their agreeable form and variety of colour, constitute very pleasing features in a group of natural objects.

Most of them are natives of the warmer climates; but more of this tribe than of any other of the Saurian order, are indigenous in the temperate countries of Europe. There are about 32 species, which Daudin distributes under seven Sections.

Sect. I. *Ameiva Lizards.*

No scaly collar on the neck; tail entirely cylindrical and verticillated.

*Species* 1. *Lacerta ameiva.* Ameiva lizard. Of a bright blue colour, with four longitudinal rows of round whitish spots on each side; neck transversely plaited below.

*Le lezard ameiva*, Daud. iii. p. 96.
*L'Ameiva*, Lacepede, vol. i. part ii. art 23.
*Lacerta ameiva*. Linn. a Gmelin, p. 1070.
*Blue lizard*, Shaw, *Gen. Zool.* vol. iii.

2. *L. litterata*. Lettered L. Bluish green, variegated above with oblong black spots, and transverse black bands, dotted with white on each side; neck transversely plaited below.
*Le L. verd a traites noires d'Allemagne*, Daud. iii. p. 106.

3. *L. graphica*. Graphic L. Bluish-green, marked with black points and characters, with a longitudinal fold on each side of the body, without white eye-like spots; neck transversely plaited below.
*Le L. graphique*, Daud. iii. p. 112.

4. *L. argus*. Argus L. Blue; back marked with blue, eyes disposed in transverse rows, with a longitudinal fold on each side of the body; tail transversely plaited below.
*Le L. argus d'Amerique*, Daud. iii. p. 117.

5. *L. gutturosa*. Swollen throated L. Sea-green, throat and neck swollen; red spots scattered over the body, especially on each side.
*Le L. verd u points rouges*, Daud. iii. p. 119.

6. *L. erythrocephala*. Red-headed L. Back dark green, with transverse undulated brown bands; throat white; breast black; sides marked with brown bands; belly striped longitudinally with black, blue, and white; head red; tail short.
*Le L. á tête rouge*, Daud. iii. p. 122.
*La tete rouge*, Lacepede, vol. i. part ii. art. 20.

SECT. II. *Green Lizards.*

Green lizards, having a scaly collar round the neck, and a verticillated tail.

7. *L. oscellata*. Eyed L. Black above, with lines and eye-like spots of a light green; light yellow below, without spots.
*Le grand L. verd ocellé du midi de l'Europe*, Daud. iii. p. 125. pl. xxxiii.
*Le L. verd*, Lacepede, i. part ii. art. 19. pl. xv. fig. 1.

8. *L. viridis*. Green L. Bright green, marked above with very numerous black or brown points; light green below without spots.
*Le L. piqueté d'Europe*, Daud. iii. p. 144. pl. xxxix.

9. *L. jamaicensis*. Jamaica L. Back reticulated with pale brown, with yellow dots; a double longitudinal row of ovate blue spots along each side; tail long.
*Le L. verd de la Jamaique*, Daud. iii. p. 149.

10. *L. bilineata*. Two-lined L. Back marked with two longitudinal white lines, edged above with brown; a longitudinal row of brown spots, and white points on each side of the body, and a long tail.
*Le L. verd a deux raies*, Daud. iii. p. 151. pl. xxxv. fig. 1.

11. *L. stirpium*. Copse L. Bright green, spotted with black; back and tail grey, with a brown interrupted line along the back; a double row of black eye-like spots along each side, and a dotted belly.
*Le L. de souches*, Daud. iii. p. 155. pl. xxiv. fig. 2.

12. *L. viridula*. Greenish L. Bright green above; yellow below; tail three times the length of the body, and black at the tip, with an orange-coloured spot on the occiput and neck.
*Le L. verdelet de Panama*, Daud. iii. p. 165.

13. *L. tiliguerta*. Tiligurta L. Tail double the length of the body; belly marked with eighty plates.
*Le L. tiligurta*, Daud. iii. p. 167.
*Lacerta tiligurta*, Linn. a Gmelin, p. 1070.

14. *L. dumetorum*. Wood L. Bright green, with the neck and belly of a bright steel colour; feet black, and the collar of the neck serrated, and of a violet colour.
*Le L. des boissons de Surinam*, Daud. iii. p. 172.

SECT. III. *Ribbon Lizards.*

Having a collar on the neck, and several longitudinal white parallel lines along the upper part of the body.

15. *L. lemniscata*. Laced L. Nine white longitudinal lines upon the back and sides; long tail, blue on the upper part; thighs spotted with white, and the middle dorsal line two-forked next the head. See Plate CCXCVII. Fig. 14.
*Le L. Galonné*, Daud. iii. p. 175. pl. xxxvi. fig. 1. Lacepede, i. part ii. art. 25.
*Lacerta lemniscata*. Linn. a Gmelin, p. 1075.

16. *L. sexlineata*. Six-striped L. Blackish brown above, with six longitudinal white lines upon the back, with another short white line extending from the eyes over the shoulders; tail twice as long as the body, and thighs without spots.
*Le L. a six raies*, Daud. iii. p. 183.
*Lacerta sexlineata*, Linn. a Gmelin. p. 1074.
*Le lion*. Lacepede, i. part ii. art. 24.

17. *L. bosquiana*. Bosquian L. Bright blue above, with nine white longitudinal lines, with intermediate dots upon the back and sides, the middle line being short and undivided; tail twice as long as the body; thighs spotted with white.
*Le L bosquien*, Daud. iii. p. 188. pl. xxxvi. fig. 2.

18. *L. cæruleocephala*. Blue-headed L. Head blue, with a white longitudinal line along the middle of the back; two yellow parallel lines on each side; white dots upon the thighs, and tail twice the length of the body.
*Le L a tête bleue*, Daud. iii. p. 19.

19 *La teyou*. Teyou L. Upper part of the head green; back violet colour, with one green line and six white ones; throat and belly of a silvery white.
*Le L. teyou verd*, Daud. iii. p. 195.

20. *L. deserti*. Desert L. Tail the length of the body; back black, with six white interrupted longitudinal lines; belly white without spots.
*Le L. du désert*, Daud. iii. p. 199.
*Lacerta deserti*, Linn. a Gmelin, p. 1076.

21. *L. velox*. Swift L. Body ash-coloured above, variegated with brown dots, and five longitudinal streaks of a lighter colour; sides spotted with black and blue.
*Le L. veloce*, Daud. iii. p. 202.
*Lacerta velox*, Linn. a Gmelin. p. 1072.

SECT. IV. *Spotted Lizards.*

22. *L. lepida*. Languedoc L. Body greenish blue above, with nine or ten transverse black bands, spotted with small round white eyes; belly whitish; tail scarcely longer than the body.
*Le L. gentil du Languedoc*, Daud. iii. p. 204. pl. xxxvii. fig. 1.

23. *L. maculata*. Spotted L. Blackish blue above, with a few round spots of a pale violet; belly whitish; tail once and a half as long again as the body.
*Le L. tacheté d'Espagne*, Daud. iii. p. 208. pl. xxxvii. fig. 2.

SECT. V. *Grey Lizards.*

24. *L. agilis*. Agile L. Ash coloured above, whitish

below; back marked with a longitudinal dotted brown line, and a subreticulated brown longitudinal stroke, edged with paler colour, on each side of the body.

*Le L. gris des murailles*, Daud. iii. p. 211. pl. xxxviii. fig. 1.

25. *L. brongniardi.* Brongniardian L. Bluish grey, irregularly marbled on the back with black spots, and with three longitudinal lines of black spots and dots on each side.

*Le L. brongniardien*, Daud. iii. p. 221.

26. *L. Sericea.* Silky L. Brownish above, shaded with glossy green and blue; pale green below; tail twice as long as the body, and a little streaked.

*Le L. soyeux*, Daud. iii. p. 224.

27. *L. laurentii.* Laurentian L. Ash brown above, every where spotted, with the spots upon the back obscure, those on the sides disposed in a triple longitudinal row.

*Le L. de Laurenti*, Daud. iii. p. 227.

28. *L. arenicola.* Sand L. Brownish grey, paler, without spots below, with a row of brown spots upon the back, and a double series of brown eyes dotted with white, and another single row of white dots on each side.

*Le L. arénicole*, Daud. iii. p. 230. pl. xxxviii. fig. 2.

29. *L. fusca.* Brown L. Dark brown, with a longitudinal row of obscure spots on each side; belly paler.

*Le L. brun*, Daud. iii. p. 237.

30. *L. arguta.* Sharp-snouted L. Tail short and verticillated, thick at the base. and very sharp at the tip; a remarkable double plate under the neck; general colour sea green, with numerous transverse black bands; belly white.

*Le L. a museau pointue*, Daud. iii p. 240.

*Lacerta arguta*, Linn. a Gmel. p. 1072.

### Sect. VI. *Dracenoid Lizards.*

Having two scaly folds under the neck, and a cylindrical tail verticillated at its proximal, and reticulated at its distal, half.

31. *L. quinquelineata.* Five-streaked L. Bluish, with five longitudinal black lines upon the back, and white spots on each side.

*Le L. a cinq raies*, Daud. iii. p. 243.

### Sect. VI. *Striated Lizards.*

32. *L. striata.* Striated L. Grey, bluish at the sides, with two longitudinal brown lines; scales of the back and belly carinated, and forming longitudinal streaks.

*Le L. strié*, Daud. iii. p. 247.

A considerable degree of uncertainty and ambiguity prevails among writers, respecting the animals called *Lizards*. If, with Linnæus and his followers, we comprehend under this name not only the species just enumerated, but the Tupinambes, the Stellios, the Basilisks, the Guanas, the Geckos, the Chameleons, the Scinks, and the other tribes of the Saurian order, we shall find it comprehend above 150 species; and even curtailed as it is by the modern French naturalists, we see that it is pretty numerous. As it is impossible for us, within the circumscribed limits of an article like the present, to describe even all the most important species, we shall here confine ourselves entirely to a general account of those which are found in the British islands.

Mr Pennant, in the 3d vol. of his *British Zoology*, has described only three species of lizard as belonging to Britain, viz. the *Scaly lizard*, (a variety of *Lacerta agilis*, Linn.) the *Warty lizard*, (*Lacerta palustris*, Linn.) and the *Brown lizard*, (*Lacerta vulgaris*, Linn.) He indeed mentions two more, the *Little brown lizard*, and the *Snake-shaped lizard*, from Ray, but gives nothing on these species from his own observation.

Mr Revett Sheppard, in a paper published in the 7th vol. of the *Linnean Transactions*, has particularized six species as being indigenous in this country, viz. *Lacerta agilis*, scaly or swift lizard; *L. ædura*, swell-tailed L.; *L. anguiformis*, viperine L.; *L. vulgaris*, brown L; *L. palustris*, warty lizard; and *L. maculata*, spotted L. Of these he seems to consider the 2d, 6th, and perhaps the 3d, as new species. His descriptions of these species are sufficiently minute, but he adds nothing respecting their habits or manner of life.

The species most common in this country are the *Warty lizard*, or water newt, and the *Brown lizard*, or common land newt; and of these the former has been most minutely examined. The warty lizard is extremely common in ponds and other stagnant waters. The young lizards continue for some time in an imperfect or larva state, and the perfect animals annually change their skin.*

### Genus XIII. Takydromus. TAKYDROME.

This genus has been formed by Daudin for the purpose of including two species, which differ from the lizards, properly so called, in having a very slender body, which, as well as the extremely long tail, is verticillated, or formed of scaly carinated rings. They have also two small vesicles at the base of each thigh, a long extensile forked tongue, and a remarkable contraction between the head and body. There are two species, viz.

*Species* 1. *Takydromus quadrilineatus.* Four-streaked Takydrome. Brown above, whitish below, with two longitudinal white lines on each side.

*Le Takydrome brun a quatre raies*, Daud. iii. p. 252.

2. *T. sexlineatus.* Six-streaked T. Bright shining blue, with three longitudinal black lines on each side of the body. See Plate CCXCVII. fig. 15.

*Le T. nacre a six raies*, Daud. iii. p. 256. pl. xxxix.

These animals inhabit dry places, and, as their generic name imports, run with great swiftness.

### Genus XIV. Scincus. SCINKS.

Body long and rather thick, entirely covered with elliptical or rounded imbricated scales. Head oblong, covered above with a few plates; tongue rather thick, short, and slightly cleft at its tip. Tail longer or shorter in the different species, covered with scales similar to those of the body. Feet strong, rather short and thin, furnished each with five long, thin, separate toes, terminating in claws.

This is a numerous tribe, comprehending 21 species, which are all natives of warm climates. They are brisk in their motions, and fond of basking in the sunshine. They live in dry stony places, and feed on insects. The species are arranged by Daudin in four sections, as follows.

### Sect. I. *Common Scinks.*

Tail short and conical; colour grey, having generally transverse bands of a deeper colour.

* We have said (p. 393.) that the lizards are innocent reptiles, a position now generally maintained by modern naturalists. We are, however, assured, by an intelligent friend, a clergyman, that when a boy, he had one of his fingers so much affected, in consequence of handling a brown lizard, as to be very nearly in a state of gangrene.

*Species* 1. *Scincus officinalis.* Officinal Scink. Grey, begirt with transverse blackish zones; back a little angular; muzzle short and acute; tail compressed at the tip; margin of the toes serrated.

*Le scinque ordinaire d'Egypt*, Daud. iv. p. 130.

*Lacerta scincus*, Linn. a Gmel. p. 1077.

*Officinal scink*, Shaw, iii. pl. lxxix.

*Le scinque*, Lacep. ii. part ii. art. 34. pl. i. fig 2.

2. *S. galliwasp.* Galley-wasp S. Thick, brown above, with large rounded imbricated scales; muzzle taper, with plates on its upper part; tail thick and short. See Plate CCXCVII. Fig. 16.

*Le gros S. gally wasp de la Jamaique*, Daud. iv. p. 239.

3. *S. gigas.* Giant S. White, with nineteen transverse bands; tail of moderate length.

*Le S. géant*, Daud. iv. p. 244.

4. *S. mabouya.* Mabouya S. Shining ash-brown, with numerous small black spots above each side; sides and belly pale; tail elongated; muzzle prominent.

*Le S. mabouya*, Daud. iv. p. 246. Lacepede, ii. part ii. art. 24. pl. ii. fig. 1.

5. *S. tiligugu.* Tiligugu S. Tail of moderate length, round, and conical; body thick, brown above, thickly set with black dots, whitish below

*Le S. teligugu*, Daud. iv. p. 251.

*Lacerta tiligugu*, Linn. a Gmel. p. 1073.

*Sardinian lizard*, Shaw.

Sect. II. *White-streaked Scinks.*

6. *S. Æneus.* Bronze S. Body slender, of a bronze colour, with a broad longitudinal pale streak upon the back; tail once and a half the length of the body.

*Le S. bronze*, Daud. iv. p. 254.

7. *S. bilineatus.* Two-streaked S. Brownish, with two white longitudinal lines upon the back, with brown spots disposed in rows.

*Le S. a deux raies*, Daud. iv. p. 256.

*Lacerta interpunctata*, Linn. a Gmel. p. 1075.

8. *S. trilineatus.* Three-streaked S. Brown above, with three longitudinal white lines; tail a little longer than the body, with the scales on its back part hexagonal.

*Le S. a trois raies*, Daud. iv. p. 263.

9. *S. quadrilineatus.* Four-streaked S. Tail long and round; fore feet four-toed; hind feet five-toed; with two longitudinal white lines on each side of the body.

*Le S. a quatre raies*, Daud. iv. p. 266.

*Lacerta quadrilineata*, Linn. a Gmel. p. 1076.

*Le quatre raies*, Lacepede, ii. part ii. art. 57.

10. *S. Algira.* Algerine S Scales of the back carinated; two yellow longitudinal lines on each side of the body; tail long and round.

*Le S. Algire*, Daud. iv. p. 269.

*Lacerta Algira*, Linn. a Gmel. p. 1073.

*L'Algire*, Lacep. ii. part ii. art. 32.

11. *S. quinquelineatus.* Five-streaked S. Blackish above, with five longitudinal yellow or white lines upon the back; whitish below; tail of moderate length.

*Le S. a cinq raies*, Daud. iv. p. 272. pl. lv. fig. 1.

*Lacerta quinquelineata*, Linn. a Gmel. p. 1075.

*Le S. strié*, Lacepede, ii. part ii. art. 38.

12. *S. cruentatus.* Bloody S. Tail a little verticillated; ash colour above, scarlet below, with a whitish tip; seven white streaks upon the neck, four of which reach to the tail.

*Le S. ensanglanté de la Siberie*, Daud. iv. p. 278.

*Lacerta cruenta*, Linn. a Gmel. p. 1072.

*Red-tailed lizard*, Shaw.

13. *S. melanurus.* Black-tailed S. Pale ash colour above, marked with seven longitudinal yellowish lines; yellowish below; tail round and black, twice as long as the body.

*Le S. a sept raies et a queue noire de l'Inde*, Daud. iv. p. 280.

14. *S. octolineatus.* Eight-streaked S. Black above, with eight longitudinal whitish lines; whitish below; tail ferruginous, and twice as long as the body.

*Le S. a huit raies de la Nouvelle Hollande*, Daud. iv. p. 285.

*The ribboned lizard*, White's *Voyage to New South Wales*, p. 245.

Sect. III. *Black-streaked Scinks.*

15. *S. sloanii.* Slonian S. Brown above, with four black longitudinal lines, of which the intermediate are shortest; tail a little longer than the body, with rounded imbricated scales on its proximal, and hexagonal verticillated scales on its distal half.

*Le S. sloanien*, Daud. iv. p. 287. pl. lv. fig. 2.

16. *S. schneiderii.* Schneiderian S. Bright brownish above, with a pale longitudinal line on each side, whitish below; tail twice as long as the body.

*Le S. schneidérien*, Daud. iv. p. 291.

*Le Dore*, Lacepede, ii. part ii. art. 36.

17. *S. tristatus.* Sallow S. Back pale brown; sides of a deeper colour, marked with a double pale longitudinal band; tail long and cylindrical.

*Le S. rembruni*, Daud. iv. p. 296.

18. *S. laticeps.* Broad headed S. Head behind the eyes, broad, colour brownish, spotted with black; tail as long as the body, having its distal part covered both above and below with transverse plates.

*Le S. a large tête*, Daud. iv. p. 301.

19. *S. carinatus.* Ridged S. Scales carinated; tail twice as long as the body, covered with scales as in the last species.

*Le S. Caréné*, Daud. iv. p. 304.

Sect. IV. *Ocellated Scinks.*

20. *S. ocellatus.* Eye-spotted S. Ash coloured above, with numerous transverse lines of black scales; yellow in the middle; tail about the length of the body.

*Le S. Ocelle de Chypre et d'Egypt*, Daud. iv. p. 308, pl. lvi.

*Lacerta ocellata.* Linn. a Gmel. 1077.

21. *S. lateralis.* Variegated S. Ash-coloured above, with transverse rows of black spots, with oblong white dots in the middle; black longitudinal lines, dotted below with white upon the sides; tail shorter than the body, and ending suddenly in a point.

*Le S. a bandes laterales*, Daud. iv. p. 314.

Of all these species, the first or Egyptian scink is the most celebrated, both from the high estimation in which it is held by the natives, and for its having been once employed in Europe as a medicine. It is a small animal, seldom exceeding six or seven inches in length, and is of a pale yellowish brown colour. In its manners it is perfectly harmless; and so active in its motions, that it hides itself in the sand in an instant. This species is so numerous in some parts of the East, that several thousands of them have been seen at once in the great court of the temple of the Sun at Balbec. The ground, the walls, and scattered stones of these ruinous buildings, were covered with them, exhibiting a beautiful appearance from their glittering colours, as they lay basking in the sun. See Bruce's *Travels.*

### Genus XV. Seps. EFTS.

Body, neck, and tail very long, thin, cylindrical, and covered with imbricated scales of a roundish or elliptical form. Head thin, oblong, covered above with few scales; tongue rather thick, short, and slightly cleft at its tip. Either four or two feet extremely short, simple, very slender, scaly, furnished with one, two, three, four, or five toes, indistinct, sometimes with claws, sometimes without.

The animals which compose this genus so nearly resemble some of the serpents, as scarcely to be distinguished from them by a casual observer. Indeed, if we except the short and often indistinct feet, and the marks of an external auditory orifice, they possess almost all the other characters of serpents; and accordingly several of them have been ranked among the Ophidian reptiles. In their habitudes and manners, they nearly resemble the scinks, though, from the shortness of their feet, their motions are rather those of snakes than lizards. Daudin enumerates six species, arranged under the two following sections.

#### Sect. I. *Four-footed Efts.*

Species 1. *Seps pentadactylus.* Five-toed Eft. Five toes on each foot, furnished with claws; bay or ash coloured above, with numerous longitudinal brown streaks; whitish below. See Plate CCXCVIII. Fig. 17.

*Le Seps quadrupède pentadactyle*, Daud. iv. p. 325.

*Lacerta serpens*, Linn. a Gmel. p. 1078.

2. *S. tridactylus.* Three-toed E. Feet furnished with three extremely short toes without nails; bay or ash colour above, with four longitudinal brown streaks; paler below.

*Le S. quadrupède tridactyle*, Daud. iv. p. 333. pl. lvii.

3. *S. monodactylus.* One-toed E. Feet extremely thin and short, composed of one toe without claw; tail three times as long as the body; scales subimbricate, and slightly carinated.

*Le S. quadrupède monodactyle*, Daud. iv. p. 342, plate lviii. fig. 1.

*Lacerta anguina*, Linn. a Gmel. p. 1079.

#### Sect. II. *Two-footed Efts.*

4. *S. schneiderii.* Schneiderian S. Whitish above, with a brown line; brown below; feet remote from the *anus*, extremely short, either two or three-toed; toes without claws, and as if arising from a common pedicle.

*Le S. schneiderien*, Daud. iv. p. 348.

5. *S sheltopusik.* Sheltopusik S. Head and body without distinct separation; tail long and round, as well as the body, covered with pale imbricated scales; rudiments of hinder feet only, two-toed, and without claws, at the *anus*.

*Le S. bipède sheltopusik*, Daud. iv. p. 351.

*Lacerta apoda*, Linn. a Gmel. p. 1079.

6. *S. gronovii.* Gronovian E. Dorsal scales dotted with brown; tail smooth at the tip; hinder feet only, very short, with one toe and no claw.

*Le S. gronovien*, Daud. iv. p. 354, pl. lviii. fig. 2.

*Lacerta bipes*, Linn. a Gmel. p. 1079.

### Genus XVI. Chalcides. CHALCIDES.

These reptiles differ from those of the last genus only in the disposition of the scales that cover the body and tail, which, instead of being imbricated as in the seps, are arranged in rings, or verticillated. They inhabit similar situations, and have similar manners. There are four species, of which three are four-footed, and one two-footed.

#### Sect. I. *Four-footed Chalcides.*

*Species* 1. *Chalcides tetradactylus.* Four-toed Chalcides. Scales of the belly hexagonal, with a longitudinal furrow on each side of the body; feet four-toed.

*Le chalcide quadrupède tetradactyle*, Daud. iv. p. 362.

2. *C. tridactylus.* Three-toed C. Feet three-toed, very short, and without claws; tail a little longer than the body. See Plate CCXCVIII. Fig. 18.

*Le Chalcide quadrupède tridactyle*, Daud. iv. p. 367. pl. lviii. fig. 3.

*Le Chalcide*, Lacepede, ii. part. ii. art. 52.

3. *C. monodactylus.* One-toed C. Feet short and very slender, with one toe without claw; tail once and a half the length of the body, and cylindrical.

*Le C. quadrupède monodactyle*, Daud. iv. p. 370.

#### Sect. II. *Two-footed Chalcides.*

4. *C. propus.* Grooved C. Fore feet only with five toes, of which four are clawed and one naked; each side of the body longitudinally furrowed.

*Le C. bipède cannelé*, Daud. iv. p. 372. pl. lviii. fig. 4.

*Bipède cannelé*, Lacepede, ii. p. 325.

Several remains of Saurian reptiles, in a fossil state, have been discovered in the bowels of the earth, particularly the bones of two species or varieties of crocodile, nearly allied to the gavial, but considered by Cuvier as distinct from that species. These remains of crocodiles have been found near Honfleur, Mons, Angers, and Havre in France; at Altorf in Bavaria; at Elston near Newark, in the English county of Nottingham; and on the coast of Whitby in Yorkshire. See *Annales de Museum*, tom. xii. p. 73, and *Phil. Trans.* vol. xxx. p. 963, and vol. l. p. 688, and 786. There have besides been found in the mountains of St Pierre, near Maestricht, some enormous bones of a Saurian reptile, which have occasioned some dispute between MM. St Fond and Cuvier; the former alleging them to be the remains of a gavial crocodile, and the latter arguing, with much plausibility, that although so large, they resemble parts of a Tupinambis rather than of a crocodile.

Parts of a winged reptile, resembling the flying dragon, have also been found in a rock near Manheim. See Daud. in *Hist. Nat. des Reptiles*, tom viii. p. 294.

## Order III. BATRACIAN REPTILE.

The animals of this order resemble those of the two preceding in several respects. Like them, they have all feet, and jaws not formed, of two branches, moveable on each other; and in one part at least of their progress towards maturity, they have all tails. Like the Saurians, their jaws are furnished with teeth, and their larynx is capable of producing sound. On the other hand, they differ from the Chelonians and Saurians, in having a naked body in many instances covered with warts or tubercles; in having the bones soft; in having no external copulative organ in the male, nor any real internal one in the female. Some of them have a sternum, but no ribs; others ribs, but no sternum. Most of the species have four feet in their perfect state. All of them swim, some crawl, and others leap; and the species of one genus attach themselves to objects by round tubercles, terminating their toes. The other characteristic marks have been already mentioned in the first part of this article.

Modern naturalists reckon six genera as belonging to this order, which Dumeril arranges under two subdivisions, as follows:

FAMILY I. *Batracians without Tails.*

GENUS I. HYLA. HYLÆ, or TREE FROGS.

Body slightly compressed, elongated, and smooth. Tongue short and thick; the two fore feet furnished with four toes; the hinder with five; all of them without claws, but terminated by lenticular tubercles.

The tree-frogs, as their name imports, have their habitation in trees, to the leaves of which they adhere by the tubercles on their toes, and where they are often seen leaping from branch to branch, or from leaf to leaf, in search of worms and insects. During winter and early spring they seek the bottom of lakes and rivulets, where, after their hybernation is over, they pair, and where the female lays her eggs. Most of the species are natives of America; but some are common in France, Italy, and other warm European countries.

At the pairing season the male makes a loud shrill croaking noise, and inflates his throat in a remarkable manner. The croaking is said to be particularly loud in the evenings on the approach of rain. It has also been remarked of these animals, that their skin has the power of absorbing water.

There are twenty-eight species, distinguished by the following names and characters.

Species 1. *Hyla viridis*. Green H. Bright green above, with a yellow line on each side, bordered with a blackish shade extending from the nostrils to each flank, and forming a sinuosity above each loin; whitish below.

*La rainette verte*, Daud. viii. p. 23. Lacepede, ii. part iii. art. 14.

*Rana arborea*, Linn. a Gmel. p. 1054.

*Tree-frog*, Shaw.

2. *H. lateralis*. Flank-striped H. Bright green, lighter below, with a straight yellow line upon the sides of the upper lip, body, and limbs.

*La R. flanc-rayée*, Daud. viii. p. 27.

3. *H. bilineata*. Two striped H. Obscure green, with two parallel longitudinal white lines a little arched upon the back.

*La R. bi-rayée*, Daud. viii. p. 30.

4. *H. femoralis*. Thigh-spotted H. Green, with seven or more yellow spots on the upper part of the thighs.

*La R. fémorale*, Daud. viii. p. 32. pl. xciii. fig. 1.

5. *H. squirella*. Yellow-rumped H. Obscure green, with brown spots upon the back, and yellow rump.

*La R. squirelle*, Daud. viii. p. 34. pl. xciii. fig. 2.

6. *H. variegata*. Variegated H. Brown above, with green denticulated spots; limbs marked with transverse green bands; toes flattened.

*La R. bigarré*, Daud. viii. p. 36.

7. *H. intermixta*. Mixed coloured H. Greenish grey above, interspersed with red spots and dots; pale red below.

*La R. mélangée*, Daud. viii. p. 38.

8. *H. bicolor*. Two coloured H. Blue above, yellowish below, with white spots surrounded with violet. See Plate CCXCVIII. Fig. 19.

*La R bicolore*, Daud. viii. p. 40.

*Rana bicolor*. Linn. a Gmel. 1052.

9. *H. cyanea* Blue H. Blue above, reddish clouded ash-colour below; hinder feet palmated.

*La R. bleue de la Nouvelle Hollande*, Daud. viii. p. 43.

*Blue frog*, White's *Voyage to New South Wales*, p. 248. pl. iv.

10. *H. frontalis*. Banded H. Body and legs reddish brown above, with ovate oblong white spots.

*La R. bandeau*, Daud. viii. p. 45.

*Rana leucophylla*, Linn. a Gmel. p. 1055.

11. *H. tinctoria*. Stained H. Body smooth, with two longitudinal and one transverse yellowish lines upon the back.

*La R. a tapirer*, Daud. viii. p. 45.

12. *H. fusca*. Brown H. Brown above; whitish ash-coloured below; entirely without spots.

*La R. brune*, Daud. viii. p. 51.

*La Brune*, Lacepede, ii. part iii. art. 16.

13. *H. rubra*. Red H. Brownish red above, with a double pale line on each side, and rounded spots above the thighs.

*La R. rouge*, Daud. viii. p. 53.

*La rouge*, Lacepede, ii. part iii. art. 20.

14. *H. quadrilineata*. Four-streaked H. Blue or sulphur-yellow above, with a double yellow or whitish line on each side.

*La R. a quatre raies*, Daud. viii. p. 55.

15. *H. aurantiaca*. Orange H. Orange-yellow, with a stain of reddish upon the back.

*La R. orangée*, Daud. viii. p. 57.

*L'Orange squelette*, Lacep. ii. part iii. art. 19.

16. *H. hypochondrialis*. Hypochondrial H. Bluish-grey above, with the sides of the body and limbs yellowish, marked with transverse brown bands; toes cleft.

*La R. hypochondriale*, Daud. viii. p. 60.

17. *H. lactea*. Milky H. Milky white, with a brownish line extending from the nostrils to the eyes; fore-feet semipalmated, hinder palmated.

*La R. lactée*, Daud. viii. p. 62.

18. *H. boans*. Croaking H. Whitish ash-coloured, with broad transverse red and brown streaks; head and mouth broad; hinder-feet semipalmated.

*La R. beuglante*, Daud. viii. p. 64.

*Rana boans*, Linn. a Gmel. p. 1055.

*Croaking frog*. Shaw.

*La Couleur-de-lait*, Lacepede, ii. part iii. art. 17.

19. *H. ocularis*. Eye-streaked H. Silvery-grey, with a lateral brown band extending from each eye to the side; limbs marked with transverse brown bands.

*La R. oculaire*, Daud. viii. p. 68.

20. *H. verrucosa*. Warty H. Uniformly brownish, with a warty back.

*La R. a verrues*. Daud. viii. p. 70.

21. *H. marmorata*. Marbled H. Yellow-ash, marbled with reddish above, dotted with black below; all the feet flat and palmated.

*L. R. marbre*, Daud. viii. p. 71. pl. xciv.

*Le Marbre*, Lacepede, ii. part iii. art. 33.

22. *H. venulosa*. Veined H. Pale reddish, marbled with irregular red streaks or spots, dotted with brown; hinder feet semipalmated.

*La R. réticulaire*, Daud. viii. p. 74.

*Rana venulosa*, Linn. a Gmel. p. 1053.

*La réticulaire*, Lacepede, ii. part iii. art 6.

23. *H. tibiatrix*. Flute H. Yellowish white, interspersed above with reddish dots; hinder feet semipalmated.

*La R. fluteuse*, Daud. viii. p. 76.

24. *H. palmata*. Palmated H. Pale reddish, marbled with reddish brown, with two streaks above the limbs; all the feet palmated.

*La R. patte d'oie*, Daud. viii. p. 80; Lacepede, ii. part iii. art. 7.

25. *H. punctata.* Dotted H. Whitish grey or brownish above, with scattered white dots, and a white line on each side; belly white.

*La R. ponctuée*, Daud. viii. p. 81.

26. *H. blochiana.* Blochian H. Ash-coloured above; whitish below, with an obscure line extending from the nostrils to the ear, and obscure transverse bands upon the thighs.

*La R. blochienne*, Daud. viii. p. 83.

27. *H. melanorabdota.* Black spotted H. Green above, with transverse black spots.

*La R. a taches noires*, Daud. viii. p. 85.

28. *H. surinamensis.* Surinam H. Ash-coloured; marked with ovate red spots above, dotted with black below; all the toes separate.

*La R. de Surinam*, Daud. viii. p. 86.

### Genus II. Rana. COMMON FROGS.

Body thick, a little compressed, elongated, moist, covered with a few small tubercles; generally granulated below, except at the thorax, which is smooth; on each side of the back, above the loins, there is in some species a longitudinal angular fold; tongue short and thick; the fore feet have four separate toes, with the thumb a little larger than the rest in the male; the hinder feet are almost always palmated, and are much longer than the body; the toes are pointed, and have usually a small tubercle under each articulation.

Common frogs cannot climb like the tree-frogs, nor can they be said to walk, their proper motion being that of leaping. They inhabit marshy and boggy places, and the borders of lakes and ponds, into which they frequently leap and swim about, either in search of insects, worms, and the fry of fishes, or for amusement. Here too they pair and lay their eggs.

About the time when the young frogs are come to maturity, it often happens that migrations take place among them from a crowded pond or stream, to one where they are less numerous. On these occasions, it is astonishing what numbers have been seen at once crossing a field or road in their way to their new habitation. According to Mr Rae, two or three acres of ground have been seen nearly covered with them. Frogs arrive at full maturity in about five years, and are supposed to live about twelve or fifteen. The croaking of some species, especially of that called the bull-frog, is remarkably loud; and in some parts of America, where the species abounds, the noise made by their united croaking is heard at a very considerable distance.

Frogs are capable of being rendered familiar, and have become so tame as to eat out of the hand. Some of the species serve for food to man, and most of them become the prey of the larger animals that inhabit marshy situations.

Daudin enumerates sixteen species of Rana, viz.

*Sp.* 1. *Rana esculenta.* Esculent Frog. Green, with black spots, and three longitudinal yellow lines upon the back; belly whitish.

*La Grenouille verte*, Daud. viii. p. 90.

*Rana esculenta*, Linn. a Gmel. p. 1053.

*La Grenouille commune*, Lacepede, ii. part iii. art. 1.

*Gibbous frog*, Pennant, *Brit. Zool.* iii. p. 7.

*Esculent*, or *green frog*, Shaw, iii. pl. xxxi.

2. *R. temporaria.* Common F. Red or brown above, or greenish, with a blackish spot extending from the eye through the opening of the ear.

*La G. rousse a tempes noires*, Daud. viii. p. 94.

*Rana temporaria*, Linn. a Gmel. p. 1053.

*La Rousse*, Lacepede, ii. part iii. art. 2.

*Common frog*, *Brit. Zool.* iii. p. 3. Shaw, iii. pl. xxxix.

3. *R. punctata.* Dotted F. Ash-coloured, dotted with green above; feet marked with transverse bands; toes separate.

*La G. ponctuée*, Daud. viii. p. 100.

4. *R. plicata.* Plaited F. Brown, with the sides double plaited; breast and arms marked with four brown spots; feet separate.

*La G. plissee*, Daud. viii. p. 102.

5. *R. clamata.* Noisy F. Dull ash-coloured, interspersed with black dots; upper lip green; hind feet palmated.

*La G. criarde*, Daud. viii. p. 104.

6. *R. typhonia.* Typhon F. Ash-coloured or reddish, with a few brown spots, and either five or three longitudinal yellow lines upon the back; belly whitish.

*La G. galonnée*, Daud. viii. p. 106. pl. xcv. Lacepede, ii. part iii. art. xii.

*Rana marginata*, Linn. a Gmel. p. 1053.

*Hurricane frog*, Shaw.

7. *R. rubella.* Reddish F. Rusty colour above, with three longitudinal black lines upon the back, and a triangular white spot upon the forehead.

*La G. rougette*, Daud. viii. p. 109.

8. *R. maculata.* Spotted F. Grey, with a square green spot upon the head, and another round one on each shoulder; whitish below, marbled with black.

*La G. tachetée*, Daud. viii. p. 111.

9. *R. pipiens.* Bull F. Very large; dark green above, whitish grey below, interspersed every where with blackish spots.

*La G. mugissante*, Daud. viii. p. 113. Lacepede, ii. part iii. art. 9.

*Rana ocellata*, Linn. a Gmel. p. 1052.

*Bull frog*, Catesby's *Carolina.*

*Rana catesbiana*, Shaw, iii. pl. xxxiii.

10. *R. ocellata.* Eye-spotted F. Very large; reddish brown above, with round brown spots, eyed with yellow on the sides and buttocks.

*La G. ocellée*, Daud. viii. p. 118.

11. *R. halecina.* Pitpit F. Green above, with brown spots eyed with yellow; three longitudinal lines shaded with yellow upon the back; white below.

*La G. hallécine*, Daud. viii. p. 122.

12. *R. tigurina.* Tigrine F. Large; greyish-brown, with a longitudinal yellow line extending from the nose to the rump; dark brown spots edged with yellow above the limbs, and yellow buttocks.

*La G. tigrée*, Daud. viii. p. 125.

13. *R. grunniens.* Grunting F. Brown or reddish, with oblong yellow spots behind the eyes.

*La G. grognante*, Daud. viii. p. 127.

14. *R. paradoxa.* Paradoxical F. Greenish-ash or reddish above, marbled with reddish brown; thighs marked below with oblique reddish lines. See Plate CCXCVIII. Fig. 20.

*La G Jackie*, Daud. viii. p. 130; Lacep. ii. part iii. art. 11.

*Rana paradoxa*, Linn. a Gmel. p. 1055.

*Paradoxical frog*, Shaw.

*Surinam frog* or *Jackie.*

The natural history of this extraordinary animal is but imperfectly understood. It has long been supposed, that it is first a frog, and afterwards changes into a fish; in which latter state it is eaten by the natives of Surinam, under the names of Jackie and Frog-fish.

Considerable light has been lately thrown on the economy of the Surinam frog by Mr W. M. Ireland and Sir E. Home, in a paper just published in *The Journal of Science* *and the Arts*, 1816, vol. i. p. 55. edited at the Royal Institution by Mr Brande. Mr Ireland has had the good fortune to witness the changes which the animal undergoes from the tadpole to the perfect state; and the following is an abstract of his observations, with those of Sir E. Home, on the internal structure of the tadpole in two of its stages.

When first seen by Mr Ireland, the tadpole was about four inches and a half long by about an inch broad, had a large head and small mouth, very much resembling those of a fish, though the rudiments of two legs were evident just behind the head. In about a fortnight, the length of the animal had increased to eight inches, and its breadth to about two and a half; and the rudiments of the legs were developed into nearly perfect members, with five clawed toes, united by a membrane, evidently the future hind legs of the animal.

On examining its internal structure during this fortnight, the intestinal canal appears very long, and coiled up, and the rudiments of the lungs are seen in the posterior part of the belly.

In about three weeks the fore legs make their appearance, the head and mouth assume their ordinary figure, the former being considerably smaller, and the latter larger than before; and the animal, which till now had lain at the bottom of the vessel in a torpid state, becomes more active and lively, and usually remains suspended in the water, with its mouth above the surface. By this time the intestinal canal is wonderfully altered in extent and appearance, being contracted apparently to less than half its length, and having but very few short convolutions, and nearly the whole of the cavity of the belly is filled with fat.

In about six weeks, the animal is greatly contracted in size, being little more than three inches long by about an inch in breadth, and has become a perfect frog, except some small remains of the tail, which has been gradually sloughing off or absorbed, and the disappearance of which has so greatly contracted the animal's length.

The appearance of the tadpole, in the state usually called the Frog-fish, is shewn in Plate CCXCV. Fig. 17. which is reduced to one-fourth of its natural length, and the animal, nearly in its perfect state, and one-half its natural size, is represented in Plate CCXCVIII. Fig. 20.

15. *R. arunco.* Arunco F. Body warty; feet palmated.

*La G. arunco*, Daud. viii. p. 134.

16. *R. thaul.* Yellow F. Body warty; yellow feet, semipalmated.

*La G. thaul*, Daud. viii. p. 136.

*Rana lutea*, Linn. a Gmel. p. 1050.

### Genus III. Bufo. TOADS.

Body thick, short, and broad, more or less warty on the upper surface; head thick and short; eyes large and protuberant, with a vertical pupil; tongue short and thick; skin dilatable by inflation; belly often granulated; fore feet with four separate toes, the thumb larger in the male; hinder feet comparatively short, and generally palmated with five toes; all the toes pointed, but without claws.

From the construction of their legs and feet, toads do not leap so well as frogs, but they walk better, and swim with facility. In their other habits and modes of life they resemble frogs, except that, when irritated or terrified, they emit from the pores of their warty skin a sort of frothy fluid, which, though not venomous, as was formerly supposed, is sufficiently irritating to affect delicate parts of the skin of an animal that touches it. It is scarcely now necessary to remark, that the stone in the toad's head, which has given rise to Shakespeare's beautiful simile, is only a poetical fiction, those substances which have received that name appearing only to be the fossil teeth of a species of fish.

Toads feed on worms and insects, and in their turn become the prey of the larger birds and snakes; and it is said, that their flesh, so far from being venomous, affords as wholesome nutriment as that of the frog. Some of these animals are also capable of being domesticated. We are informed by Mr Pennant, that an individual of the common toad was known to frequent the steps of a gentleman's house in Devonshire for thirty-six years, where it was accustomed to be fed every evening by the family and their visitors.

The accounts that have been published in various works, respecting living toads found in hollow trees and blocks of stone, however extraordinary, seem so well authenticated, that we can scarcely doubt the reality of such occurrences, though we cannot satisfactorily account for them.

There are about thirty-two species of toad, which are thus distinguished.

*Species* 1. *Bufo vulgaris.* Common Toad. Pale reddish-ash coloured, with red pustules above, reddish-white below.

*Le crapaud cendre a pustules rouses*, Daud. viii. p. 139.

2. *B cinereus.* Cinereous T. Uniformly ash coloured, pustular.

*Le C. cendré*, Daud. viii. p. 141.

3. *B. flaviventris.* Yellow-bellied T. Ash coloured and pustular above, sulphur-yellow below.

*Le C. a ventre jaune*, Daud. viii. p. 143.

4. *B. panamensis.* Panama T. Ash coloured; pustules tipt with violet, yellowish below; feet semipalmated.

*Le C. de panama*, Daud. viii. p. 145.

5. *B. bombinus.* Natter-jack T. Olive-brown above, orange-yellow below, with bluish spots and a fold below the throat.

*Le C. sonnant ou pluviale*, Daud. viii. p. 146.

Among other synonymes under this species, Daudin refers to

*Rana bombina*, Linn. a Gmel. p. 1048; *Rana rubita*, ibid. p. 1047; *Rana salsa*, ibid. p. 1049.

*La sonnante*, Lacepede, ii. part iii. art. 4; *La pluviale*, ibid. art. 3.

*Natterjack*, Pennant, *Brit. Zool.* iii. p. 12.

6. *B. roeselli.* Roesellian T. Greenish above, with elevated dark brown spots; greenish-ash coloured below; feet palmated.

*Le C. de roesel*, Daud. viii. p. 150. plate xcvi.

*Rana bufo*, Linn. a Gmel. p. 1047.

*Toad*, Pennant, *Brit. Zool.* iii. p. 7; Shaw's *Gen. Zool.* iii. plate xl.

*Le Crapaud commun*, Lacepede, ii. part iii. art. 21.

7. *B. calamita.* Calamite T. Olive above, with dark spots, reddish pustules, and a longitudinal yellow line along the middle of the back.

*Le C. calamite*, Daud. viii. p. 153; Lacep. ii. part ii. art. 25.

8. *B. viridis.* Green T. Marked above with contiguous green spots, and irregular whitish-livid lines dotted with red; feet semipalmated.

*Le C. verd*, Daud. viii. p. 156; Lacep. ii. part. iii. art. 22.

9. *B. gibbosus.* Gibbous T. The body ovate, smooth, convex, brownish above, with a longitudinal yellow indented band along the middle of the back; toes separate.

*Le C. bossu*, Daud. viii. p. 158; Lacep. ii. part iii. art. 29.

*Rana gibbosa*, Linn. a Gmel. p. 1047.
*Gibbous toad*, Shaw.

10. *B. fuscus*. Brown T. Marked above with broad brown spots, interspersed with livid ash-coloured lines, and one pale longitudinal line; hind feet palmated.
*L. C. brun*, Daud. viii. p. 161; Lacep. ii. part iii. art. 24.

11. *B. cursor*. Courier T. Smoothish above, spotted with reddish and black, with warty sides, yellowish below, with three black spots upon the breast; toes separate.
*Le C. courier*, Daud. viii. p. 164.

12. *B. gutterrosus*. Swelled throated T. Grey, spotted with brown, warts sharp, and reddish at the tip; throat swoln.
*Le C. goitreux*, Daud. viii. p. 166; Lacep. ii. part iii. art. 28.

13. *B. ventricosus*. Inflated T. Mouth narrow, arms and thighs surrounded with a lax skin, capable of inflation.
*Le C. ventru*. Daud. viii. p. 168.
*Rana ventricosa*, Linn. a Gmel. p. 1049.
*Humid toad*, Shaw.

14. *B. lævis*. Smooth T. Pale yellow, with a smooth, rather flattened body, and a longitudinal row of small pointed tubercles above each side.
*Le C. lisse*. Daud. viii. p. 171.

15. *B. dorsiger*. Surinam T. Dark brown, head flat and triangular; eyes minute, situated at the top of the head; toes of the fore feet separate, and three or four forked at their tips; hind feet palmated; cells on the back in the female.
*Le C. pipa*, Daud. viii. p. 172; Lacep. ii. part iii. art. 30.
*Rana pipa*, Linn. a Gmel. p. 1046.
*Surinam toad*, Shaw, iii. plate xxxi.

16. *B. obstetricans*. Accoucheur T. Dirty green, with small irregular brown spots above; whitish below.
*Le C. accoucheur*, Daud. viii. p. 176.

17. *B. Margaritifer*. Pearly T. A coriaceous auricular lobe above each side of the head; numerous warts upon the body, bearing some resemblance to pearls; hinder feet semipalmated.
*Le C. perlé*, Daud. viii. p. 179.
*Rana margaritifera*, Linn. a Gmel. p. 1050.
*Pearled toad* Shaw.
*La perle* Lacep. ii. part iii. art. 10.

18. *B. Surinamensis*. Dwarf Surinam toad. Bright brown above; belly dotted with grey, with a white line on the hips; all the toes separate.
*Le C. de Surinam*. Daud. viii. p. 184.

19. *B albonotatus*. White spotted T. Brown; slight-warted, with a white line extending from each nostril to each thigh; upper part of the limbs spotted with white.
*Le C. a taches blanches*, Daud. viii. p. 185.

20. *B. ovalis* Oval T. Head short; muzzle long; body ovate, nearly globular; brownish or bluish above, yellowish below; feet palmated.
*Le C. ovale*, Daud. viii. p. 187.

21. *B. lineatus*. Striped T. Warty, brownish red, with a white line drawn from each nostril through the eyelids to the hind feet, another on each arm; white bands upon the limbs, and all the toes separate.
*La C. rayé* Daud. viii. p. 188.

22. *B. musicus*. Musical T. Brown above, with blackish spots; head furrowed above; limbs marked with blackish bands.
*Le C. criard*, Daud. viii. p. 190.
*Rana musica*. Linn. a Gmel. p. 1046.
*Musical toad*, Shaw.

23. *B. Scaber*. Rough T. Yellowish, with black lips; body a little spinous, especially about the legs; head furrowed above; hind feet slightly palmated.
*Le. C. rude*, Daud. viii. p. 194.
*Le pustuleux*, Lacepede, ii. part iii. art. 27.

24. *B. bengalensis*. Bengal T. Body thickly covered with warts; yellowish grey; head slightly furrowed above; black sharpish pointed warts below the feet; hind feet semipalmated.
*Le C. du Bengale*, Daud. viii. p. 197.

25. *B. spinosus*. Spinous T. Dark brown above, with broad spots of a paler hue; pale grey below, with tubercles tipt with a black spine.
*Le C. epineux*, Daud. viii. p. 199.

26. *B. horridus*. Horrid T. Dark green above; warty, with numerous small black spines on each tubercle, marbled below with green and paler shades; all the toes separate.
*Le C. hérissé*, Daud. viii. p. 201.
*Australian frog*, Shaw.

27. *B. spinipes*. Spine-footed T. Brown above, bluish below; sides marked with ochry colour; fore feet spinous above.
*Le C. spinépede*. Daud. viii. p. 203.

28. *B. humeralis*. Shoulder-knot T. Very large; ash-grey, irregularly spotted with brownish; parotid glands large and gibbous.
*Le C. epaule armée*, Daud. viii. p. 205.
*Rana marina*, Linn. a Gmel. p. 1049.
*La grenouille epaule armée*, Lacep. ii. part iii. art. 8.
*Marine toad*, Shaw.

29. *B. semilunatus*. Semilunated T. Blackish, with a white spot behind each ear; head slightly furrowed above; hinder feet semipalmated.
*Le C. demi-lune*, Daud. viii. p. 208.

30. *B. agua*. Brazilian T. Very large; beautifully marbled with yellow, brown, and grey, and rough with tubercles; large parotid glands; hinder feet very slightly palmated.
*Le C. ague*, Daud. viii. p. 209.—Lacep. ii. part iii. art. 32.
*Rana braziliensis*, Linn. a Gmel. p. 1049.

31. *B cyanophlytis*. Blue-warted T. Bluish brown above, with blue pustules on each side, extending from the eyes to the lower part of the breast and sides, and thence to the rump.
*Le C. a pustules bleues*. Daud. viii. p. 212.

32. *B. cornutus*. Horned T. Head large, with a long conical protuberance, or horn, upon each upper eye-lid.
*Le C. cornu*, Daud. viii. p. 214.—Lacepede, ii. part iii. art. 31.
*Rana cornuta*, Linn. a Gmel. p. 1050.
*Horned frog*, Shaw.

### FAMILY II. *Tailed Batracians.*

### GENUS IV. SALAMANDRA. SALAMANDERS.

Body elongated, cylindrical, naked, sometimes warty, and terminated by a tail that is either cylindrical or flattened, so as to form a fin, and persistent. No external ears; tongue short, thick, and entirely fixed within the lower jaw. Fore feet having either three or four toes; hinder furnished with five toes, all blunt, and without claws.

Till within these few years, the salamanders had been ranked among the lizards, to which they are allied only from their having a tail, and from the similar position and structure of their legs. In their internal organization and their general habits, they are entirely distinct from all the Saurian order, and more nearly resemble the frogs and toads. They have no true ribs; they respire in the same manner as the Batracians already described, and in most of them the fecundation of the ova takes place in a similar manner. In a few of them, indeed, the young are extruded from the ova while still within the oviduct of the female; and the species in which this takes place are called *ovoviviparous*. In their metamorphoses, the young salamanders pass through the early stages of existence with much the same appearances as we have described in the tadpole of the frog, except that the number of stages is rather less. The tadpole of the salamander bursts the ovum within ten days after it is dropped from the mother, and takes about four months to arrive at its perfect state, during which time it subsists entirely on vegetables; while in their perfect state, they feed on snails, worms, and insects. The number of young produced by one female salamander sometimes amounts to thirty or forty.

These animals are found in most warm climates; and at least six of them are natives of the south of Europe. They inhabit the banks of unfrequented streams, moist shady woods, and high grounds; but are seldom seen except during wet weather. They appear to live equally well in the water and on land, and they swim with great facility. During winter they lie concealed about the roots of old trees, in the cavities of old walls, or in subterranean recesses, where they are sometimes found twisted together. In their general habits, they are very sluggish, and their pace is slow.

It was believed by the ancients, and is still a popular superstition among the vulgar in most countries, that salamanders are not only capable of existing with impunity in fire, but have the power of putting a stop to a considerable conflagration when thrown among the flames. This absurd idea has perhaps arisen from the fact which has been observed by Maupertuis, that when one of these animals is placed upon a fire, its whole body soon becomes covered with drops of a milky fluid, which oozes through the pores of the skin, and quickly dries upon its surface.

There are about fourteen species, which are thus distinguished.

*Species* 1. *Salamandra terrestris.* Common salamander. Blackish, variegated with irregular blackish spots; tail cylindrical, and a little obtuse.

*La Salamandrie terrestre*, Daud. viii. p. 221. pl. xcvii. fig. 1.—Lacepede, ii. part ii. art. 54. pl. viii. fig. 1.

*Lacerta salamandra*, Linn. a Gmel. p. 1066.

*Salamander*, Shaw, iii. pl. lxxxii.

2. *S. atra.* Black S. Uniformly black without spots; tail cylindrical and a little obtuse.

*La S. noire*, Daud. viii. p. 225.

3. *S. rubra.* Red S. Red interspersed with numerous black points, with a blackish streak upon the belly: hinder feet semipalmated.

*La S. rouge*, Daud. viii. p. 227.

4. *S. venenosa.* Venemous S. Ground black, with round yellow spots, arranged in a double row along the back.

*La S. venimeuse*, Daud. p. 229.

*Lacerta punctata*, Linn. a Gmel. p. 1076.

*La ponctuée*, Lacepede, ii. part ii. art. 56.

5. *S. alleganiensis.* Alleghany S. Large, brown, paler below, with a shortish compressed tail, slightly crested.

*La S. des monts alleganis*, Daud. viii. p. 231.

6. *S. cristata.* Crested S. Blackish above, marked below with large rounded orange-coloured dots; sides granulated with white, and dotted with black; tail compressed; back of the male furnished with a fimbriated crest.

*La S. crêtée*, Daud. viii. p. 233.

7. *S. rubriventris.* Orange bellied S. Black above, with brownish spots; orange below without spots, except a few black dots under the neck.

*La S. a ventre orangé* Daud. viii. p. 239. pl. xcviii. fig. 1.

8. *S. marmorata.* Marbled S. Olive green above, marbled with brown; brownish below, with white granular dots; tail compressed.

*La S. marbrée*, Daud. viii. p. 241.

9. *S. abdominalis.* Abdominal S. Olive green above, dotted with yellow below, with a longitudinal yellowish line on each side of the back; all the toes separate.

*La S. abdominale*, Daud. viii. p. 250

10. *S. palmipes.* Webfooted S. Head and arms yellow, slightly dotted with black; back olive brown; belly yellowish; hind feet palmated.

*La S. palmipéde*, Daud. viii. p. 253. pl. xcviii. fig. 2.

11. *S. elegans.* Elegant S. Head and feet yellow, slightly dotted with black; back olive; belly yellowish; all the toes separate, but those of the hind feet lobated.

*La S. elegante*, Daud. viii. p. 255.

12. *S. punctata.* Dotted S. Olive ash above, yellow below, every where interspersed with black bots; tail very much compressed; all the toes separate.

*La S. ponctuée*, Daud. viii. p. 257.

13. *S. cincta.* Girded S. Yellowish olive above, dotted yellow below with a white streak; edged below with black dots; all the toes separate.

*La. S. ceinturée*, Daud. viii. p. 259.

14. *S. Trydactyla.* Three-toed S. Fore feet three-toed; hind feet four-toed.

*La S. tridactyle*, Daud. viii. p. 261.—Lacep.

*Le Lizard tridactyle*, Lacep. ii. part. ii. art. 59.

### Genus V. Proteus. PROTEUS.

Body elongated, cylindrical, terminated by a compressed tail forming a fin; tongue short, thick, adhering within the lower jaw; fore feet furnished with three toes, and the hinder with two; all without claws; branchiæ persistent.

*Species. Proteus Anguinus.* Serpentine Proteus. Fore feet three-toed; hind feet two-toed.

*Le proté anguillard*, Daud. viii. p. 266. pl. xcix. fig. 1.

*Proteus anguinus*, Laurenti, *Synops. Reptil.* p. 37. pl. ii. fig. 3.—Scopoli, *Annales Hist. Nat.* vol. v. p. 70.—Linn. a Gmel. p. 1056, note.—Herman, *Tab. Affinitat. Animal.*—Schneider, *Hist. Amphib. fascic.* i. p. 45.—Schreiber, *Phil. Trans.* 1801.

The curious animal for which the present genus has been constituted, was first observed at the bottom of a lake in Carniola in Germany, and described in 1768, by Laurenti, in the work referred to above. It was afterwards described by Scopoli, and was briefly noticed by Linnæus in his *Systema Naturæ*, who, however, considered it as the tadpole of a salamander; but the most complete account of the animal has been given by Schreiber, a German naturalist, in a memoir of his, published in the Transactions of the Royal Society of London for 1801. From this account it is now generally allowed, that the Proteus is to be considered as a perfect animal, differing from all the other reptiles with which we are acquainted.

Its general length is about thirteen inches by about one inch of medium breadth, and the head is nearly two inches long. It has no external nostrils; and its eyes, which are black, and situated towards the base of the muzzle, are so small as with difficulty to be distinguished. The colour of the living animal is a flesh red, and the gills are scarlet;

but when immersed in spirits after death, it becomes white. It appears to walk with difficulty, but swims with great ease. One that was kept by Baron Zois lived for about ten days, and during that time refused all nourishment, and appeared in a torpid state.

The Proteus undergoes three degrees of metamorphosis before arriving at its perfect state. In the two former, it is blind and without feet.

It is said on certain occasions to utter a sound resembling that made by forcing down the piston of a syringe.

Two reptiles have lately been noticed by the French naturalists, bearing a near relation to the Proteus above described. One has been described by Cuvier, under the name of *Axolote Mexicaine*, and has four toes on each fore foot, and five on each hinder. This we might call *Proteus mexicanus*. The other is described and figured by Lacepede, in the tenth volume of the *Annales de Museum*, p. 230. pl. xvii. by the name of *Protée tetradactyle*, (*Proteus tetradactylus*,) with four short pointed toes on each of the fore feet. It differs from the Proteus anguinus in having a thicker and shorter body, a much broader tail, and the legs larger and shorter.

### Genus VI. Siren. SIREN.

Body elongated, cylindrical, and terminated by a compressed tail, forming a fin; tongue short, thick, and adherent; fore feet digitated; no hind feet; branchiæ persistent.

*Species. Siren lacertina.* Lacertine Siren. Feet four-toed.

*La Siren lacertine*, Daud. viii. p. 272, pl. xcix. fig. 2.

*Siren lacertina*, Linn. *Amœnit. Academ.* vii. p. 311.

*Muræna siren*, Linn. a Gmel. p. 1136.

*Siren lacertina*, Shaw's *Naturalist's Miscellany*, N°. 20, pl. lxi.—Schneider, *Hist. Amphib.* fascic. i. pl. 48.

The extraordinary reptile which constitutes this last genus of Batracians, was first observed in 1765, by Dr Alexander Garden, in a fresh water lake near Charlestown in Carolina, and was described by Linnæus in the Memoirs of the Academy of Upsal for that year. He considered it either as the tadpole of a species of lizard or salamander, or as a new genus of his order Nantes, to which he gave the name of Siren. Soon after, Linnæus placed the Siren in the order Amphibia, which he denominated Meantes, from which Gmelin, in his edition of the *Systema Naturæ*, injudiciously removed it to the class of Fishes, and considered it as a species of *muræna*.

The Siren very much resembles an eel in the general form of the body and tail. Its mouth is small, and furnished with small sharp teeth, set partly in the palate, and partly in the lower jaw. Its eyes are very small, but more evident than those of the Proteus. Its skin is of a blackish colour, slightly grained and porous, with a longitudinal white line, extending on each side from the feet to the tail, and a shorter one along the middle of the back. The whole length of the animal sometimes exceeds three feet; and the feet, which are small, and composed of a *humerus*, a fore arm, and four small pointed toes, furnished with claws, are about an inch long.

Its tongue is bony, and formed like that of fishes; the gills are composed of three fimbriated plates on each side, are very apparent, and are above half an inch long. It has a real larynx, and its lungs resemble those of salamanders. In its metamorphosis from the ovum to the perfect state, it seems to follow the same degrees with the *Proteus*, except that its eyes are sooner open.

This animal appears to reside entirely in the water, where it must swim with great facility. It was supposed by Linnæus, from the form of its feet, that it can also move with tolerable ease upon the land; but we believe it has never yet been seen in that situation.

## EXPLANATION OF PLATES.

### PLATE CCXCV.

Fig. 1. Skeleton of a species of Tupinambis.

Fig. 2. The head of the same animal. *a*, the intermaxillary bone; *b*, *b*, the two superior, or coronal maxillary bones; *c*, the nasal bone; *d*, one of the zygomatic arches; *e*, a supernumerary bone; *f*, *f*, the two sides of the frontal bone; *g*, the parietal; *h*, *h*, two bony arches forming the interior border of the temporal fossa; *i*, a small portion of the left basilar jaw; *k*, the bone with which this is articulated; *l*, *l*, the occipital bone; *m*, its condyle.

Fig. 3. The jaws of the Nilotic crocodile extended, shewing the mode of their articulation.

Fig. 4. Stomach of the common land tortoise.

Fig. 5. Stomach of the Gavial crocodile, with a portion of the intestinal canal commencing at *a*, the pylorus.

Fig. 6. Stomach of the Nilotic crocodile partly laid open; *a*, a pouch into which the aliments pass before proceeding out at *b*, the pylorus.

Fig. 7. Stomach and intestines of the Chameleon; *a*, the *pylorus;* from *a* to *b*, the small intestine; *b*, the commencement of the large intestine.

Fig. 8. Part of the intestines of the land tortoise; *a b*, a part of the small intestine; *b*, the commencement of the large intestine.

Fig. 9. The *rectum* of the Nilotic crocodile insensibly commencing from the small intestine; *a a*, a valve between the two.

Fig. 10. *Rectum* of the Gavial; *a*, the termination of the small intestine; *b*, the rectum; *c*, a projection from the small intestine into the large for acting as a valve.

Fig. 11. Stomach and intestines of the Siren; *a* the *pylorus;* *b*, the termination of the hepatic duct.

Fig. 12. The heart of the crocodile seen on its lower surface; *a a*, the right auricle; *c*, the common trunk of the right carotid and right brachial arteries; *d*, the common trunk of the same arteries on the left side; *e e*, the continuation of the right posterior *aorta;* *f f*, the left posterior aorta: *g h*, the left and right pulmonary arteries; *i k*, the pulmonary veins; *o*, the opening by which the right auricle communicates with the inferior compartment of the ventricle; *p*, an orifice by which this compartment communicates with the pulmonary cavity of the ventricle; *q r*, two valves at the commencement of the left aorta; *s*, *t*, the trunks of the two arteries *c* and *d* laid open; *v*, the trachea; *x x*, its sub-divisions into bronchi; *y y*, situation of the lungs.

Fig. 13. The heart of the crocodile viewed on its inferior surface, but a little more to the left side.

Here the letters *a*, *c*, *d*, *e*, *f*, *g*, *h*, refer to the same parts as in the preceding figure. *b*, the left or pulmonary auricle; *m*, a row of tubercles behind; *x*, *y*, the valves guarding the entrance of the left pulmonary artery; *z*, the communication between the inferior and pulmonary compartments of the ventricle.

Fig. 14. The crocodile's heart seen on its upper surface; where the letters *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *k*, refer to the same parts as in the former figures. *l*, the upper compartment of the ventricle laid open.

Fig. 15. The general appearance of the ova of frogs, as extruded from the oviduct.

Fig. 16. The tadpole of the frog, when only a few days old.

Fig. 17. The tadpole of the Surinam frog in that stage called *frog fish*.

Fig. 18. Is the under surface of one of the toes of the *Gecko Egyptiacus*, of the natural size. See p. 29.

Fig. 19. Is a toe dissected to shew the appearance of the pockets on its under surface, their serrated cuticular edges, the depth of the pockets, and the small muscles by which they are drawn open, the parts being highly magnified: *a a* are the two muscles which lie on the sides of the bones of the toe, with their tendons inserted into the last bone, close to the root of the claw. The muscles belonging to the pocket go off from these tendons.

PLATE CCXCVI.

Fig. 1. *Chelonia mydas.* Green turtle.
Fig. 2. *Testudo Græca.* Common land tortoise.
Fig. 3. *Crocodilus Niloticus.* Crocodile of the Nile.
Fig. 4. *Dracæna.* Dragon lizard.
Fig. 5. *Tupinambis ornatus.* Ornamented tupinambis.
Fig. 6. *Basiliscus mitratus.* Mitred basilisk.
Fig. 7. *Iguana delicatissima.* Common guana.
Fig. 8. *Draco volans.* Flying dragon.

PLATE CCXCVII.

Fig. 9. *Agama calotes.* Galeot Agama.
Fig. 10. *Stellio brevicaudatus.* Short-tailed stellio.
Fig. 11. *Chameleo vulgaris.* Common chameleon.
Fig. 12. *Gecko Egyptiacus.* Egyptian gecko.
Fig. 13. *Anolis bimaculatus.* Two-spotted anolis.
Fig. 14. *Lacerta lemniscata.* Laced lizard.
Fig. 15. *Takydromus sexlineatus.* Six-striped takydrome.
Fig. 16. *Scincus officinalis.* Common scink.

PLATE CCXCVIII.

Fig. 17. *Seps pentadactylus.* Five-toed eft.
Fig. 18. *Chalcides tridactylus.* Three-toed chalcides.
Fig. 19 *Hyla bicolor.* Two-coloured tree-frog.
Fig. 20. *Rana paradoxa.* Surinam frog.
Fig. 21. *Bufo dorsiger.* Surinam toad.
Fig 22. *Salamandra terrestris.* Common salamander.
Fig. 23. *Proteus anguinus.* Common proteus.
Fig. 24. *Siren lacertina.* Lacertine siren.

# INDEX.

## AUTHORS' NAMES.



## INDEX OF GENERA, AND REMARKABLE CIRCUMSTANCES.

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HERRING. See ICHTHYOLOGY.

HERRING FISHERY. See FISHERIES.

HERTFORD TOWN, in the hundred of Hertford, in Hertfordshire, is pleasantly situated 21 miles north from London, on the river Lea, which is navigable for barges to the town. The streets are chiefly neat and clean, and the houses well built. It contains two parish churches; a handsome sessions house, in which the assizes for the county are held; a market house and town hall, in which are kept the quarter sessions and county courts; and a county gaol and penitentiary house, built on Mr Howard's plan. The most important public seminaries for education consist of the East India College, for the education of youth destined to fill the various offices in the civil departments in India; and a large school belonging to Christ's Hospital in London, where about 500 of the younger children are kept prior to their being sent to the metropolis. Hertford returns two members to parliament. The right of election is vested in the inhabitants who do not receive alms; and in such freemen only as, at the time of their being made free, were inhabitants of the borough. Their number is about 700. The only article of consequence manufactured here is malt, by which, and the large quantities of corn and wool sent down the river to London, the inhabitants are principally supported.

In 673, a synod was held at Hertford, and King Alfred here built a castle, by means of which the Danes, who had come up the Lea from the Thames, were destroyed. On the site of the ancient castle the present one, now the East India College, was erected in the time of Charles I. The manor of Hertford belonged to the Crown from 1345 till the sixth year of Charles I., when it was granted to William Earl of Salisbury, whose descendant, the present marquis, is now owner of it. In the 25th year of the reign of Elizabeth, and afterwards, in the 34th and 35th of the same reign, the Michaelmas term was adjourned from London to this town, on account of the plague then raging in the metropolis.

At Haileybury, in the parish of Amwell, in the vicinity of the town of Hertford, and about 19 miles from London, is situated the East India College. This site was chosen by the directors of the East India Company, when they formed the determination of abandoning the grand and extensive plan of a college at Calcutta, sketched out and partly begun by the Marquis of Wellesley, during his administration of India. The object of both institutions is to give a suitable education to those persons who are meant to occupy civil employments under the company in India.

The college near Hertford was instituted in April, 1805, and the foundation stone of the building was laid on the 12th of May, 1806. The beauty of the building, the fineness of the situation, the salubrity of the air, and the object of the institution, render it an object of considerable interest. The college is capable of accommodating above 100 students, and rather more than thirty, on an average, are annually sent from it to India. According to the plan of the institution, young men are received when they have completed their 15th year, and they continue at the college till they are 18, or till the court of directors shall deem it proper to send them to their respective destinations. A nomination to the college, on the part of the court, is equivalent to an immediate appointment. The students are instructed by courses of lectures, nearly on the plan pursued at the universities of Oxford and Cambridge. The college council, under whose direction and authority the institution is more immediately placed, consists of a principal and several professors. Besides the general superintendance of the college, it is the duty and office of the principal more especially to watch over the moral and religious conduct of the students, to instruct them in the principles of ethics and natural theology, and in the evidences, doctrines, and duties of revealed religion. Besides, he, as well as such of the professors as are in holy orders, preach in the college chapel. The principal is assisted in the superintendance of the college by the dean, who is annually chosen from among the clerical members of the college council.

The lectures of the professors are arranged under four heads, viz. oriental literature: 1st, Practical instruction in the rudiments of the oriental languages, especially the Arabic, Persian, Hindostanee, Sanscrit, and Bengalee. 2d, A course of lectures to illustrate the history, customs, and manners of the people of India. In these two departments there is a professor for the languages, a professor of Hindoo literature, and of the history of Asia, two assistants who are natives of the East, and a Persian writing master. There is also a visitor and councillor in the oriental department. Under the second head are included mathematics and natural philosophy, for which there are two professors. The third head comprises classical and general literature, for which there are two professors. The fourth head comprises a course of lectures on general polity, and on the laws of England, and the principles of the British constitution; a course of lectures on general history, and on the history and statistics of the nations of modern Europe; and a course of lectures on political economy. For these subjects there are two professors. There are also attached to the college, masters for French, drawing, and fencing.

The college year is divided into two terms of twenty weeks each, with a summer vacation of eight weeks, and a winter vacation of four weeks. The principal examination takes place previous to the winter vacation, and continues three weeks. It is terminated by a visitation of the court of directors, when the result of the examination is presented by the principal, in separate lists for each department, of the respective merits of each student. These lists are inserted in the public records of the company. Other lists are also given in, exhibiting a relative view of the conduct and proficiency of each student. Prizes of books, medals, &c. and certificates of superior merit, are publicly given by the chairman. Every student going to India carries with him a certificate under the college seal, attesting what his attainments have been during his academical course.

In 1801, Hertford contained 515 houses, and 3360 inhabitants. In 1811, the population abstract gave as follows:

| | |
|---|---|
| Houses inhabited | 592 |
| Families inhabiting them | 735 |
| Males | 2038 |
| Females | 1862 |
| Total | 3900 |

See Arthur Young's *Agriculture of Hertfordshire; Beauties of England and Wales*, vol. v.; Lyson's *Environs of London*. (W. S.)

HERTFORDSHIRE is an inland county of England, bounded by Bedfordshire and Cambridgeshire towards the north and west, Buckinghamshire towards the west, Essex towards the east, and Middlesex towards the south. Its limits are principally artificial, except on the south east, where it is separated from Essex by the rivers Lea and Stort. From Bailey to Royston, the Ikenild Street, one of the four Roman highways running through the island, divides the counties of Cambridge and Hertford. It is intermixed with Buckinghamshire in a singular manner, so that its shape on the western side is rendered extremely irregular by projections and indentures. It is situated between the parallels of 51° 37′ and 52° 5′, north latitude. Its greatest length may be reckoned at 25 miles, and its breadth from north to south at 35 miles. According to Halley, it contains 451,000 acres; but according to the poor's rate returns, only 385,000. It is among the smallest counties in England. The general aspect of this county is pleasant. The northern part is the most hilly, forming a scattered part of the chalky ridge which extends across the kingdom in this direction. A range of high ground stretches out from the neighbourhood of Kings Langley, towards Berkhampstead and Tring. Another elevated ridge commences at St Albans, and proceeds in a northern direction towards Market Street. A number of streams take their rise from this side of the county.

Hertfordshire contains 1 county town, Hertford; 8 hundreds; 19 market towns; 120 parishes; returns 6 members to parliament, viz. 2 for the shire, 2 for Hertford, and 2 for St Albans; and is in the province of Canterbury, and diocese of London. There are no places of any consequence in it besides Hertford, St Albans, Royston, and Ware.

Most of the county is enclosed; and in consequence of its being very ill situated for coals, the old hedges are every where filled with oak, ash, sallow, &c. Independent of the wood thus distributed in hedge-rows, very fine timber, in considerable quantity, is spread over every part of the county. The prevailing soils are loam and clay, in general not of a very fertile quality. The vales, however, through which the rivers and brooks flow, are composed of a rich sandy loam. The most productive soil of this nature is on the west side of the river Lea. The principal clay district is on the north-east on Essex side. In the parishes of North Miny, &c. the general description of soil is extremely barren. The chalky soil prevails on the north side of the county. The basis, indeed, of the whole of Hertfordshire is chalk, intermixed with a great quantity of flints. The landed property is greatly divided, in consequence of the vicinity of the metropolis.

The principal rivers are, the Lea, the Rib, the Quin, and the Colne. The Lea enters this county near Bower-heath, and traverses it in a direction nearly from north-west to south-east, to its confluence with the Stort, after which it runs nearly south, washing the towns of Hertford and Ware, from the last of which it is navigable to the Thames. It collects, in its course, all the streams in the northern and eastern part of the county. The Rib, which rises in this county, joins the Lea between Hertford and Ware: the Quin also rises in this county, and falls into the Rib. The Colne rises near Kits-end, in Middlesex; and after uniting various streams on the south-western side, conveys them out of the county near Rickmansworth. In one part of its course, near Colney Park, it has a short underground passage, though not particularly observable, except in dry weather. The nine sister-springs of the Cam, and the springs which constitute the source of the New River, are in Hertfordshire. The grand junction canal enters this county above Berkhampstead, and leaves it following the course of the Colne. The Watford canal commences near the town of Watford, where it unites with the grand junction, and goes to St Albans.

Farms are in general small. Perhaps the size most common is from 150 to 400 acres. The principal part of the land is under tillage, and the produce in wheat, barley, and oats, is very considerable. Wheat and barley in particular are grown here, of as good a quality as in any other part of the kingdom. In the neighbourhood of Wheathampstead, great quantities of wheat have been grown for a very considerable length of time, whence this place takes its distinctive appellation. Indeed, in the opinion of many, Hertfordshire was distinguished for the excellence of its tillage husbandry, even before Norfolk. Turnips and clover are supposed to have been introduced in the time of Cromwell, who, it is said, gave 100*l.* a year on that account, to a farmer of the name of Howe. Even the judicious culture and application of tares were practised in this county upwards of 80 years ago—at a period when they were scarcely known in any other part of England. It does not seem, however, that the arable husbandry of Hertfordshire has improved much latterly; and the kind of plough still in general use will, with many, be deemed a proof of this remark. This plough, known by the name of the great Hertfordshire wheel plough, though of great merit and utility in breaking up strong flinty fallows in a dry season, ought certainly to be dispensed with in all the other operations of husbandry; and, even for that purpose, it might be constructed in such a manner as to do its work with more ease to the horses. It is excessively heavy, and so ill formed, that it will not move in its work one yard without the ploughman. The plough-shares alone weigh from 50 to 70 lbs.

The grass-lands of Hertfordshire, compared with those under tillage, are very trifling: in fact it may be said, that there is no grass district in it, except a very narrow margin in the south line, in the vicinity of Barnet, which, being near London, is made artificially productive, by means of manure brought by the hay carts. There are, however, some tolerably good meadows, especially those on the Stort, extending from Hackerell to Hertford, and those in the vicinity of the Lea, and about Rickmansworth. The many streams that flow through the county are extremely favourable to irrigation, though that system is not carried to any great extent. In the south-west corner of the county are many orchards. Apples and cherries are their principal produce.

As the land in this county is chiefly arable, and the artificial grasses are cultivated almost entirely for hay for the London market, live stock is an object of very inferior consideration. The Suffolk breed of cattle is regarded as the best. The sheep are mostly ewes of the Southdown and Wiltshire breeds. The horses are of various kinds, but the Suffolk punch appears to be preferred.

The principal roads in Hertfordshire, in consequence of its vicinity to the metropolis, are very good. Six great leading turnpikes pass through this small district. Many of the cross roads are nearly as good as the turnpikes.

The great business of the county is the traffic of corn, and the malting trade. The latter is carried on to a very great extent in the towns of Hitchin, Baldock, Royston, and Ware. Ware alone sends a greater supply of malt to London than any other place; and it always obtains the highest price, not only on account of the excellence of the barley from which it is made, but also for the excellence of the mode in which it is manufactured. The Hertfordshire malt, however, is not all made from barley grown in the county; large quantities being purchased in all the surrounding districts, which after being malted in the towns above mentioned. is sent to London chiefly by the navigation of the Lea. There are very few manufactures in Hertfordshire of any consequence; at St Albans there is a small cotton manufactory, and two silk-mills. The machinery of the latter is particularly well contrived. At Berkhampstead fringe lace is made; and also a considerable quantity of wooden shovels, bowls, spoons, &c. In this, and some other parts of the county, plaiting straw is a resource for poor women and children. At Watford there are some silk mills, one of which is worked by the waters of the Colne; the rest by horses. In 1803 the poor rates amounted to 71,291*l.*: in 1815, they had increased to 98 380*l.*

There are several antiquities of great interest in this county. The British City of Verulam, on the site of which St Albans stands, is of greater antiquity than even London itself; and, under the dominion of the Romans, acquired the dignity and privileges of a municipium. In the vicinity of this place Cæsar defeated Cassivellaunus; Boadicea conquered and massacred 70,000 Romans and Britons; and two bloody battles were fought between the rival houses of York and Lancaster, in 1455 and 1461. The field of Barnet, between St Albans and London, was also the scene of a bloody battle in the destructive wars of the two houses, which proved decisive in favour of Edward IV., his great foe, the Earl of Warwick, surnamed the king-maker, being there slain in 1471. During the Saxon Heptarchy, this county was partly in the kingdom of the East Saxons, and partly in Mercia. The king of the latter resided in a castle at Berkhampstead. At this place a parliament was held in 697, and the laws of Ina were published. William the Conqueror here swore to preserve the laws made by his predecessors. King Henry II. kept his court here, and granted it all the liberties and privileges which it had engaged under Edward the Confessor; and so lately as the reign of James I the royal nursery was established here. Upon a hill in Harborough field, near Ashwell, are evident marks of a Roman fortification, (now called Ardbury Banks,) a large square work enclosed with a trench or rampart. Here the Romans had a standing camp, so advantageously situated, that they could discover the approach even of a small body of men at a great distance. Several Roman coins and earthen vessels have been dug up here at different times.

In 1801 there were 18.172 houses in this county, and 97,577 inhabitants. In 1811, it appears, from the population abstract, that there were—

| | |
|---|---|
| Houses inhabited | 20,345 |
| Families inhabiting them | 22,744 |
| Houses building | 131 |
| ——— uninhabited | 436 |
| Families employed in agriculture | 11,998 |
| ——————— trade | 7,192 |
| ——————— other lines | 3,554 |
| Males | 55,023 |
| Females | 56,631 |
| Total inhabitants | 111,654 |

The following is the statistical state of the county in 1811:

| | |
|---|---|
| Area in square statute miles | 528 |
| English statute acres | 337,920 |
| Rental of land | *l.*342.350 |
| Amount of tithe | 45 292 |
| Annual value of a square mile | 735 |
| Number of persons in a square mile | 211 |
| Agricultural population in centesimal parts | 52 |
| Net product per family | 32 |

(W. S.)

HESIOD, one of the earliest Greek poets. Little is known of his life, and the few facts that have reached us have occasioned much controversy among the learned. It appears that his father Dius had originally resided at Cuma, a town of Æolia in Asia Minor, whence he afterwards removed to Ascra, now Zagara, situated in a valley of Mount Helicon. (See Helicon and Clarke's *Travels*, part ii. sect. iii. p. 112.) It is uncertain whether Hesiod accompanied his father from Cuma, or was born at Ascra. The latter is perhaps the more probable conclusion. In one of his poems he mentions a short voyage to the isle of Eubœa as the only occasion on which he had ever been on shipboard; but if he had come from Cuma, he must have crossed by sea into Greece. It is true, in the passage alluded to, he speaks of his nautical experience, but the affirmation is unlimited; and it may be supposed, had there been any exception, that exception would either have been noticed, or the expression modified. There is another presumption in favour of Ascra, given by Plutarch on the authority of Ephorus, the historian of Cuma, who relates that Dius had been compelled to emigrate to Ascra, on account of debt, and there married Pycimede the mother of Hesiod. What was Hesiod's occupation is uncertain. La Harpe, in his *Cours de Literature*, supposes him to have been a priest of the Temple of the Muses. Others have maintained, that, according to the Proem to his Theogony, he tended sheep in the vallies of Helicon; a mode of life, it has been thought, better suited and more congenial to the bard of husbandry; though it is evident, as the writer of the Theogony, the same reason applies with equal force in favour of his sacerdotal profession. From the picture of the Muses presenting him with a laurel branch, Mr Elton infers, with Pausanias, that he was not a minstrel or harper, but a rhapsodist, and sang or recited to the branch instead of the lyre." He is reported to have carried off the prize from Homer at a poetical contest. That he won a contested prize in Eubœa, as noticed in his poem of the *Works and Days*, cannot reasonably be doubted; but that he vanquished Homer has been justly regarded as a fiction of later times. Hesiod is noted for longevity, but it is uncertain whether he was permitted to die a natural death. There is a tradition that he was murdered at Ænoe, on a pilgrimage to the Delphic oracle, by the son of his host Ganyetor. Ganyetor having entertained Hesiod, and a Milesian, his fellow-traveller, and his daughter having been violated in the night, suspicion fell upon the aged bard, who, without further ceremony, was put to death by the brothers, and thrown into the sea. The body being cast on shore, or, as fiction will have it, conveyed to land by a dolphin, was recognised by his dog, and the murderers, upon confession, were drowned in the waves.

The era of Hesiod is still more doubtful than his birthplace. Some authors, as Quintilian, Heinsius, and Justus Lipsius, give him a greater antiquity than Homer; Cicero, Pliny, and Paterculus, place him a century later; while a third party, among whom are Plutarch and Varro, supported by the venerable authority of Herodotus, concur in making him a contemporary. The attempts to decide the question of priority, from philological criticism and astronomical calculations, are equally vague and ineffectual. The inference in favour of Homer, which has been drawn from his use of the word θεμιστας for law, when Hesiod employs νομους, alleged to be of more recent origin, is of no force, as Mr Elton justly remarks, "unless we suppose that Homer's poems contained every word in the language." The ingenious argument of Dr Samuel Clarke, on the same side, with regard to the quantity of καλος, of which in Homer the first syllable is long, while Hesiod varies it at pleasure, and of οπωρινος, the penult of which in Homer is long, and short in Hesiod, is scarcely more successful. The difference of locality, of dialect, and, more particularly, the very considerable alterations which the original poems have manifestly undergone since their collection and arrangement, do not admit of any conclusive argument being founded on such minute diversities. Paterculus places Hesiod 800 years before Christ, and Homer 920; and Herodotus, making them contemporaries, fixes their common era at 884 years before Christ. According to the Parian marbles, Hesiod flourished before Christ 944 years, and Homer 907.

Few of the poems* ascribed to Hesiod are now extant, and there is much difference of opinion respecting the small number that have reached us; these are the Theogony, the Works and Days, and the Shield of Hercules. These remains have manifestly suffered greatly from corruption and mutilation. The many spurious additions and alterations with which modern interpolators have loaded and disfigured them have so changed their original simple character, as to raise serious doubts of their antiquity.

Joseph Scaliger denies that the Shield of Hercules is the production of Hesiod, while Tanaquil Faber as confidently affirms it to be genuine. This contrariety of decision, in persons so competent to decide, can be accounted for only by the unauthentic and adulterated state of the poem. With regard to his rank as a poet, Quintilian has given him the slender praise of mediocrity. "If the Battle of the Titans," says Mr Elton, "be Hesiod's genuine composition, and if the Shield, as there is reason to believe, contain authentic extracts from his heroical genealogies, we shall decide that Hesiod, as compared with Homer, is less rapid, less fervent in action, less teeming with allusions and comparisons; but grand, energetic, occasionally vehement and daring; but more commonly proceeding with a slow and stately pace. In mental or moral sublime, I consider Hesiod as superior to Homer."

We subjoin a list of the lost poems of Hesiod.—The Catalogue of Women or Heroines, in five parts, of which the fifth appears to have been entitled "The Herogony." The Melampodia, a poem on divination. The great Astronomy, or Stellar Book. Descent of Theseus into Hades. Admonitions of Chiron to Achilles. Soothsaying and Explications of Signs. Divine Speeches. Great Actions. Of the Dactyli of Cretan Ida; discoverers of iron. Epithalamium of Peleus and Thetis. Ægemius. Elegy on Batrachus, a beloved youth. Circuit of the Earth. The Marriage of Ceyx. On Herbs.

See an ingenious dissertation on the *Life of Hesiod*, prefixed to a new translation of his *Remains*, by Charles Abraham Elton. Lond. 1815. (*v*)

HERSCHEL, is the name given by some astronomers to the Georgium Sidus. See Astronomy and Uranus.

HESSE, a principality of Germany, is bounded on the south by the bishopric of Fulda, the principalities and the counties of Irenburg, Nidda, and Solms; on the east, by Brunswick Eichsfeld and Thuringia; on the west, by Solms, Nassau, Westphalia, and Waldeck; and on the north, by Waldeck, Padenborn, and Brunswick. Its figure is irregularly oval, and it extends about 60 miles from north to south, and from 50 to 70 from west to east. It occupies 2760 square miles, and contains 750,000 inhabitants.

The greater part of this principality was annexed by Bonaparte to the new kingdom of Westphalia; and the grand duchy of Hesse, which was one of the states of the Confederation of the Rhine, was formed out of new territories. Before the peace of Presburg it contained 154 square German miles, and had a population of 319,000; after the peace of Presburg, its extent was 202 square miles, its population 478,800, its military contingent 4000, and its revenue in rixdollars 1,660,000. An account of this principality will be found in our article on the circle of the Rhine, of which it forms a part. See Cassel and Darmstadt.

HEVELIUS, or Hoevelke, John, a celebrated Polish astronomer, was born at Dantzic on the 28th January 1611, and was the son of a brewer of that city. After studying mathematics under Peter Cruger, he travelled through Holland, Germany, England, and France, between the years 1630 and 1634; and upon his return to his native place, he was principally employed in the affairs of the republic of Dantzic, of which he was made consul in 1651. About the year 1660, by the advice of his former master, he devoted himself wholly to the study of astronomy. In the year 1641, he built an observatory at his own expense, and furnished it with excellent telescopes and graduated instruments, which he constructed with his own hands. With these instruments, which consisted of a sexant, a quadrant 6¾ feet radius, and very large telescopes, he made numerous observations, the result of which appeared at Dantzic in the year 1647, in his work entitled "Selenographia, sive Lunæ descriptio, atque accurata, tam maculorum ejus, quam motuum diversorum, aliarumque omnium vicissitudinum phasiumque telescopii ope deprehensarum, delineatio: in qua simul cæterorum omnium planetarum nativa facies, variæque observationes, presertim autem macularum solarium et jovialium tubo specillo acquisitæ, figuris sub

* "The Bœotians," says Pausanias, "have a tradition that Hesiod only wrote the poem of the Works and Days."

aspectum ponuntur; necnon quam plurimæ astronomicæ, opticæ, physicæque quæstiones resolvuntur. Addita est nova ratio lentes expoliendi, telescopia construendi, et horum adminiculo varias observationes exquisite instituendi."

In 1650, he published an epistle to his friend Eichstad, on the eclipse of the sun, on Nov. 4th, 1649; and in 1652, appeared another epistle on the solar eclipse, addressed to Gassendi and Bullialdus.

About this time, Hevelius made the important discovery of the moon's libration, of which he gave an account in a letter to Riccioli, which was published in 1654, and entitled *De motu Lunæ libratorio in certas tabulas redacto.* In 1656 he published his *Dissertatio de Nativa Saturni facie, ejusque variis phasibus, certa periodo redeuntibus cui addita est Eclipsis Solis anni* 1656, *observatio et diametri solus apparentis accurata dimensio.*

In 1661, Hevelius had the good fortune to observe the transit of Mercury on the sun's disc: and in 1662, he published his observations, entitled "Mercurius in sole visus anno 1661, cum aliis quibusdam rerum cœlestium observationibus, rarisque phenomenis; cui annexa est Venus in sole pariter visa 1639, Liverpoliæ a Jeremia Horroxio, nunc primum edita, notisque illustrata. Accedit succincta historiola novæ ac miræ stellæ in collo Ceti certis anni temporibus clare admodum effulgentis, rarsus omnine evanescentis; necnon genuina delineatio paraselenarum et parheliorum* quorundam rarissimorum."

The reputation of Hevelius was now so great, that the illustrious Colbert recommended him to the notice of Louis XIV. who granted him a pension. A copy of the letter, in which Colbert announced this act of liberality to Hevelius, is preserved in the Royal Library at Paris. Hevelius shewed his gratitude by dedicating to Colbert his "Prodromus Cometicus, quo Historia Cometæ anno 1664 exorti cursum, faciesque diversas capitis ac caudæ accurate delineatas complectens, necnon dissertatio de cometarum omnium motu, generatione variisque phenomenis exhibetur," *Dantz.* 1665. A supplement to this work appeared in 1666, entitled "Descriptio Cometæ anno 1665, exorti cum genuinis observationibus tam nudis quam enodatis mense Aprili habitis; cui addita est mantissa *Prodromi Cometici*, observationes omnes prioris Cometæ 1664, ex iisque genuinum motum accurate deductum, cum notis et animadversionibus, exhibens."

In the year 1668, he published in folio, his great work on comets, under the title of "Cometographia, totam naturam Cometarum, utpote sedem, parallaxes, distantias, ortum et interitum, capitum caudarumque diversas facies, affectionesque, necnon motum eorum summe admirandum, beneficio unius, ejusque fixæ et convenientis hypotheseos, exhibens; in qua universa insuper phenomena, questionesque de cometis omnes rationibus evidentibus deducuntur, demonstrantur, ac iconibus æri incisis plurimus illustrantur; cumprimis vero Cometæ annorum 1652, 1661, 1664, 1665, ab ipso auctore summo studio observati.—Accessit omnium Cometarum, a mundo condito huc usque, ab historicis philosophis et astronomis annotatorum, historia, notis et annotationibus locupletata, cum peculiari tabula Cometarum Universali."

When this work was completed, Hevelius sent a copy of it to Dr Hooke, and to other distinguished members of the Royal Society. In return for this work, Dr Hooke presented Hevelius with a Description of the Dioptric Telescope, and the method of using it; and recommended it as preferable to the use of plain sights in astronomical instruments. In this way commenced the celebrated controversy respecting the use of plain and telescopic sights. Hooke maintained, that with an instrument of a span radius, the distances and altitudes of celestial objects could be measured to a second by telescopic sights; and Hevelius insisted, in his reply, that with a good eye, and great experience, he had obtained the same accuracy in the use of his instruments; and he sent eight distances between stars, for the purpose of being examined by Dr Hooke. Here the controversy was for the present terminated.

In the year 1673, Hevelius published in folio, the first part of his "Machina Celestis, organographiam, sive instrumentorum astronomicorum omnium quibus auctor sidera hactenus rimatus et dimensus est, accurata delineatio et descriptio pluribus iconibus æri incisis illustrata et exornata; cum aliis quibusdam tam jucundis quam scitu dignis, quæ ad mechanicam opticamque pertinent, animadversionibus, imprimis de maximorum tuborum constructione et commodissima directione, necnon nova facillima lentes quasvis ex sectionibus coni expoliendi ratione." Hevelius sent copies of this work to all his friends in England except Dr Hooke; who, in revenge of the affront, published in 1674 his "Animadversions on the First Part of the *Machina Celestis* of the honourable, learned, and famous Joannes Hevelius, together with an explication of some instruments made by R H." Lond. 4to. This work was characterised by the irritability of its author. It was written with that tone of arrogant superiority, which injured his own cause, and excited the highest resentment on the part of Hevelius. In the same year, Hevelius sent a letter to the Royal Society, containing a reply to the objections of Hook and Flamstead, and appealing to observation for the correctness of his opinions. He complained of the "bitterness and boasting" with which he had been attacked, and requested that the Royal Society would send some eminent astronomer to examine his instruments and method of using them. This reasonable demand was acceded to; and Dr Halley, who held nearly the same opinions as Hooke, was requested to repair to Dantzic. He arrived in that city on the 26th May 1679, and continued with Hevelius till the 18th of July. By means of a good instrument, furnished with telescopic sights, Halley compared his own observations with those of Hevelius; and he particularly attended to the successive observations made upon the same stars by Hevelius, with his large brass sextant. The result of this examination was highly favourable to our author. Halley left an attestation, dated July 8-18th, 1679, declaring himself "abundantly satisfied of the use and certainty of these his instruments and observations. And whereas he had before been always doubtful, that his observations by naked sights might as to some minutes be uncertain, and had therefore wondered why he declined the use of telescopic sights; he had, partly to gratulate the author's publishing of his observations, and partly to satisfy his own scruples, undertaken that journey, which he now considers as no small happiness, and declares himself abundantly pleased with it: and offers himself a voluntary witness of the almost incredible certainty of these instruments, as having seen with his own eyes, not one or two, but a multitude of observations of the fixed stars performed with his great sextant, even by divers observers, and by himself sometimes, though less expert therein, being often repeated, most accurately and almost incredibly to agree, and never to differ more than by an inconsiderable part of a minute."

In the year 1679, Hevelius published his "Machinæ Celestis Pars Posterior; rerum Uranicarum observationes, tam eclipsium luminarium quam occultationum planetarum et fixarum, necnon altitudinum meridianarum, po-

* These Paraselenæ and Parhelia are described in our article Halo, and represented in Plate CCLXXXVII. Figs. 4, 5, 6.

larium, solstitiorum et æquinoctiorum, una cum reliquorum planetarum fixarumque omnium hactenus cognitarum globisque adscriptarum, æque ac plurimarum huc usque ignotarum, observatis, pariter quoad distantias, altitudines, meridianas et declinationes, additis innumeris aliis notatu dignissimis atque ad astronomiam excolendam maxime spectantibus rebus, plurimorum annorum summis vigiliis indefessoque labore ex ipso æthere haustas, permultisque iconibus, auctoris manu æri incisis, illustratas et exornatas, tribus libris exhibens."

Hevelius had fortunately presented about 30 copies of this work to his friends; for before it was published, his property of every description was consumed by a dreadful fire, on the 26th September 1679. No fewer than seven houses, containing his money, plate, gold, silver, household goods, printing houses, great part of his library, the remaining copies of all his printed works, published at his own expence, from the year 1647 to 1679, and particularly his observatory, with all his optical and astronomical instruments, were completely reduced to ashes. Among the articles preserved were the latter part of his *Machina Celestis*, containing the observations of nearly 50 years, and his *New Catalogue of the Fixed Stars*.

A full account of this calamity, and of his dispute with Dr Hooke, were published in 1685, in his "Annus Climactericus, sive rerum Uranicarum et observationum annus quadragesimus nonus, exhibens diversas occultationes tam planetarum quam fixarum, post editam Machinam Celestem observatas, necnon plurimas altitudines meridianas solis, et distantias planetarum fixarumque, eo anno impetratas cum amicorum nonullorum epistolis ad rem istam spectantibus et continuatione historiæ novæ stellæ in Collo Ceti, ut et annotationum rerum celestium."

This work was the last which Hevelius published. Worn out with the infirmities of age, and with the labours of science, he died on the 28th January 1687, in the 76th year of his age. Hevelius left behind him the reputation of having been one of the most industrious and ingenious practical astronomers of the age in which he lived. The surprise which Halley expressed at the wonderful accuracy of his observations, must be felt by every person who examines them, and who considers that they are well made by unassisted vision, and that the instruments were constructed and graduated with his own hands.

Hevelius left behind him two complete works, and many other manuscripts. The first of these made its appearance in 1690, in folio, entitled "Prodromus astronomiæ, exhibens fundamenta quæ tam ad novum plane et correctiorem stellarum fixarum catalogum construendum quam ad omnium planetarum tabulas corrigendas omnimode spectant, necnon novas et correctiores tabulas solares, aliasque plurimas ad astronomiam pertinentes, utpote refractionum solarium, parallaxium, declinationum, angulorum eclipticæ et meridiani, ascensionum rectarum et obliquarum horizonti Gedanensi inservientium, differentiarum ascensionalium, motus item et refractionum stellarum fixarum, quibus additus est uterque catalogus stellarum fixarum, tam major ad ann. 1660, quam minor ad ann. completum 1700. Accessit Corollarii loco tabula motus lunæ libratorii, ad bina sæcula proxime ventura prolongata, brevi cum descriptione ejusque usu."

This work, which was published by his widow, contains the catalogue of 1888 stars. It was afterwards reprinted in the 3d vol. of Flamstead's *Historia Celestis*, and is incorporated in the catalogue of stars given in our article Astronomy.

In the same year appeared his other posthumous work, entitled "Firmamentum Sobiescianum sive Uranographia, totum cœlum stellatum, utpote tam quodlibet sidus quam omnes et singulas stellas, secundum genuinas earum magnitudines nudo oculo et olim jam cognitas, et nuper primum detectas, accuratissimisque organis rite observatas, exhibens; et quidem quodvis sidus in peculiari tabella, in plano descriptum, sic ut omnia conjunctim totum globum celestem exactissime referant: prout ex binis hemispheriis majoribus, boreali scilicet et australi, adhuc clarius cuique patet." This work contains 54 charts, representing the whole heavens.

Hevelius was elected a Fellow of the Royal Society of London in 1664, and contributed several papers to the *Philosophical Transactions*.

When M. Delisle passed through Dantzic on his way to Russia in 1626, he purchased all the manuscript observations of Hevelius, along with his extensive correspondence, forming seventeen folio volumes, four of which were occupied with his observations. These manuscripts contain much curious information respecting the history of astronomy. They were lodged by Delisle in the depot of of the marine at Paris. Those who wish for farther and more minute details respecting the life and writings of Hevelius, will find much information in a life of him, published at Dantzic in 1780 by Benjamin Leugnich, and entitled, *Hevelius, oder Anekdoten und Nachrichten von diesem beruehmten Manne*. Many particulars respecting our author will also be found in Bernoulli's *Travels in Prussia, Poland, and Warsovia*, 1782, p. 183. A figure of his mausoleum is given in Bernoulli's *Collection of Voyages*, tom. ii. 1781. See also the *Journal de Savans, Aout*, 1782, and Murr's *Journal Literaire, Nuremb.*

HEXACHORD *Major* of Galileo, is an interval of music, whose ratio is $\frac{16}{27}$, $= 462\,\Sigma + 9\,f + 40\,m$, or the *Comma-redundant major* SIXTH. See that article.

Hexachord *Major* of the Greeks, or hexachordon major of Holder, &c. has the ratio $\frac{3}{5}$, $= 451\,\Sigma + 9\,f + 39\,m$, or the *Major* SIXTH, which see.

Hexachord *Minor* of Didymus, has the ratio $\frac{81}{128}$, $= 404\,\Sigma + 8\,f + 35\,m$, or the *Comma-deficient minor* SIXTH, which see.

Hexachord *Minor* of Galileo, has the ratio $\frac{50}{81}$, $= 426\,\Sigma + 8\,f + 37\,m$, or the *Comma-redundant minor* SIXTH, which see.

Hexachord *Minor* of the Greeks, or hexachordon minor of Holder, &c. has the ratio $\frac{5}{8}$, $= 415\,\Sigma + 8\,\Sigma + 36\,m$, or the *Minor* SIXTH, which see. (ϱ)

HEXAEDRON. See Crystallography.

HEXAGON. See Geometry.

HEXHAM, is a market-town of England, in the county of Northumberland, finely situated on the south side of the river Tyne, at the confluence of the north and south Tyne. The two long streets, of which the town consists, are narrow, and not well built; but the town contains some good houses. The road from Newcastle to Hallwhistle passes through one of the streets, and the other principal street runs at right angles to this. At the intersection of these streets stands the spacious market-place in a large square, with a convenient piazza for the butchers' market, which has moveable stalls, and which is well supplied with water from a fountain. The church of Hexham, which forms a part of its ancient monastery, founded in 1112, is highly ornamented in the inside, and contains many fine sepulchral monuments. This church was dedicated to St Andrew, and was much celebrated for its beauty and extent by ancient historians. It is in the form of a Greek cross. The tower, which is in the centre, appears low and broad, though it has a height of 102 feet. The architecture is Gothic and Saxon. A double gallery runs round the whole structure, opening with Saxon arches, each opening being composed of three arches, the middle circular, and the others pointed, with very light pillars. The nave was burnt down by the Scots in 1296, and nothing remains of it but part of its western door. The choir now forms the parish church, and is crowded with inelegant pews and galleries. The priory stood at the west end of the church; and not many years ago its cloister and chapels were to be seen. There are two ancient stone towers at Hexham, one of which is used as a session-house, and formerly belonged to the priors of Hexham. The other is situated on the top of a hill near the Tyne.

It appears from two Roman inscriptions, found in a crypt of the church, that the Romans had a station, or town, at this place; for it is obvious, that this was not the *Epiacum* of the ancients, as Horsley supposed. The crypt, where they were found, is a place fifteen feet by nine, and contains a number of carved stones, which seem to have once formed part of a Roman fortress.

The town is governed by a bailie chosen annually. The principal employment of the inhabitants consists in tanning leather, and in making shoes, hats, and gloves.

The following is a statistical abstract of the parish for 1811:

| | |
|---|---|
| Inhabited houses, | 729 |
| No. of families, | 1171 |
| Do. employed in trade and manufactures, | 639 |
| Males, | 2136 |
| Females, | 2719 |
| Total Population, | 4855 |

See Pennant's *Tour in Scotland*, vol. iii.; Hutchinson's *History of Northumberland;* and the *Beauties of England and Wales*, vol. xii. p. 158—168.

HEXHAM, Battle of. See England.

HEYWOOD, Jasper, D. D. a writer of the age of Queen Elizabeth, and son of the epigrammatist Heywood, whom we shall immediately have occasion to mention. He was born in London 1535, and studied at Merton College, Oxford; from whence, according to Wood, he was on the point of being expelled for his irregular life, when he resigned his fellowship. Soon after he repaired to St Omers, and entered into the Society of Jesus at that place. From thence he went to Diling in Switzerland, where he distinguished himself by his learning and zeal for disputing with heretics; so as to obtain the rank of doctor of divinity. In the year 1581, Pope Gregory the XIII. sent him at the head of the first mission of Jesuits to England, but her majesty shipped him off, with 70 of his associates, out of the kingdom; and, returning to Italy, he died at Naples, where the zealous catholic Joannes Pittseus contracted an intimacy with him, and speaks of him with great respect. He translated three of the tragedies ascribed to Seneca, viz. the *Thyestes*, *Hercules Furens*, and *Troas*, in the measure of the syllables, and from that circumstance has obtained a name in poetical biography. (*n*)

HEYWOOD, John, father of the preceding writer, was one of the earliest dramatic writers that England produced. Warton says of him, that he drew the Bible from the stage, and introduced representations of popular life, and familiar manners. He was born at North Mims, near St Albans, in Hertfordshire, and in his youth contracted an intimacy with Sir Thomas More, who introduced him to the patronage of the princess (afterwards queen) Mary. His jests, and musical talents, made him a favourite with Henry VIII. who frequently made him handsome presents. When Mary came to the throne, he was admitted to her most intimate conversation, and is said to have amused her with his diverting stories even in her last illness. On the accession of Elizabeth, being a bigoted catholic, he naturally anticipated the loss of his court favour; and, going into voluntary exile, he settled at Mechlin in Brabant, where he died in 1565.

As a poet, he was famous in his time, and his plays are still curious relics. One of them, *The Four P's*, is in Dodsley's *Collection*. His longest work is the *Spider and Fly*, of which honest Holingshed says, "that the author dealeth so profoundlie and beyond all measure of skill, that neither he himself that made it, nor any one that readeth it, can reach unto the meaning thereof." His *Dialogue of Proverbs*, and *Six Hundred Epigrams*, give us but a humble idea of the wit and conversation of our ancestors. (*n*)

HEYWOOD, Thomas. This author was an actor as as well as a writer, and flourished in the reigns of Queen Elizabeth, James I. and Charles I. The date of his birth and death, (we might almost add, the whole history of his life,) is unknown, except his profession and character as a writer. In the latter capacity he is distinguished as one of the most prolific that ever existed; for, besides his prose compositions of *The English Traveller*, *Apology for Actors*, &c. &c. he tells us, that the plays in which he had either a principal share, or wrote entirely, amounted to two hundred and twenty. Of this number, it is true, that but a few comparatively remain. Different reasons have been assigned for the loss of so many of them. It has been alleged, that they were lost from the desultory manner in which he wrote them, on the backs of play-bills and tavern bills, as he was a great frequenter of taverns; but the true reason seems to have been, that the managers, in those days, purchased the sole property of the copies of plays, and it was not their interest to let them be published till the public had been completely satiated with them; of course, when plays ceased to be attractive, the memory of them would perish, and the actors would not much trouble themselves about compositions, which, if they had been printed, might not have repaid the cost.

Of 23 of his plays that remain to us, there is one that ought especially to redeem his name from oblivion. This is, *The Woman killed with Kindness*. The interest of it is founded, like of that Kotzebue's *Stranger*, on a story of domestic infidelity, and the repentance that ensues; but it terminates more tragically, and with a severer moral lesson. Mrs. Frankland, the penitent, though forgiven by her husband, cannot forgive herself, and dies broken-hearted. In this, and in several other pieces, Heywood, though not highly fanciful nor poetical, and though he seems to have hardly possessed the common ambition of a poet—to be thought such,—is nevertheless exceedingly natural and touching. The last scene between Frankland and his wife is very touching. It concludes thus:

Acton, (*the brother of Mrs. Frankland*) How do you feel yourself?
*Mrs. Frank.* Not of this world.
*Frank.* I see you are not, and I weep to see it.
My wife, the mother to my pretty babes,
Both those lost names I do restore thee back,
And, with this kiss, I wed thee once again;
Though thou art wounded in thy honoured name,
And with that grief upon thy death-bed liest,
Honest in heart, upon my soul, thou diest.
*Mrs. Frank.* Pardoned on earth, soul, thou in heaven art free
Once more. Thy wife dies thus, embracing thee! (*n*)

HIBERNATION. See Hybernation.

HIERA. See Kammeni.

HIERES, is a town of France, in the department of the Var, about nine miles east of Toulon. It is situated in a delightful valley, about four leagues long and one broad, open on the south to the sea, and bounded on the north, east, and west, by lofty mountains. Between the northern and western chain is a narrow pass, which is the road to Toulon. At the sloping entrance of this pass, on the declivity of a mountain that defends the whole plain, is situated the town, which is built in the form of an amphitheatre. The summit of the mountain is bare, and is cleft in several places, to give it the appearance of a fortification from a distance. Towards the base of the mountain stands the modern part of the town, which contains the principal street, the square, and the inns; but it has a gloomy and dirty appearance. The old town, which stands on the highest part of the mountain, presents a heap of uninhabited ruins; but the suburbs, which skirt the mountains, are cheerful and clean, and have a neat and rural appearance.

Near the mouth of the small river Gapeau, which intersects the plain of Hieres, are the salt-pits, consisting of a number of small basins separated by canals. The houses of the superintendants, excisemen, and workmen, have the appearance of a little sea-port. The salt is sent to Toulon, Marseilles, and Genoa, and the annual revenue amounts to about 500,000 francs.

About four English miles from the town is the Etang, situated in the centre of an isthmus, running from the southern coast. It is about a league long, and half a league broad, and the three little islands in the middle of it contain a great number of aquatic birds. The eastern part of the isthmus joins the road of Hieres, and is called La Plage de la Munasse. The lower part of it is the peninsula Giens, which contains many interesting objects.

Hieres is celebrated for the mild temperature of its winters; but it is reckoned unhealthy from May to October.

At the chapel of Notre Dame, on a hill situated near the sea-shore, and about a league from the town, is a good painting of the Twelve Apostles, and a bas-relief, by Puget.

The garden of M. Fille is well worthy of being visited. Its annual revenue is about 24,000 francs. In the garden of M. Beauregard, which is excellent, a crop of artichokes sold, in 1793, for 1800 francs. The chief exports from Hieres are, oil, wine, fruit, vegetables, flowers, and salt, which are sent almost exclusively to Toulon and Marseilles. A thousand oranges are sold for 45 livres. Vessels are loaded in summer at the beach near the salt-works; but in winter, all the merchandize must be conveyed to Toulon by land. East Long. 6° 7′ 55″, and North Lat. 43° 7′ 2″. Population about 7000. See Christ. August. Fischer *Reise nach Hyeres, im Winter von* 1803 *und* 1804. Leipzic. 1806; and Millin's *Voyages dans les Departemens du Midi de la France*, tom. ii. chap. 61.

HIERES, Isles of, (the *Insulæ Arearum*,) are a cluster of three small islands in the Mediterranean, situated about four leagues from the town of Hieres. They are called Porquerolles, Porticros, and the isle of Titan. They were called Stoechades by the Marseillois, who first inhabited them. The most western of these is Porquerolles, which is the largest and best wooded, and contains 85 inhabitants. Porticros is three leagues farther to the east, and is more elevated and fertile. It has a haven, and contains about 50 inhabitants. The other island is about three quarters of a league to the east of Porticros. It has fewer inhabitants, and is less fertile than the rest. All these islands may be seen from the town of Hieres. They are defended by small forts, and are covered with lavender and strawberries. They are frequently visited by parties of pleasure from the town. See Fischer's *Reise nach Hyeres.*

HIERO. See Syracuse.

HIERO'S Crown. See Hydrodynamics.

HIEROGLYPHICS, (from ἱερος, *sacred*, and γλυφειν,) *to carve*, properly sculptures or carvings, (and hence, by an easy and obvious transition, *paintings* also,) symbolically denoting, by particular figures and collocations of external or corporeal objects, sacred, moral, and religious truths.

Hieroglyphics may be considered as a *species*, of which *symbol* is the *genus*; for hieroglyphics are a particular class of symbols, differing however from other symbols, as well by the nature of the truths of which they are the signs, as by the mysterious and recondite mode in which these truths are exhibited. The truths denoted by hieroglyphics properly relate not to common or trivial objects, but to things sacred or divine; and the mode of exhibiting these is designedly obscure and enigmatical, requiring sagacity and acuteness, as well as patient attention, to develope their meaning.

The origin of hieroglyphical writing has generally been derived from Egypt; and undoubtedly it appears to have been there that hieroglyphics first assumed the form of a regular system. But, in fact, the first steps in the formation and employment of hieroglyphic emblems may be traced as nearly coeval with the earliest attempts of mankind to communicate their thoughts by visible marks, in addition to articulate sounds. In such attempts, it seems plain, that the first, as being the most natural, way of accomplishing the end, would be by presenting a picture or delineation of the object to be denoted. To express a *man*, an *animal*, or a *tree*, the figure of the object would be drawn and exhibited. To intimate that a man had been slain by a wild beast, the figure of a man stretched on the earth, and the animal standing over him, would be formed; to indicate that a hunter had caught his prey, the picture of the man with the prey in his hands would be given. Such was probably the earliest mode of writing. It is the opinion of the best informed writers, that it prevailed among the Phœnicians, Egyptians, and other early communities; and we know with certainty, that it was in use among the Mexicans when invaded by the Spaniards,—intelligence of their arrival having been transmitted to the emperor in a picture, and even the history of the empire having been delineated by paintings upon skins, afterwards found in one of the temples.

This way of communicating thoughts, however, was, of necessity, liable to much inconvenience. It was often difficult, and generally bulky. To lessen the toil, and abridge the size of the picture, different modes of abbreviation were resorted to. The principal part of the object might first be made to stand for the whole; as the head for the man, a hand holding a weapon for a warrior. Next, the principal circumstance in a complicated action might denote the entire action; two or more hands, with weapons opposed, might denote a battle; a scaling-ladder, set against a wall, a siege. In a short time, a farther improvement would occur; to put the instrument of an action for the thing itself, as, we are informed by Hori Apollo, two feet standing in water represented the fulling of cloth. Nearly connected with this, was the practice of denoting the efficient cause by the effect produced; as harvest, by a sheaf of corn—winter, by a leafless tree—hostile incursion, by ruined buildings and dead bodies.

From these different kinds of contracted characters, the transition was easy to the third stage in the progress of writing; to make one thing represent another, where any resemblance sufficiently striking between the two objects could be perceived. To this mode of communication it became frequently necessary to have recourse. Intellectual objects of every kind; the passions and feelings of men; the moral qualities of actions admit of no direct delineation by picture, they must therefore be represented, if represented at all, by sensible objects, to which they either bear, or are supposed to bear, some resemblance. Under the view of such analogies, wisdom was signified by an eye; ingratitude, by a viper biting the hand that offered it food; courage, by a lion; cunning, by a serpent. This constitutes what may properly be termed the *symbolic* mode of writing. It is in some measure analogous to that stage in the progress of speech observed among all rude tribes, where figures, tropes, and metaphors, fill up a great portion of every harangue.

This mode of writing is founded on resemblances perceived or supposed; and as it is difficult to set limits to the power of imagination in discovering or figuring resemblances, it might be supposed that the symbolic mode of writing could be carried to an indeterminate extent. But in fact it has its limits; it must be understood, if it is to be useful at all; the resemblance, therefore, must be either obvious and discerned by mere intuition, or so generally perceived and recognised, that the persons to whom it is addressed may easily pass from the sign to the thing signified. If the resemblance be very recondite and remote, if the analogy is traced from qualities not generally observed, the symbolic writing becomes proportionally obscure, and to the uninstructed not even intelligible.

It is thus, by a natural progress, that we can trace the origin of hieroglyphics. Mere picture writing was an obvious invention; contraction of picture writing was probably taught by necessity: symbols required the exercise of imagination; at first, probably, plain and perspicuous, they soon became more complicated and obscure.

Among a people who had no mode of representing their thoughts but by means of figures or characters of this description, the very progress of knowledge, or the extension of enquiry beyond the mere objects of sense or immediate observation, could not fail both to add to the number, and augment the obscurity of the symbolic signs made use of. New discoveries, new truths, new subjects of thought, required appropriate and expressive symbols; these might either be drawn from objects not hitherto delineated, or figures previously in use might be employed, arranged in forms and collocations remote from their former delineations. In either way it would follow, that to persons unacquainted with the very subjects to which the signs related, the symbols, until explained, would present confused and unintelligible groups. It was in this manner that the universe, or universal nature, came to be denoted by a winged globe, with a serpent issuing from it; and a serpent itself was made to represent the divine nature, on account of its supposed vigour and spirit, its great age, and the reverescence ascribed to it.

Hieroglyphics then are only an extension of picture writing, adapted to remote or mysterious objects. The first use, even of the simple hieroglyphic writing, was to record the history, the laws, and civil polity of the community; not, as Bishop Warburton justly observes, to conceal knowledge, but in fact to preserve and communicate it. But afterwards hieroglyphics came to be employed for a very different use. From the very nature of such a mode of writing, it is easy to see how conveniently, in the hands of a set of men aiming at pre-eminence by the reputation of superior wisdom, it might be used either to conceal their knowledge, or veil their ignorance from the people. Enigmatic figures, explained only to the initiated, were admirably fitted for such an end; and where the situation and circumstances of the people permitted this mode of concealment, we might expect to find it introduced and carried on. The extent, however, to which it could be carried, must be determined by the character or by the peculiar institutions of a people. Where superiority in knowledge in any class of the community was small, and the separation of professions not very rigid, the opportunities of concealing knowledge would be few, and the use of enigmatic figures less frequent; but where distinctions were strongly marked, particularly where a separate class of men were set apart to the conducting of religious rites and ceremonies, there, if no counteracting circumstance occurred, the occasions and means would be numerous and readily embraced.

Upon these principles it is not difficult to discover in the situation and character of the Egyptian priesthood, the circumstances which, though they did not indeed produce the invention of hieroglyphics, certainly occasioned a more extensive use of them than prevailed elsewhere. The Egyptian priests were a separate class of men, closely united among themselves, but sacredly distinct from the people, at a time when the only mode of writing in Egypt was by pictures or symbolic signs. Their retired life, joined with the objects about which they were chiefly employed, gave them the means and inclination of carrying their researches into abstract truths farther than the rest of their countrymen; the fruits of these researches were denoted by peculiar, often by the most grotesque and capricious symbols, conveying a secret meaning only to the initiated. In no other community, probably, did the same opportunies occur. Among some communities the separation of the different classes was neither wide nor permanent, and even where they were, yet as soon as alphabetic or even character writing was introduced, the use of symbolic writing would be in a great measure superseded. Hieroglyphics from that period, cultivated only for sacred purposes by the priests from the love of mystery and concealment, would soon lose their meaning, and in time become wholly unintelligible to all but the priests and their disciples.

Such appears to have been the history of hieroglyphic writing. The nature of it has been already explained. The symbols made use of in it were formed by assemblages of various objects, plants, animals, parts of the human body, heavenly objects, terrestrial appearances; all these combined in groups, which being first probably put together upon fancied resemblances, could hardly be deciphered, after the secret of their composition was lost. Some learned men have supposed that the Egyptian hieroglyphics contained much secret knowledge; probably they contained but little, and to employ pains in deciphering them, would only be a waste of labour.

Hieroglyphics abound on the ancient monuments of Egypt; the great obelisk brought from Egypt to Rome, is full of such figures; and on almost all the obelisks now existing they are met with. Many curious hieroglyphic figures were engraved on what was termed the Isiack Table, a large black table, long preserved at Rome, and at the sacking of that city, in 1525, found by a poor tradesman, and afterwards removed to Mantua, where it disappeared at the capture of the place. It had been previously engraved, and a plate of it is given in Montfaucon's *Antiquities*. Many Egyptian hieroglyphics were also engraved on gems, and small figures, which are still to be met with in cabinets. Hieroglyphics, properly so called, seem to be almost peculiar to Egyptian antiquities; the uncouth and distorted figures of some of the Hindoo gods have been conjectured to constitute significant emblems, somewhat of the nature of hieroglyphics; but it appears to have been in Egypt alone that they were extensively employed; a circumstance that may easily be accounted for upon the principles already explained.

Sir John Marsham supposes hieroglyphics to have been the origin of the worship of animals; the figure and the thing signified being, as he supposes, so connected, that both began to be held equally sacred. This is by no means improbable, though no direct proof of it is to be had. It seems certain, however, that hieroglyphics were often engraved on gems, as a kind of magical spell; these gems were termed Abraxas; they were exhibited by certain corrupted Christians, natives of Egypt, who had mixed a great deal of Paganism with their Christianity: many of them are still to be met with in the cabinets of the curious. These abraxas were superseded among the superstitious orientals by talismans.

The subject of hieroglyphics has been frequently treated of. Among the ancients, *Horus Apollo*, or *Horapollo*, wrote a treatise expressly on the subject. In modern times, one of the most laborious writers on hieroglyphics was the learned Jesuit Kircher. His *Oedipus Ægyptiacus* contains a great collection of curious particulars; but his explanations are fanciful, and indicate little judgment. In the second book of Montfaucon's *Antiquities* is given a general account of hieroglyphics, illustrated with accurate engravings. By far the most ingenious and philosophical account, both of the history and nature of hieroglyphics, is given by Warburton in the 4th book of the *Divine Legation*. The Bishop has not, however, been careful to distinguish between emblems in general, and hieroglyphics properly so called. Dr E. D. Clarke, in his *Travels* lately published, maintains, but by no means upon certain grounds, that the hieroglyphic characters were the letters of an ancient alphabet, and the more compound forms probably a series of monograms. (δ)

HIEROGRAMMATIST, (from ιερος, *holy*, and γραμματιστης, *a writer*,) an order of priests among the ancient Egyptians. To them was committed the care of the hieroglyphics, the exposition of religious doctrines, and the superintendance of the Egyptian learning in general. They were regarded as a kind of prophets; and to establish their reputation for this, they made use of their knowledge of the heavenly bodies, or meteoric phenomena, to impose upon the people. They were always near the person of the king, to whom they were next in dignity, and were exempted from all civil employments. When Egypt became a Roman province, they fell into total neglect. (δ)

HIEROMANCY, the art of divining futurity from observing the sacrifices when in the act of being offered up. See Divination and Sacrifice. (δ)

HIGHGATE, is a village in Middlesex, about four miles north of London, delightfully situated on the top and sides of one of the highest hills in the county, commanding the most beautiful and extensive prospects over Essex, Surry, and Kent, in one direction, and Hertfordshire, Bedfordshire, and Buckinghamshire, in another. It consists principally of the villas of the opulent merchants, &c. of London, and its buildings are equal, if not superior, to any in the neighbourhood of the metropolis. In order to avoid the steep hill, it was proposed to cut a tunnel through it, which was begun in 1808. The roof of it, however, fell in after the work had made some progress, and it was found necessary to make an open cut through the hill. This great improvement is now completed; and the London road passes below an arch, which it became necessary to build for the purpose of carrying a cross road over the cut.

HIGHLANDS. See Scotland.

HILDESHEIM, is the name of a German bishopric, founded in 822 by Charlemagne. It extends about 50 or 60 miles from east to west, and about 35 from north to south, and contains about 54 square German miles. The soil of the greater part of the district is good, and produces abundance of corn, flax, hops, and vegetables. The southern districts are hilly, and covered with forests; some of the hills containing excellent quarries and iron mines. The wood is principally oak, beech, ash, and birch. The diocese contains 16 bailiwicks, 75 manors, 13 towns, 234 villages, and 85,000 inhabitants, with an annual revenue of 250,000 rix-dollars. The principal towns are Hildesheim, Peina, Rosenthal, and Marienburg. After the secularization of the diocese in 1803, it was given among the indemnities to the king of Prussia. After the peace of Tilsit, it formed part of the kingdom of Westphalia.

HILDESHEIM, or Hillesheim, the *Bennopolis* of the ancients, is a town of Germany, and the capital of the diocese of the same name. It is situated on a rugged declivity, watered by the river Innerste; about six leagues S. E. of Hanover, and 10 W. S. W. of Brunswick. The town is tolerably large, but is irregularly built, and old fashioned. It is divided into the Old and New Town, which were united in 1583. The principal public buildings are the Cathedral, Holy Cross Abbey, the Gymnasium Andreanum, about eight Protestant churches, and several monasteries. The Cathedral belongs to the Roman Catholics, and its bishop was the only catholic one in all Saxony. It is a richly ornamented Gothic building, and contains among its antiquities the celebrated Pagan monument of Irminsal, which fronts the great choir. It is a column which serves to support a chandelier of several branches. Population 12.600.

HIMALEH, or Himalaya mountains, the *Emodus*, *Himaus*, or *Imaus*, of the ancients, is a stupendous range of mountains, which bound Hindostan on the north, and separate it from the country of Great and Little Thibet. In East Long. 76°, and North Lat. 34° 30′, the Himaleh range joins the mountains of Cashmere on the west, the northern range of the latter being as it were a continuation of the former. The Himaleh mountains being supposed to commence at this point, take a S. E. direction to Bootan, and form the boundary between that country and Thibet, in about 90° E. Long. and 28° N. Lat. stretching still farther to the east they terminate to the north of Asham. The river Burram-pooter is supposed to wind round the eastern extremity of the range about 95° of East Long. It appears from Col. Crawford's observations, that one of the peaks of Himaleh, seen from Patna, is more than 20,000 feet above Nepaul, or about 25,000 feet above the level of the sea. The country declines in height from the summit of these mountains to the south, the surface being irregularly mountainous to the borders of Bengal, Oude, and Delhi, where the plains begin, which stretch to the sea. Several of the tributary streams of the Indus, and probably the Indus itself, have their origin from the western side of these mountains. It is supposed that the sources of the Sanpoo, or Burram-pooter, and its tributary streams, are separated only by a narrow range of snow clad peaks, from the sources of the streams which form the Ganges. See Rennel's *Memoir*, and *Asiatic Researches*; Hamilton's *Gazetteer*; and our articles India and Thibet.

HINCKLEY, is a town of England, in Leicestershire, situated near the borders of Warwickshire. The town is divided into the *Borough* and the *Bond* without the liberties. The limits of the borough were formerly those of the town, which has been extended by the successive addition of four streets, the Bond End, the Castle End, the Stocken Head, and the Duck Puddle. The parish church is a neat large structure, with a modern built spire, erected in 1788, on the old tower. The body of the church seems to have been built about the 13th century. Its length, from the chancel to the west door, is 66 feet, and its width near the chancel about 80 feet. There are three other places of worship, and a Roman Catholic chapel. The town-hall, school-house, and ball-house, are very curious, but in a ruinous state.

Hinckley was once of much greater extent, and was encircled with a wall and deep ditch, traces of which are still to be seen. The part called the Jewry-wall is said to have been part of the temple of Janus. There is near the river a mount, supposed to have been a Roman fortification; and near the church are the ruins of a bath, with three mineral springs. Tesselated pavements, and other Roman antiquities, have been discovered here. This town is said to form the middle of the highest ground of England, and commands a view of no fewer than fifty churches. Its principal manufacture is that of coarse stockings of cotton, thread, and worsted. A larger quantity of stockings is supposed to be made here than in any town in England. The number of frames in the town and neighbourhood is computed at 1200, which give employment to nearly 3000 persons. The town is likewise noted for the goodness of its ale.

In 1811, the parish of Hinckley, including Dadlington and Stoke Golding, contained

| | |
|---|---|
| Inhabited houses | 1097 |
| Families | 1224 |
| Do. employed in trade and manufactures | 1010 |
| Males | 2872 |
| Females | 3186 |
| Total population | 6058 |

See Nichol's *History of Hinckley*; and the *Beauties of England and Wales*, vol. ix. p. 473.

HINDOSTAN. See INDIA.

HINZUAN. See JOHANNA.

HIPPARCHUS. See ASTRONOMY.

HIPPIAS. See ATHENS.

HIPPOCRATES, commonly called the Father of Physic, was the most renowned physician of ancient Greece, and the oldest medical writer of whom there are any authentic works now extant. He was a native of the island of Cos, which had been long celebrated in the annals of medicine, being the seat of one of the schools founded by the Asclepiades or descendants of Æsculapius. Hippocrates himself belonged to that family, and is reckoned by his biographers the 18th in a direct line from that personage. Among the number of his ancestors was Podalirius, the son of Æsculapius, who, along with his brother Machaon, followed the Grecian army in the Trojan war. His genealogy by the mother's side was equally honourable; as, in this line, he was the 20th descendant of Hercules. These genealogies may be fabulous, but they were credited among the ancients, and tended to increase the veneration in which the character of this great physician was held. Very few details of the life of Hippocrates have been transmitted to us; but the singular eminence of his character makes the biographer dwell with pleasure on circumstances, which, in the life of another man, would appear unworthy of attention. Hence a variety of unimportant rumours are stated, and the arguments for and against their probability are studiously discussed.

He was born in the first year of the 80th Olympiad, or 458 years before Christ, in the reign of Artaxerxes Longimanus of Persia, and was the contemporary of Socrates, Herodotus, and Thucydides. His father Heraclides, and his grandfather Hippocrates the elder, who were both eminent physicians, bestowed much pains on his education in literature and general science, as well as in medicine. He studied polite literature and eloquence under Gorgias of Leontium, a celebrated rhetorician. He is said to have studied the physical sciences under Democritus; but it rather appears that he was not acquainted with that philosopher till he was more advanced in life, and already celebrated as a medical practitioner. He enjoyed, from the circumstances of his ancestors, and the spirit of the place of his nativity, great incitements to medical studies, and great advantages for the prosecution of them. Under these favourable auspices, he acquired an early relish for the medical profession, and devoted himself to it ever after, with ardour and assiduity. Besides studying in the school belonging to his native islands, he studied the gymnastic medicine under Herodicus, by whom it was invented, and he travelled much in Greece, Thessaly, and Thrace, where he made many observations on the history of epidemic diseases. The greater part of his professional life seems to have been spent at Larissa, in Thessaly. One Andreas, who wrote on the history of medicine, assigns a less honourable motive for his peregrinations. He says that he absented himself, in order to escape from the punishment due to some larcenies which he had committed in the library of the medical school of Cnidos, where he was said to have transcribed some of the books, and then burned the originals. This account, however, entirely originated in the jealousy of the Cnidian school, to which Andreas belonged, and the precepts of which were controverted by Hippocrates. It is inconsistent with the sentiments of high honour which were conspicuous in all the conduct of Hippocrates. Others said that he fled, because he had copied some inscriptions in the temple of Æsculapius, detailing the cures of sick persons, who thus recorded their acknowledgments to that deity. This report is equally groundless with the other, and does not correspond with any thing that we know of the tendencies of ancient prejudice. He seems to have also travelled in Africa and Asia; but the chief scenes of his travels were on the European continent, where he frequently visited different cities and countries, for the purpose of relieving epidemic distempers, with which they were occasionally afflicted. While a dreadful pestilence prevailed among the Illyrians, he was earnestly invited by that people to favour them with the advantages of his medical skill; but, on inquiring into various circumstances attending that epidemic, he concluded that his services would be ineffectual. He declined the journey; and finding reason of apprehension that the same disease would extend to Thessaly and Greece, he sent his sons to these countries, for the purpose of preparing them to meet the visitation with proper precautions. In a plague at Athens, he is said to have contributed much to the health of the city, by ordering large fires to be lighted for purifying the air, and by burning various perfumes in private houses, in the manner of the Egyptians. His sons, also, gave material assistance. These accounts, however, do not well correspond with historical dates. The great plague of Athens, described by Thucydides, happened when Hippocrates was only thirty years of age, and could not have sons capable of giving medical directions. The inhabitants of Abdera, observing that their fellow-citizen Democritus had contracted much singularity of manners, that he had become addicted to immoderate and ill-timed laughter, and secluded himself from society, conceived him to be insane, and invited Hippocrates to go and pronounce a judgment on his case, and take him under his medical care. Hippocrates went, and finding Democritus a man of deep research, who engaged himself with unwearied assiduity in philosphical pursuits, pronounced him the wisest man in Abdera. Ten talents were offered to him on this occasion, but he declined accepting of any recompense.

Kings and princes are said to have made different attempts to engage him in their service. We are told, that Perdicas, king of Macedon, invited him to his court to cure his son of a consumption; and that Hippocrates discovered the whole complaint to consist in the workings of a secret passion which the young man cherished for Phyla, the mistress of his father. This story, however, coincides so exactly with the accounts of the cure performed by Erasistratus on Antigonus, the son Seleucus Nicanor, that we are forced to conclude it to be fabulous; and it must be confessed, that the other anecdotes of his life do not rest on the most satisfactory evidence. They are all derived from the same source, a collection of letters and other pieces, called τα εξωτικα, sometimes published with the works of Hippocrates.

Artaxerxes offered him large sums, and a splendid establishment, to induce him to enter his service during a destructive epidemic which desolated some of the provinces, and also the armies of Persia. Hippocrates refused the offer in a haughty style, expressing his contempt of barbarians, and the indignity to which he would find himself subjected by leaving the Greeks, to devote his services to that people. This unnecessary affront, arising from an excess of national pride, highly offended Artaxerxes, who then demanded of the inhabitants of Cos, that Hippocrates should be delivered into his hands, threatening them with the extremity of his vengeance in case of refusal. The people of Cos, however, were too honourable, and too much attached to their illustrious countryman, to yield to these intimidating threats; and Hippocrates remained unmolested.

The high character of this physician gave him, on one occasion, an opportunity of performing an important political service for his native country, which he tenderly loved. The Athenians threatened the island of Cos with a formidable invasion. Hippocrates solicited the assistance of the people of Thessaly and the adjoining countries, and at the same time sent Thessalus his son to Athens, to avert the storm by negotiation, and sage remonstrances on the baneful tendency of ambition. The exertions both of the father and the son were successful. The Thessalians, the Messenians, and the states of the Peloponnesus, engaged to espouse the interests of the island of Cos; and the Athenians, partly out of regard for Hippocrates, and partly from the apprehensions which so much resistance created, abandoned their hostile designs.

Hippocrates entertained a deep sense of the importance of the duties of the professional character. He spared no pains which were necessary for his own improvement, and the successful practice of his art. He was aware that medicine requires more assiduous attention than other employments; he exacted of all his pupils an oath, binding them to certain rigid principles of duty, and, among other things, to engage, that they would enter no house whatever, except for the purpose of relieving those who needed their assistance. This rule, if taken according to the strict meaning of the words, appears somewhat fantastic, as it supposes that the number of patients and of practitioners should always be nicely accommodated to one another. It shews, however, the abhorrence which Hippocrates had of any degree of negligence and frivolity in the medical character. He was ready at all hours to attend on a call; and submitted with as much willingness to all those minute attentions which were necessary for the welfare of his patients, as to professional offices which were apparently the most dignified. It also redounded to his honour, that his attention was not less directed to the gratuitous object of preventing, than to the lucrative employment of curing disease. Of this he has left a testimony in his writings, by treating on the subject of diet and of water. These features of disinterestedness would not merit great praise in modern times, in which they are so common, and are requisite to establish a character, and are therefore often either mimicked for this express purpose, or avoided, if they interfere with false and fashionable notions of dignity. They acquire greater lustre from the consideration of the different sort of manners which prevailed in the days of Hippocrates, as well as the complete superiority to intrigue, by which, in his conduct, they were accompanied.

His zeal for science and humanity was rendered efficient by his excellent talents, and the weight of his personal character. His sagacity in observing nature was a resource to him on every emergency; and the accuracy of his judgment led him to resist the useless frivolities which superstition had introduced into medical practice. Inviolable secrecy, justice, and good faith, marked the whole of his conduct. Uniting dignity with humanity in his deportment, he employed firmness or complacency on such occasions as called for the exercise of either quality. He spoke but little; and his language was masculine and concise. His actions were never conducted with agitation; no prescription was given with precipitance; no circumstances were neglected; nor was the result ever left in any degree to accident. If at any time he failed of success, from want of previous experience adapted minutely to any individual case, he acknowledged his failure in the most ingenuous manner. In his writings, he sometimes warns his readers against mistakes and errors which he himself had committed, and which were attended with fatal consequences. He exhibited in all respects a bright example of the qualities which he himself enumerates, with so much eloquence and good sense, as contributing to the perfection of the medical character. Hence his precepts on that subject acquire a double authority.

Hippocrates lived to a great age; some say 109, others, however, make it much less. He died at Larissa, and was buried between that city and Gyrtona. He left, among numerous other disciples, his two sons, Thessalus and Draco, both eminent physicians, and his son-in-law Polybus, who had been a favourite pupil, and afterwards became a celebrated teacher, and arranged and published the works of his friend and master. In statues and paintings Hippocrates is represented with his head covered, which is different from the usual manner of the Greeks, and was probably done on account of his having been so great a traveller, as that was the only description of individuals who were uniformly thus distinguished.

Hippocrates has always been regarded as the father of his art. The honour in which he was held, both during his life and after his death, was very high. The inhabitants of Argos erected a statue of gold to him. The Athenians more than once voted him a crown of gold, and initiated him in their great religious mysteries. This last was a favour very seldom conceded to strangers. Although he did not cultivate general philosophy, except as subservient to medicine, he exemplified so ably its spirit, that Plato, Aristotle, and others, looked up to him as a master, and sometimes commented on his opinions. Aristotle even followed him as a model of style. His works have been held in high esteem in all subsequent ages; they have been translated or commented on by Galen, Celsus, and numerous other physicians of the most eminent genius, both in ancient and modern times.

The treatises which have gone under his name are 72 in number; but they are not all of equal authenticity. Doctrines so contradictory are sometimes contained in them, as shew them plainly to have been the works of distinct authors. Some are probably of much more ancient origin than Hippocrates himself. Some are thought to have been written by his grandfather, who bore the same name: and several have been either much altered and interpolated, or entirely written by subsequent authors. Those which are universally allowed to be genuine are, "The Aphorisms," "The Prognostics," the first and third book "On Epidemics;" and the book "On the Influence of Air, Water, and Local Situation." Some are regarded as supposititious, because they deviate from the character of Hippocrates, as shown in the works now enumerated, both in solidity, method, and correctness of language; while others bear only in part the character of this master, and incline the critical reader to suspend his judgment of their authenticity. These last seem to have been such as Hippocrates left in an unfinished state, or the substance of notes or copies taken from his prelections by his pupils. Such are "The Four Prognostics;" "The Predictions;" the 2d, 5th, 6th, and 7th, books "On Popular Diseases;" that "On Diet in acute Diseases;" the books "On the Parts of the Human Body;" "On Aliment;" "On the Recoveries that happen on critical Days;" and "On the Humours." There is considerable difficulty, however, in deciding in the negative respecting the works said to belong to a particular author. We may give a judgment on the positive authenticity of certain performances, which bear the stamp of the genius and manner of a masterly writer. But such writers often produce works which are not equal to their genius, works which have been written under inauspicious circumstances, which have diminished their attachment to their subject, impaired their confidence in themselves, and obstructed the full exercise of their talent. Great differences may also depend on the period of life. Juvenile performances may be comparatively lame or volatile, and old age brings along with it a decay of the mental powers, which may appear in the literary performances to which it gives origin. Differences of the time of life will sometimes also account for inconsistencies of doctrine, produced by changes of opinion, which have taken place between the times at which different works have been composed.

The principal editions of the works of Hippocrates in the original are, those of Aldus at Venice in 1526; and of Frobenius at Basle in 1538, both in folio.

The editions of Greek accompanied by Latin translations are, those of Hieronymus Mercurialis, at Venice, in 1578; of Zwinger, at Basle, in 1579; of Anutius Foësius, at Francfort, in 1595; of J. A. Vander Linden, at Leyden, in 1665; of Renatus Chartrier, with the works of Galen, at Paris; and of Stephen Mack at Vienna, in 1743, 1749, and 1759.

The editions of Latin translations, without the original, are that of Cratander at Basle, by several translators, in 1526; of M. F. Calous, at Rome, in 1525, from MSS. in the Vatican; of J. Cornarius, at Venice, in 1545; and that of Anutius Fœsius, at Francfort, in 1596, in 8vo, by Wechel.

As Hippocrates was the first author who applied philosophical reasoning to medicine, the sect of the Dogmatists looked up to him as their head. But he did not cultivate theory to the exclusion of observation and experience: he was one of the most accurate observers that any age has produced, and his reasoning has much less mixture of error than might have been expected, from his deficient knowledge of anatomy, and the want of good logical methods at the time at which he wrote.

He gave a general theory of the formation and conservation of the universe, in conformity to the doctrine of the four elements; and he applied the same doctrine to account for the formation of the human body. In explaining the doctrines of health and disease, he acknowledged a general active principle, which he called *nature*, to which he ascribed the attribute of justice. This agent he considered as the cause of nutrition in the animal economy, by attracting what is good, retaining and preparing it, and rejecting what is superfluous and hurtful. The manner in which he accounts for the formation of the brain, the bones, the membranes, and all the various parts, has that air of absurdity which is universal in the physical philosophy of the ancients. His anatomy and physiology are not very fully contained in the works which have reached our times, and are evidently imperfect and fanciful. He divides the constituent parts of the animal economy into the solids, the fluids, and the spirits. The solids are the containing parts, the fluids the parts contained, and the spirits those which give motion to the whole. On this division, followed up with various subdivisions, he establishes his doctrine of the causes of disease. He divides the humours, for example, into the blood, the phlegm, the yellow bile, and the black bile, and distinguishes these by the possession or the want of heat or of moisture. The blood is warm and moist; the phlegm cold and moist; the yellow bile warm and dry, and the black bile cold and dry. The most valuable parts of the writings of Hippocrates are his histories of diseases. In delineating these, we find him a faithful and laborious observer of facts; hence he was deeply skilled in the diagnosis and prognosis of diseases. By far the greater part of his descriptions are still recognised as accurate by all who follow him in the path of careful observation. The article in which his observations are most deficient, is the pulse, which he so much overlooked, that some have supposed him altogether unacquainted with the changes to which it is liable. It was chiefly from the degree of heat, and the difficulty of respiration, that he judged of the state of a fever.

In the treatment of diseases, he inculcated a profound respect for the progress of nature, whom he regarded as the arbiter and judge of diseases, and as having certain salutary objects in view in the greater part of those successive changes in the constitution which they implied. This doctrine is in fact the same which has been maintained by various later theorists, under a different set of terms, and with slight modifications, such as the *archæus* of Van Helmont, and the *vis medicatrix naturæ* of Dr Cullen. The opinions of Hippocrates on this general point made him unwilling to use any means for interrupting the course of nature, as exhibited in the phenomena of disease: hence his practice is culpably feeble; and those whom an admiration of his genius has led to follow him closely, have been too prone to satisfy themselves with the exercise of tracing the course of diseases, rather than to resist their progress. These have been most numerous in France, where the study of the Greek medicine is treated as a separate branch of education. The Hippocratic method is denominated the method of expectation, and is extolled as rational and sure. But it deserves, in some measure, the sarcasm of the Roman physician Asclepiades, who called it a mere meditation on death, a solicitude to observe how a disease would terminate, and what length of time it would require to destroy the patient. Hippocrates indeed recommends some practical remedies for the purpose of aiding the good intentions of nature, and gently correcting some slight deviations incident to it. His precepts in this department are delivered with some formality, in conformity to the style of the early philosophy; but they are not characterised by that emptiness and unmeaning mystery which often prevailed, and they exhibit a justness of remark which was entirely his own. His general principle was, to cure contraries by contraries, cold by heat, heat by cold, evacuation by repletion, and repletion by evacuation. In idiopathic fevers, he began with the regulation of diet, which consisted in prescribing abstinence, with a very sparing allowance even of liquids, for three or four days, that no morbid matter might be added to the system, while nature threw off that which was already present. This was succeeded by the exhibition of various liquids till the fourteenth day, and it was not till a late period that any solid food was allowed. Medicinal preparations were also long deferred, and consisted of gentle laxatives and emetics. In inflammatory complaints his practice was more active; he used fomentations, blood-letting, and purging. He also gave some weak wine and aromatics, which are, it must be confessed, less correct prescriptions in diseases requiring the strictest anti-phlogistic treatment. In empyema (a collection of pus in the cavity of the thorax) he first drew out the patient's tongue, then poured a little irritating liquid, prepared from the root of arum, from hellebore or copper, into the trachea, for the purpose of exciting a violent cough, and thus discharging the purulent matter. He was also in the practice of shaking violently the patient's body, with a view to detach the matter from the parts to which it adhered. In diseases of the head, he first applied fomentations, and then excited sneezing for bringing off the phlegm.

In pharmacy he made extensive improvements. His preparations are diversified in their composition and consistence, so as to answer minutely the various purposes of external medicine. He paid great attention to the diversities of state, and the shades of morbid sensation in diseased parts, and nicely adapted to them the forms of his remedies. In this respect he may often serve for a model to correct the gross ideas of those who exclusively venerate the agency of powerful simples. As a surgical author, Hippocrates had great merit; though the vigour of his practice in this department sometimes exceeded the bounds of moderation. He placed great reliance on the revulsion produced by powerful discharges by means of blood-letting, and which was assisted by the use of cupping instruments; and when this failed, he formed extensive and deep ulcers, by the actual cautery. A full account of the opinions, theoretical and practical, of this ancient author, would fill a large volume. In this country, an acquaintance with them is, even among medical men, reckoned an object of curiosity rather than an attainment necessary to the physician; but the perusal of the works of Hippocrates himself has an excellent tendency to cherish in the mind of a professional man, that zeal for the objects of his art, and that keen and persevering attention to his duties, which renders his life most satisfactory to himself, and most useful to society. See Le Clerc's *Histoire de la Medicine*; Fabricius; also the *Life of Hippocrates*, by Soranus; and the introduction to Pinel's *Nosographie Philosophique.* (*H. D*)

HIPPOCRENE. See Helicon.

HIPPOPOTAMUS. See Mammalia.

HIRE, Philip de la, an eminent and industrious French astronomer, was born at Paris on the 18th March, 1740. His father was painter to the king, and instructed his son in the same art, particularly in drawing, and such branches of the mathematics as related to his profession. In the year 1761, three years after he had lost his father, De la Hire went into Italy to re-establish his health, and to study those fine models of painting and sculpture which every artist was ambitious to imitate; but, during the three years which he spent in that country, he discovered that he was more fitted to excel in astronomy and geography than in the fine arts, and he henceforth devoted his whole time to these interesting studies.

Upon his return to Paris, he was nominated one of the members of the Academy of Sciences; and in 1699, he was named *Pensionnaire Geometre.* Between the years 1678 and 1718, he published no fewer than *two hundred and forty-four* memoirs on almost every branch of mathematics and natural philosophy.

When the great Colbert had resolved to make a correct map of France, De la Hire was associated with M. Picard in this important duty, which occupied him for several years. In 1683, he was employed in continuing to the north of Paris the meridian which Picard had begun in 1669, while Cassini was employed in extending it to the south. The death of Colbert having put an end to this great undertaking, De la Hire was next employed in the formation of the great water-works with which Louis XIV. embellished his palaces. De la Hire filled also the situation of royal professor of mathematics and architecture, and was much esteemed among his countrymen. His name, however, is not associated with any great invention or discovery; and we are called upon only to admire the extent of his knowledge, and the persevering industry which he exhibited, both in acquiring it for himself, and in communicating it to others. The works which he published separately were,

1. Nouveaux Elemens des Sections Coniques. Paris, 1678, 1 vol. 12mo.
2. La Gnomonique. 1682.
3. Traité du Nivellement de M. Picard, avec des additions. Paris, 1684.
4. Sectiones Conicæ in novem Libris distributæ. Paris, 1685, folio.
5. Traité du mouvement des eaux et des autres corps fluides; ouvrage Posthume de M. Mariotte. 1686.
6. Ecole des Arpenteurs. 1689.
7. Traité de Mecanique. 1695, 1 vol. 12mo.
8. Tabulæ Astronomiæ Ludovici Magni jussu et munificentia exaratæ. 1702.

De la Hire died on the 28th April, 1718, and left behind him a son, Gabriel Philip de la Hire, who was much esteemed as a physician, and who published several papers on medicine and natural philosophy in the Memoirs of the Academy from 1699 to 1720.

HIRUDO. See Intestina.

HIRUNDO. See Ornithology.

HISPANIA. See Spain.

HISPANIOLA. See St. Domingo.

# HISTORY.

In this article it is proposed, in the first place, to point out and explain the various advantages of the study of history; secondly, to enumerate those branches of study which ought to be entered upon, previous to, or contemporary with the study of history; thirdly, to give a brief and rapid sketch of the order in which ancient and modern general histories may most conveniently and advantageously be read; fourthly, to point out the order in which the history of particular countries may be read, so that they may be illustrative of one another; fifthly, to notice the different species of history besides what is emphatically called History.

I. With respect to the advantages which may be derived from the study of history, they are various and important:

if the value of that department of science is to be rated highest, which combines advantages of the most obvious and beneficial nature, history possesses a very strong claim to our attention and study. It is equally attractive to the unreflecting and philosophical mind: the former it interests by the excitation of novelty; the latter by the usefulness and importance of the general principles which may be deduced from the facts which it records. But perhaps the utility and value of this branch of study cannot be placed in a more obvious and conspicuous point of view, than by stating that it combines amusement of the deepest interest; the exercise and improvement of the best faculties of man; and the acquisition of the most important species of knowledge.

History, considered merely as a source of amusement, is infinitely preferable to novels and romances, the perusal of which too frequently debilitates the intellect by inflaming the imagination, and corrupts the heart by the infusion of what may justly be regarded as moral poison. Whatever valuable impressions are made upon the mind by fictitious adventures, the same in kind, though, perhaps, generally not equal in degree, are made by the perusal of history; and while works of fiction are not in their nature capable, in general, of any other uses than the authors had in view, which must necessarily be very limited; true history, being an exhibition of the conduct of Providence, has infinite relations and uses, and may be regarded as an inexhaustible mine of the most valuable knowledge. It has been very justly remarked, that "works of fiction resemble those machines which we contrive to illustrate the principles of philosophy, such as globes and orreries, the uses of which extend no farther than the views of human ingenuity; whereas real history resembles the experiments made by the air-pump, the condensing engine, or electrical machine, which exhibit the operations of nature, and the God of nature himself, whose works are the noblest subject of contemplation to the human mind, and are the ground-work and materials of the most extensive and useful knowledge."

But a higher use of history is, to improve the understanding and strengthen the judgment: by studying history, and examining into the causes and consequences of the events which it unfolds, the penetration is sharpened, the attention of the mind is fixed, and the comprehension enlarged: hence are acquired the faculty of discovering quicker, and that flexibility and steadiness so necessary to be found in the conduct of all affairs, that depend on the concurrence or opposition of other men. It is a great, but a prevalent mistake, to imagine, that history is calculated to enlighten the judgment only on those subjects which are connected with the welfare of the community at large; it is nearly in an equal degree calculated to enlighten the judgment on those that bear on individual utility and comfort. In this respect the advantages of history are more important than those we derive from our own individual observation and experience; for though the impressions made by the latter will be more vivid, and probably more permanent, yet the knowledge we derive from history is more correct, and consequently a better guide to us, in our intercourse with the world; for the examples which it presents are generally complete; the whole is before us; whereas in real life, every scene opens very slowly, and we consequently see but a small part of a thing at a time;—hence we are liable to be deceived in our judgment of it.

The history of Great Britain will sufficiently illustrate the truth of the preceding remarks; if entered upon merely as a source of amusement and interest, it is rich and valuable in this point of view. The rude and barbarous state in which this country and its inhabitants existed, at the period of the Roman conquest, contrasted with its present situation, when it has attained an infinitely higher rank in the scale of intellect and power than Rome ever reached, cannot fail to act as a stimulus to the curiosity, to learn the various events which occurred between these two states so diametrically opposite. Besides this general source of interest and amusement, which the history of Britain holds out, there are many particular periods in it, which are almost equally calculated to excite and gratify these feelings. This is considering the history of Great Britain in its lowest character; it further illustrates our preceding remarks, by the constant exercise which it affords for our judgment and penetration; so that it may be justly affirmed, that the faculties of the human mind will derive from its perusal a great accession to their strength.

But the great advantage to be derived from history,—and this advantage flows in the most direct manner, of the highest character, and in the utmost abundance, from the history of Britain,—consists in this, that by means of it we gain our knowledge of the mechanism of society; of the reciprocal influence of national character, laws, and government; of those causes and circumstances, that have operated towards the production and advancement, or the destruction and retardation of civil and religious liberty, and the various branches of science and literature. It leads to a knowledge of man in his social relations: it exhibits the various operations of different systems of polity upon human happiness. In a country which enjoys so great a portion of civil liberty as happily falls to the lot of the inhabitants of the British empire, almost every order of the community has its influence upon the measures of the legislative and the executive powers; consequently, a knowledge of history should be diffused to as wide an extent as possible among them. A familiar acquaintance with the history of their country was, in the best times of the Roman republic, held to be essentially requisite to qualify youth for stations of dignity, power, and profit, in the administration of public affairs. Hence the bitterness of the sarcasm, uttered by Marius, when he asserted, that, in his degenerate days, men of illustrious birth did not begin to read the history of their country till they were elevated to the highest offices of the state, that is, as he said, "they first obtained the employment, and then bethought themselves of the qualifications necessary for the proper discharge of it."

In this brief enumeration of the principal uses to be derived from the study of history, it is presupposed that historical facts are made the subjects of mature reflection. He who is satisfied with merely storing his mind with a multiplicity of events, even though those events may be of the highest class in point of importance, and calculated to establish or illustrate the most useful principles, will derive little profit from a great expence of time and labour.

II. The sciences which are of the most constant and general use in the study of history, so as to have deserved to be called its two eyes, are geography and chronology. Without the former, no reader of history can have any clear and distinct idea of what he reads. Moreover, by a knowledge of this science, we are able to verify many past transactions, which, if they ever happened, must have left indelible traces on the face of the earth. Many curious examples of this nature may be seen in Addison's Maundrels, and Shaw's Travels. With respect to chronology, it is absolutely impossible to form clear and distinct notions of the intervals of time, of the rise and fall of empires, and of the successive establishment of states, without some such general comprehension of the whole current of time, as may enable us to trace out distinctly the dependence of events, and distribute them into such periods and divisions, as shall place the whole train of past transactions in a just and orderly manner before us. For a further illustration of the uses of Geography and Chronology, as applicable to history, we refer our readers to those two articles in this work.

Another branch of study, which ought to be pursued along with the study of history, is what is called statistics; or that branch which comprehends an account of the sources of the wealth and power of different states, such as their population, habits of industry, agriculture, manufactures, trade, commerce, and finances. Unless we possess information on this head, it is obvious that we shall be much perplexed, and frequently led astray, in our endeavours to account for the comparative influence and exertions of different nations. Thus, for example, a person ignorant of the advances which Britain has made in agriculture, manufactures, commerce, and what may be called the economics of the state, cannot possibly satisfactorily account for the high rank which she holds in the scale of European nations,—a rank, to which, from the mere inspection of the map of Europe, she does not seem by any means to be entitled.

Another collateral branch of study ought to be that of the governments of nations; not a minute investigation of the various parts of their government, but such a knowledge of their general and leading principles, as would enable us to ascertain, how far, and in what respects, the influence and advances of each state might justly be attributable to their respective constitutions. In this point of view, also, Great Britain may be cited as an instance peculiarly illustrative of the justice and truth of our observations. A person who had made himself acquainted with the progress of this country in agriculture, manufactures, and commerce, and who beheld in them the sources of her wealth and power, would still be desirous of learning the causes, which had enabled her to make this progress so far beyond that of other nations; and of these causes, on investigation, he would find her free constitution to be the most prominent and operative. The observations which we have now offered, respecting the connection between the history and the statistics and government of a country, will be most fully and satisfactorily confirmed and illustrated by reading the articles Britain, *History of;* England, *History and Statistics of;* and Scotland, *History and Statistics of;* in this work. It is only within these few years, that the study of statistics has been much attended to; and we think we may, without the charge of vanity, or partiality, refer to this *Encyclopædia*, as connecting the history and statistics of the various civilized countries of the world more intimately and fully together, than they had been previously done in any work of the same nature.

Whatever illustrates the manners, customs, feelings, circumstances, and condition of the inhabitants of a country, in the various periods of its history, ought also to be studied by him who wishes to derive from history its highest gratification and its full advantage. The popular ballads of a nation, in this respect, ought to be perused; collections of the laws, ordinances, and internal regulations enacted in a state, during any particular period of its history, are well calculated for the same object; they give information respecting the condition of the great mass of the community, whether they were free or slaves; and also respecting the prevalent crimes and vices of the age, and what measure of punishment was necessary to expiate or repress them.

All these are collateral branches of study, which are connected with the proper and advantageous perusal of history in general; but those who wish to enter more minutely into the history of any country, and to gain access to as many sources of evidence respecting it as possible, may derive great advantage and assistance from the records of the courts of law. These furnish a vast variety of historical facts, most minutely investigated. To refer again to the particular instance of our own country: It may with truth be affirmed, that no one can form an adequate and correct idea of the gradual amendment effected in our institutions, and of the value of those constitutional principles and efforts from which those amendments have been derived, who has not read with attention the state trials. Treaties with foreign powers should also be perused; and the despatches of ambassadors, especially the confidential communications made by diplomatic agents. In the official letters of Barillon, published by Sir John Dalrymple and Mr Fox, the impolicy of Charles II. and of his unfortunate successor, is clearly traced; and in the papers of Sir Robert Walpole, as published by Mr Cox, a striking picture is exhibited of the difficulties incident to the administration of a free government. How much history may be illustrated by the publication of such official papers, or rather how inexplicable the facts it records may often be, if not illustrated by such papers, is proved in a most striking and interesting manner in the following instance. In the years 1775 and 1776, General Washington lay encamped before the town of Boston, at the head of a force far superior to that of the British, for the period of nine months, without striking a blow. The general's official correspondence with Congress, published in the year 1795, accounts for this dilatoriness, which, till this publication, was inexplicable. From it, it appears, that, during a great part of this time, he was so scantily provided with powder, that, had the British been aware of his situation, and marched to attack him, he would have been under the necessity of abandoning his position.

Biography also may be brought to the elucidation and assistance of history. In the lives of sovereigns, eminent statesmen, generals, and lawyers, peculiarities of character, prejudices, motives, and reasons for conduct, which history cannot detect, and other circumstances, are often brought to light, which serve to elucidate what is obscure, to connect what is disjointed and abrupt, and to account for what before seemed without an adequate and appropriate cause.

The history of many nations may also be elucidated by visible monuments, such as pillars, edifices, or mere heaps of stone; and by the names given to counties, towns, &c. Of the same nature with public monuments are national customs, in commemoration of remarkable historical events; such as the Athenians sending annually a ship to Delos; the paschal supper among the Jews; the Lord's Supper among the Christians; our making bonfires on the 5th of November, and carrying oak boughs on the 29th of May.

Coins and medals are also of great use, in the illustration of history. On ancient medals, a number of events have been recorded, so that they serve to confirm such passages as are true in old authors, to ascertain what was before doubtful, and to record such as were omitted. By means of them, Vaillant has been enabled to ascertain, in a very great degree, the chronology of three important kingdoms of the ancient world, viz. Egypt, Syria, and Parthia. Of Balbec and Palmyra, whose ruins are so famous, history scarcely makes any mention, and we have little knowledge of them, but what is supplied by medals and inscriptions. In modern times, coats-of-arms have been made use of for the purpose of distinguishing families. They must, therefore, be of great use in tracing pedigrees, and consequently in ascertaining persons and events in history. See Medals.

III. One of the most important directions for facilitating the study of history, is to begin with authors who present a general view of the whole subject. This is like sketching an entire outline, before any part of the picture is finished; and learning the grand divisions of the earth, before the geography of particular countries is studied. The principal advantage of this method is, that it gives a clear idea of the comparative importance, as well as of the connection, which the history of any particular country bears to the history of the world. The same advice is applicable to a person who proposes to study any particular period of the history of any particular country. He ought, in the first place, to make himself acquainted with the history of the country in general, and then study the history of the particular period. The history of the civil wars, during the reign of Charles I. will excite comparative little interest, and afford comparatively little instruction, unless an acquaintance with the previous history of England enables us to trace the causes of those wars, and the condition, feelings, opinions, influence and views, not merely of the different parties, but also of the different classes of the community.

A general acquaintance with the whole course of history, will render it less necessary to attend to the order in which particular histories are read; for if the reader is thus previously prepared, by a general acquaintance with history, he will be able to refer any particular history he engages in to its proper place in universal history. Indeed, after a thorough introduction to a whole course of history, it is comparatively a matter of little moment, in what order and connexion particular histories are read; for they will easily, and without confusion, range themselves in the mind in their proper place, and appropriate rank in point of importance.

There are several epitomes of universal history. While the custom of giving lectures prevailed in the foreign universities, the most celebrated were Tursellius's and Le Clerc's; but the use and popularity of these Latin epitomes has very considerably diminished, since the lectures have been given in the vernacular tongues of the respective countries of Europe. Tursellius's is a judicious and elegant performance; but by no means impartial or candid, where the interests of the Catholic church interfere. That of Le Clerc's is not liable to the same objection; but at the same time it must be remarked, that it is not entitled to the same praise. With these epitomes may be mentioned, as also written in Latin. Sleidan's *Introductio ad Historiam*, or a brief account of the Babylonian, Persian, Macedonian, and the Roman monarchies.

Bossuet's *Discours sur l'Histoire Universelle*, which may be regarded as an epitome of ancient history, as it comes down only to the period of Charlemagne, acquired a reputation at its first appearance hardly warranted by its merits, and which it has by no means supported. It is an elegant, and in some parts even an eloquent performance; but these are recommendations to history of very small comparative importance, when contrasted with credulity, bigotry, and partiality, with which this performance is justly chargeable. One of the most useful epitomes, upon the whole, is that written by Baron Holberg, in Latin, and translated, with improvements and additions, into English, by Gregory Sharpe. Its most prominent and serious defect is, that too little notice is taken of the history of Greece. None of these epitomes direct the attention of the reader to any other subject than the political part of history; they seldom or ever enter into the consideration of the causes or consequences of events; and never digress, if digression it may be properly called, into the consideration of the state of the arts and sciences, religion, laws, manners, government, and literature, during the different epochs of which they treat. In fact, they will by no means satisfy the mind that wishes to attain a proper introduction to history, as it is now generally written. For this purpose, the *Elements of General History, Ancient and Modern*, by the late Alexander Fraser Tytler, Lord Woodhouselee, ought to be read: In point of arrangement, due proportion and connection of parts, perspicuity and interest of style, a philosophical spirit, and the elucidation of the state of the arts and sciences, literature, &c. this work may be justly commended in the highest terms. *The Philosophy of History*, by Logan, and a larger work said to be written by the same author, but published under the name of *Rutherford*, should also be perused, preparatory to entering upon a regular course of history. Of the larger epitomes of ancient history, that of Rollin is the most interesting and complete: it is compiled with scrupulous fidelity from the best Greek and Latin historians: its style is fluent, and even elegant: its great fault is credulity, which prevents the author from discriminating in his recital of events between the marvellous and the true. The ancient history of the Abbe Millot, which constitutes the first part of his *Histoire Generale*, is more brief than that of Rollin; but, at the same time, more full than the epitomes we have mentioned above. The arrangement of this work is judicious; the style precise and compact. In his preface he informs his readers, that his plan is to seize those topics of historical narrative, which present the greatest portion of utility. He gives a bold, and in general a faithful and impartial sketch of events and characters; but the observations with which he relieves and intermixes his narrative, are frequently more distinguished for their obvious truth, than their originality or profoundness.

The reader having been thus prepared for a regular progress in ancient history, by the perusal of such parts of the above epitomes as confine themselves to that period, (for some of these epitomes, it may be observed, embrace modern as well as ancient history,) we shall now lay down a method by which the principal authors of antiquity may be read, so as to collect from them a pretty regular series of facts, which will comprise the history of Asia, Africa, Greece, and Rome, till the dissolution of the empire of Constantinople.

Herodotus is the earliest historian extant, next to the authors of the historical books of the Old Testament. His history comprises every thing he had an opportunity of learning respecting the Lydians, Ionians, Lycians, Egyptians, Persians, Greeks, and Macedonians, from the year 713 to the year 479 before the birth of Christ. Perhaps no author of history, ancient or modern, might be appealed to, as more fully illustrating the truth of the remark made at the beginning of this article, that, even in respect to amusement, history presents claims to attention not inferior to works of fiction. The great merits of this author are, his diligence, accuracy, fidelity, and impartiality. The accuracy of the geographical knowledge which he displays, is continually receiving confirmation from the discoveries of the moderns. His style is simple and elegant. His faults and defects are his digressive method, and his intermixture of fable. A more particular account of several events in the period of Herodotus' History may be extracted from the following authors: Justin, books i. ii. iii. and vii.; the 7th book of Xenophon's *Cyropædia;* the lives of Aristides, Themistocles, Cimon, Miltiades, and Pausanius, by Plutarch and Cornelius Nepos; and those of Anaximander, Zeno, Euripides, Heraclitus, and Democritus, by Diogenes Laertius, will illustrate not only the history of Herodotus, but also the state of manners and philosophy at that period.

Thucydides must be read after Herodotus. In his introduction he connects his history with that of Herodotus, by giving a summary view of the history of Greece, from the departure of Xerxes to the commencement of the Peloponnesian war. He proposed to write the entire history of that war, but his work reaches only to the 21st year of it. The method he pursues is directly the reverse of that followed by Herodotus; for his exact and scrupulous observance of chronological order, obliges him to interrupt his narrative, in a manner that is very painful and disagreeable to his reader. His style is uncommonly compact and dense; so that his meaning is frequently not brought out with sufficient fulness and perspicuity. His reflections are acute and profound, but more interesting to the politician than the philosopher. After the first book of this author, the 11th and 12th of Diodorus Siculus ought to be read; and, after the whole of his work, the 4th and 5th books of Justin, and the lives of Alcibiades, Chabrias, Thrasybulus, and Lysias, by Plutarch.

The 1st and 2d books of Xenophon's History of Greece complete the account of the Peloponnesian war, with the contemporary affairs of the Medes and Persians. After this the expedition of Cyrus, by the same author, should be read; and, lastly, the remainder of his History of Greece, which contains an account of the affairs of the Greeks and Persians till the battle of Mantinea, in the year 363 before Christ. All the historical books of Xenophon comprise a period of about 48 years. The style of Xenophon is remarkable for its elegance; his impartiality is undoubted; and his manner and plan form a happy medium between the loose and slightly connected excursions of Herodotus, and the extreme rigour of Thucydides. His account of the retreat of the Ten Thousand, in which he bore a principal part, is perhaps as interesting a portion of history as ancient or modern times can present, and is told in the most interesting manner. To complete the history of all that period of which Xenophon treats, the lives of Lysander, Agesilaus, Artaxerxes, Conon, and Datames, by Plutarch or Cornelius Nepos, and the 13th, 14th and 15th books of Diodorus Siculus, ought to be read. The continuation of the work of Diodorus Siculus brings the history of Greece and Persia down to the commencement of the reign of Alexander the Great, in the year 336 before Christ. The history of Alexander has been written by Arrian, Plutarch, and Quintus Curtius. After these authors, may be read the 18th, 19th, and 20th books of Diodorus Siculus, together with the 13th, 14th, and 15th books of Justin;—these contain the history of Greece from the year 323 before Christ to the year 301. At this period, the course of historical narrative may be traced from the 16th to the 30th books of Justin, and all that follow till the two last, which complete the history of Greece till it mingles with that of Rome.

The object of Diodorus Siculus was, by reading and travelling, to collect materials for an universal history, from the earliest account of things to the time of Augustus, when he flourished. But only a small portion of it has come down to us. Of 40 books, of which the entire work consisted, the first five, which bring the history of the world to the Trojan war, are entire; the next five are wanting; but from the 11th to the 20th inclusive the work is complete. The work of Justin is an abridgment of an universal history, written by Tropes Pompeius, who lived in the age of Augustus. It is written in a style of considerable perspicuity and force, and a due proportion and connection is observed among its several parts. Plutarch's lives of Pyrrhus, Aratus, Agis, Cleomenes, and Philopæmon, should be read to complete this portion of history.

As these authors contain not only the history of Greece, but that of all the nations of the world that were known to the historians; so the following course of Roman history must also be regarded as comprehending all that is now to be learned of the subsequent ancient history of all other nations.

The early part of the Roman history is treated in the most full and satisfactory manner by Dionysius of Halicarnassus. His entire work consisted of 20 books, and brought down the history to the commencement of the first Punic war; but of these, only the 11 first are now extant, and they terminate in the year 341 before Christ, after the dissolution of the decemvirate, and the resumption of the chief authority by the consuls. This author pays much more particular attention to manners, customs, and laws, than the ancient historians usually did; and, on this account, is peculiarly interesting and instructive. He is, however, very credulous; and his style, though pure, is harsh. To complete the history of the period of which Dionysius treats, the 1st, 2d, and 3d books of Livy, and the lives of Romulus, Numa Pompilius, Valerius Poplicola, Coriolanus, and Camillus, by Plutarch, should be read.

After Dionysius, by reading from the 4th to the 10th books inclusive of Livy, the history of Rome will be brought down to the year 292 before Christ. The entire work of Livy consisted of 142 books; but it has come down to us in a very mutilated and imperfect state, only 35 being left. This author is entitled to the highest praise for fidelity, impartiality, and the rich and eloquent grandeur of his style. A chasm occurs between the 10th and 20th books of Livy, which may be, however, in some measure, filled up, by the perusal of the 1st and 2d books of Polybius; the 17th, 18th, 22d, and 23d books of Justin; and Appian's Punic and Illyrian wars. From Polybius we may learn many curious and important particulars respecting the art of war among the ancients. His topographical descriptions of the places which have been the site of the remarkable events he records are uncommonly accurate. His style is harsh and involved; his reflections bear evidence of a strong and reflecting mind. After Appian should be read the remainder of Livy from the 21st book to the end, which brings the history of Rome to the year 166 before Christ. The lives of Hannibal, Scipio Africanus, Quintus Flaminius, Paulus Æmilius, Cato major, the Gracchi, Marius, Sylla, Cato minor, Sertorius, Lucullus, Pompey, and Brutus, by Plutarch, will not only serve to complete the history of Livy, but will also afford some striking particulars respecting the manners and state of society of Rome during the most interesting period of its history.

The war of Jugurtha, and the conspiracy of Cataline, which happened respectively 100, and 62 years before Christ, have been narrated by Sallust. The great merit of this writer is his impartiality at a time when prejudice and party spirit must have been very common and very powerful in Rome. His style is remarkable for its conciseness; and this quality is particularly conspicuous in the characters which he draws.

Most of the transactions in which Julius Cæsar was engaged, are best illustrated by his celebrated Commentaries, and the supplement to it compiled by Hirtius and others. In the Commentaries we may gain some very authentic and interesting information respecting the early state, manners, laws, and customs of those nations which now hold the most distinguished place in modern Europe. The merit of this work of Cæsar's is very high, in respect both to matter and style; the advantage which he derived, in respect to accuracy of information, from narrating his own exploits, is not, in a single instance, counterbalanced by vanity, partiality, or the concealment of his faults: his style is remarkable for its simplicity and ease. The secret history of this important period will be most clearly understood from a perusal of Cicero's Epistles, which may also be consulted for information respecting the state of society, manners, customs, &c. The fragments of the history of Dio Cassius contain a detail of the events, which took place between the period when Lucullus flourished and the death of the Emperor Claudian. In combination with this author may be read the elegant compendium of Velleius Paterculus, from the foundation of Rome to the reign of Tiberius, at which period he lived.

The Lives of the Twelve Cæsars, written by Suetonius, will prepare the way for the study of the works of Tacitus; and, together with the Epistles of Pliny, will afford a pretty clear insight into the state of society, and manners of the Roman empire at this period.

Tacitus wrote annals of the public affairs from the death of Augustus nearly to the end of the reign of Nero; but only a small portion of them have come down to us, viz. the four first books; a small part of the 5th; all the 6th from the 11th to the 15th; and part of the 16th. There is also a history, by the same author, which extends from the beginning of the reign of Galba to the end of that of Domitian. His work on the manners of the Germans is particularly interesting and instructive, as a preparatory study to the modern history of the northern and middle states of Europe. His life of Agricola is perhaps the finest specimen of biographical writing extant. Tacitus justly deserves the name of a philosophical historian: his insight into human nature, especially into the sources and workings of the worst passions, is deep and penetrating: his style is uncommonly dense.

On the times of servility that succeeded the period in which Tacitus lived, a dim light is shed by the works of Aurelius Victor, Herodian, the six compilers who are commonly known by the name of *Scriptores Romani*, Eutropius, Zosimus, Zonaras, Jornandes, Ammianus Marcellinus, Procopius, Agathias Nicetas, Nicephorus Gregoras, and Joannes Cantacuzenus. Procopius, &c. are distinguished by the appellation of the Byzantine historians. Their works relate to the history of the Greek or Eastern Empire to the period of its destruction by the Turks. Of all these authors, the only two that possess much merit are Herodian and Ammianus Marcellinus. The former wrote the history of his own times from the death of Antonine to the reign of Balbinus and Pupienus, A D. 238. His manner of narrating events is uncommonly engaging and happy. Every scene, with its causes and effects, is presented in the clearest and best point of view. Simplicity and elegance characterise his style. Ammianus Marcellinus wrote 31 books, from the beginning of the reign of Nerva to the death of Valens, in whose court he lived; but of those, the first thirteen, a superficial epitome of 257 years, are now lost. In those which are extant, he begins with Gallus Cæsar, about the year of Christ 353, and largely describes the actions of Constantius, Cæsar, Julian, Jovian, Valentinian, and Valens—a period of 25 years, bringing down the history of Rome to the year of Christ 378. He was the last subject of Rome, who composed a profane history in the Latin language. He well deserves the character and the praise which Gibbon gives him: "It is not without the most sincere regret (says that author) that I must now take leave of an accurate and faithful guide, who has composed the history of his own times, without indulging the prejudices and the passions which usually affect the mind of a contemporary." (Gibbon's *Roman Empire*, Vol. IV. chap. xxvi. p. 426. 8vo. edition.)

A most important series of events, connecting ancient and modern history, is supplied by Gibbon's *History of the Decline and Fall of the Roman Empire*. This work commences with a view of the policy which swayed the Roman cabinet in the time of Augustus. Rapidly passing on to the age of the Antonines, A. D. 180, it exhibits the extent and military force, the union and internal prosperity, and the constitution of the empire, at that period. It then begins to assume the form of a history in detail, which is brought down to the total extinction of the Roman Empire in the west; is afterwards continued to the taking of Constantinople by the Turks, A. D. 1453; and concludes at the establishment of the Papal power in the city of Rome, and the adjacent territory. The minute and extensive learning displayed in this important work not only supports the authenticity of the facts which it records, but also enables the author to discuss many correlative or incidental subjects, which elucidate either the manners, customs, laws, and state of society, at the different periods of which he treats, or those institutions that even at present characterize and distinguish the principal nations of Europe. His style is by no means chaste; the unremitting pomp of his periods fatigues his readers; and he deserves unqualified and severe censure, for the disingenuous manner in which he has insinuated his animadversions on the Christian religion. But, after all these deductions from the merit and value of this work, it is highly useful; and indeed the only work for the reader who wishes to obtain a clear, full, and interesting view of history, and the state of society between the period of the declension of the Roman empire and the infancy of the principal European states.

Those epitomes of modern history, which are connected with ancient history, have already been mentioned. We shall now notice such epitomes as are confined to modern history. A good general epitome was a work long wanting to the republic of letters. We have omitted to notice the Ancient Universal History in the former part of this article, because it is much too voluminous to serve as an introduction to a general knowledge of ancient history. The same remark applies to the Modern Universal History. Both of them are much more useful as books of reference, or for consultation, after a tolerably accurate and extensive knowledge of history has been acquired, than as introductory works; besides, the various portions of both are executed with very unequal degrees of merit. Voltaire's *Essai sur les Mœurs et l'Esprit des Nations* is rather a commentary on facts, an acquaintance with which is presupposed, than a detail of the facts themselves. The *Histoire Moderne* of the Abbe Millot is a judicious abridgment. It deserves the character of accuracy and impartiality; but, besides being liable to the objections that have been offered to the ancient history of the same author, it is too much compressed, for the extent and importance of the topics which it embraces. Russel's History of Modern Europe is a work of a much higher character, and much more valuable and useful to the student in every respect. Its merits appear to us not sufficiently known and prized. Probably, by those who have never read it, it is supposed that no great talents could be required or exercised in drawing up a mere abridgment of history. But the contrary is the fact: to judge from this work of Russel's, he must have been a man of considerable penetration, sound judgment, a philosophical spirit, and correct taste. His work is divided into two parts; the first embracing the period from the rise of modern kingdoms to the peace of Westphalia in 1648, and the second comprehending the events of history from the peace of Westphalia to the peace of Paris in 1763. A third part, bringing the history down from the peace of Paris to the treaty of Amiens in 1802, has been added by Dr Coote, who, though he has strictly adhered to the plan, has by no means attained to the merits of the original work. The subdivision of the plan is effected with considerable skill and ingenuity in a series of letters, in which the principal transactions of the leading European states are concatenated with as rigid adherence to chronological order, as was consistent with the mixed and fluctuating interests of those states. By passing over events which derived their importance and interest merely from the period in which they occurred, or the personages who were concerned in them, he has been enabled to give more room for those of a more permanent nature. As a repository of facts, therefore, judiciously selected, methodically arranged, and authenticated with sufficient learning and diligence, this modern history of Europe may justly be regarded as a work of very great utility; but it deserves higher praise. The causes and consequences of the most important events are traced with great ingenuity and penetration, at the same time that fanciful speculations regarding them are carefully avoided. The observations on the characters of the principal personages are distinguished by the vivid and faithful pictures which they exhibit. The progress of society from the rise of modern kingdoms down to the peace of Paris in 1763, exhibiting the manners of the people in their rudest state, and in their highest polish, is given at stated periods with much ability and research. The advances made in taste and science, and the usurpations of the ecclesiastical at the expense of the civil power, are clearly developed; and, being connected with the progress of war, politics, and legislation, exhibit, in a clear and conspicuous manner, the intellectual and moral improvement of European society. The style of this work is pure, elegant, and concise; and the reflections that are interspersed always illustrate and confirm the sacred principles of public and private justice.

This work will serve to exhibit the great and leading outlines of the events of modern history; and from Gibbon's Decline and Fall may be traced the origin of those barbarous tribes, whose chiefs, at different periods, making themselves masters of the various subdivisions of the Roman empire, laid the foundations of the modern kingdoms of Europe. The student having thus gained a general knowledge of modern history, as well as a more particular insight into the origin of the European states, ought, in the next place, to peruse those works which exhibit a general view of the history of modern Europe at various periods.

Much valuable information relative to one of the most important of the early periods of modern history is to be derived from the *Histoire de Charlemagne*, published by M. Gaillard in the year 1782, in four vols. 12mo. The general state of Europe in the 11th century is described by Mr Berrington in the second edition of the Lives of Abelard and Eloise. In the Abbe Sade's *Memoires sur la Vie du Francois Petrarque*, the author, by regularly indulging in details of circumstances with which Petrarch has little or no connection, has contrived to interweave into these memoirs a minute and elaborate account of the events which took place in Italy, France, and other parts of Europe, during the greater part of the 14th century. The history of this period may still be further illustrated by the Chronicles of Froissart, which, besides a minute detail of the transactions which occurred from 1326 to 1400, give a most interesting and amusing insight into the manners, customs, habits, and feelings of that period. A succinct narrative of general history is also to be found in Shepherd's Life of Poggio, which, relating to the origin of the famous ecclesiastical feud, the schism of the West, almost touches the period of Petrarch, and traces the principal occurrences which took place in Italy, and Europe in general, beyond the middle of the 15th century. The Life of Lorenzo de Medici, by Mr Roscoe, may be next perused: as Lorenzo's political connections were very extensive, his history embraces the principal occurrences which happened in the more civilized portions of Europe during his life, from 1448 to 1492. The succeeding period of general history is illustrated by the same author in his Life of Leo X. In this work, Mr. Roscoe enters fully into the state of Italy and Europe, which had so much influence on the fortune of that people, and which was also in no small degree modified by his actions. In both these works Mr Roscoe has given a copious history of the progress of literature and the fine arts.

The History of Charles V. next becomes the most prominent in the general history of Europe; and, with this view of it, it has been most ably written by Dr Robertson. The first volume of his work contains a view of the progress of society in Europe, from the subversion of the Roman Empire to the beginning of the 16th century, embracing the several heads of government, laws, manners, military establishments, and the political constitution of the principal states of Europe. The History itself comprehends the eventful period between the years 1500 and 1559, during which events took place which materially affected the state of society, and the advancement of literature, knowledge, and liberty, in Europe. The Histories of Philip II. and III., by Drs Watson and Thompson, may also be read with reference to a general acquaintance with the history of Europe during the period of their reigns, and to a knowledge of several events, which tended materially to change the relative situation and importance of the various states of Europe. Indeed, the political alliances and wars of these monarchs involve the interests of so many kingdoms, that their history displays the general topics of the history of Europe till the year 1621, the period of the death of Philip III.

Soon afterwards the French monarchy began to assume such a rank, and to connect itself with so many states, that its history ought to be perused, as throwing more light on the general history of Europe than that of any other kingdom at this time. Harte's Life of Gustavus Adolphus, and Scheller's History of the Thirty Years' War, also illustrate, in some degree, the history and state of the north of Europe about the same period; and bring down the narrative of events nearly to the age of Louis XIV. Voltaire's life of this monarch will conduct the reader to the period when, in consequence of the alliances formed by the English nation with various continental powers, the history of the world is strictly connected with that of our native land.

IV. Under the 4th division of this article, we proposed to point out the order in which the history of particular countries may be read, so that they may be illustrative of one another. "Nature," as Mr. Gibbon justly observes, "has implanted in our breasts a lively impulse to extend the narrow span of our existence, by the knowledge of the events that have happened on the soil which we inhabit, of the characters and actions of those men from whom our descent as individuals or as a people is probably derived. The same laudable emulation will prompt us to review and to enrich our common treasure of national glory; and those who are best entitled to the esteem of posterity, are the most inclined to celebrate the merits of their ancestors. The history of Britain, therefore, naturally will and ought to claim our highest interest. Under the article Bri-

TAIN, in this *Encyclopædia*, will be found a history of the Island from its first population by the Celts, until the arrival of the Saxons in the year 449. As our constitution, our national character, the tone of our manners and feelings, and our language, are, in a great measure, derived from our northern ancestors, the articles GERMANY and SCANDINAVIA ought to be read in connexion with the early part of the history of Britain. From the arrival of the Saxons till the union of the crowns of ENGLAND and SCOTLAND in the year 1603, the histories of these two countries are treated distinctly under the respective articles; but the connexion between them during the greater part of this period, was so close, though generally of a hostile nature, that their histories are necessarily mutually illustrative of each other. The history of FRANCE, also, given under that article, ought to be read, for the purpose of illustrating the histories both of England and Scotland; while an attentive consideration of the language, the manners, and the state of society in France, will afford elucidation, and give additional interest to the English and Scotch history during the same period. Under the article BRITAIN is given the history of the island, from the union of the crowns of England and Scotland to the commencement of the year 1812; and the most interesting portion of the foreign history of Britain, from 1812 to the last peace of Paris in 1815, will be found under the article FRANCE. A more full account of the war between Great Britain and her colonies, than is to be found under the former article, is given under the article AMERICA (*American United States.*) After the perusal of the histories of England, Scotland, and Britain, read in this order, and thus elucidated, the reader should peruse the history of IRELAND, given under that article: and as INDIA forms now such an extensive and valuable portion of the British empire, the history of it, under that article, ought to be read in connection with the history of the united kingdom.

If the student is desirous of entering more fully and deeply into the history of this country than the articles in this *Encyclopædia*, necessarily succinct, will enable him to do, Rapin will afford him a very elaborate, and in general a very faithful, history of England till the close of the 17th century; while, in Hume's History, he will find infinitely more philosophy, but far less impartiality and accuracy. The history of England, from the period of the Revolution, cannot boast any writer of standard excellence. In Henry's History of England, and Andrews' History of Great Britain, connected with the chronology of Europe, the literature, arts, and manners, religion and government, of the several periods, which these works respectively comprise, are elucidated.

The very early history of Scotland has been most elaborately elucidated by Pinkerton; the same author, and Lord Hales, have also treated, in a masterly and satisfactory manner, the history of this country during a less remote period. After the second work of Pinkerton, should be read Robertson's History of Scotland, during the reigns of Queen Mary, and James VI. till his accession to the crown of England; and Laing's History of Scotland from the union of the crowns to the union of the kingdoms. Leland's History of Ireland traces, in a masterly manner, the transactions which took place in that country, from the invasion of Henry II. to the treaty of Limerick in the reign of William III. Those portions of the history of this ill-fated and ill-used country since that period, which are particularly full of incidents, cannot yet be treated in an impartial manner. In the History of Wales, by the Rev. W. Warrington, all the facts are collected which can throw light upon the government, manners, and final subjugation of a people, still strongly marked by a peculiar character, manners, and customs.

Next to the history of the United Kingdom, the history of France claims the attention and investigation of the student, both on account of its connection with the history of these islands, and on account of the relative importance of that state in Europe. Under the article FRANCE will be found a sketch of its history, as full as the limits and nature of this work will allow, accompanied by a statistical account of that country, which, as we have already remarked, ought always to be read in conjunction with history. The early portion of the history of France admits of and requires elucidation, from a knowledge of the manners, laws, &c. of the ancient German tribes, nearly as much as the early history of Britain; the article GERMANY, therefore, may be profitably consulted for that purpose. After the affairs of France cease for a time to be intimately interwoven with the affairs of England, its history becomes connected with, and therefore may be elucidated by, the history of Austria under the Emperor Charles V. and by the history of Italy. During the 17th and the early part of the 18th centuries, the history of France requires a reference to the histories of the Netherlands and of Spain. From the commencement of the war between Britain and France in 1744 to the present time, the histories of the two countries are mutually illustrative of each other.

The history of Spain, perhaps, both on account of its relation to the histories of Britain and France, and on account of the importance of that kingdom in the scale of Europe, at least during a certain period, next claims the investigation of the student. Besides the article SPAIN, the article ARABIA may advantageously be consulted, in elucidation of the manners, customs, &c. and the early history of the peninsula. After the expulsion of the Moors, the histories of France, Spain, and Italy, from the end of the 15th to the beginning of the 16th centuries, are intimately connected. As the discovery of the new world happened at that period, the articles AMERICA, MEXICO, and PERU, ought to be consulted for an account of the transactions of the Spaniards there. Soon afterwards the history of this country becomes connected with that of the Netherlands. After the separation of the United Provinces from Spain, its history may be chiefly elucidated by the histories of Portugal, Italy, France, and Britain. The history of Portugal admits of little elucidation from the history of any other country except Spain; the articles AFRICA and ASIA, however, may be consulted for a brief account of their discoveries and settlements in these quarters of the globe.

As an introduction to the history of the German kingdoms and states, the article GERMANY ought to be perused: this will prepare the way for the history of Austria, illustrated in its progress by the histories of Switzerland, Italy, France, Spain, Russia, Turkey, Sweden, and the Netherlands: the history of Prussia, illustrated by the history of Brandenburgh, Russia, Austria, and France; the history of Bavaria, Saxony, &c. The account of the Reformation, given in the article ECCLESIASTICAL *History*, ought to be consulted, with reference not only to the history of Germany, but also to those of Britain, France, and the Netherlands, during the 16th and part of the 17th centuries. The history of Russia will receive elucidation from the histories of Austria, Prussia, Sweden, Poland, Turkey, and Persia. The article SCANDINAVIA ought to be consulted for a general view of the manners, customs, laws, &c. and early history of Denmark, Sweden, and Norway. These countries, besides mutually illustrating the history of one another, will receive elucidation principally from the history of Russia and Germany. Under the article NETHERLANDS, will be found the history of that country, not only while it remained undivided, but also of the United Provinces, and of the new kingdom, which has reunited the whole seventeen provinces. That portion of the history of this country, which properly relates to the United Provinces, will receive elucidation from the history of Spain, France, and England, during nearly the whole of the period, from the establishment of their independence till they were merged in the kingdom of the Netherlands. The comparatively pacific history of SWITZERLAND admits of illustration, in no important degree, except from the history of Austria, during the very early period of the establishment of its independence, till, like nearly all the other states of continental Europe, its history becomes involved in the revolutionary history of France.

The general account of ITALY ought to be consulted previous to the histories of Naples, Sicily, Venice, Tuscany, the Popedom, &c.; and these will be elucidated by the histories of France, Spain, Austria, and Turkey. The history of the Popedom, indeed, both in its ecclesiastical and civil character, is so intimately connected with the history of all the European kingdoms, (except Russia and Poland,) till the Reformation, that it ought to be studied carefully; for this purpose the article ECCLESIASTICAL *History* may be consulted. The history of Poland will be elucidated principally by that of Turkey, Austria, and Russia.

Respecting the histories of the kingdoms of Asia, Africa, and America, our notices must be very short. Of course, before the history of any particular country in any of these divisions of the globe is studied, the description of that particular division, under its proper head in this work, ought to be consulted. Turkey, from its connection with the histories of Austria, Poland, and Russia, claims perhaps the first notice. The history of Arabia, illustrated by the life of Mahomet, is an interesting object of study, not only on account of the conquests and literature of the Arabs, but also from the connection of their history with that of the Peninsula. Though the history of CHINA has little or no connection with the history of any European state, yet the peculiarities of its inhabitants must render its history interesting: Under that article will be found not only an accurate and well-proportioned abridgment of the history, but also a very faithful and detailed description of the manners, language, institutions, &c. of that singular country. Since the middle of the last century, the history of INDIA has become so intimately connected with the histories of France and Britain, and that country at present forms so large and valuable a portion of the British empire, that its modern history ought to excite considerable interest, even though its ancient history, and the character of its inhabitants, and their laws, institutions, &c. did not put forth strong claims to our attention. For an account of the histories of the other kingdoms of Asia, we must barely refer our readers to the articles of PERSIA, BIRMAN EMPIRE, JAPAN, THIBET, TARTARY, MALACCA, CEYLON, SIAM, &c. The history of the principal states of Africa will be found under the articles EGYPT, ABYSSSINIA, CAPE OF GOOD HOPE, ALGIERS, MOROCCO, TRIPOLI, TUNIS, &c. The history of the United States of America, as already mentioned, should be sought for under the articles AMERICA and BRITAIN; of the British colonies there, under the articles CANADA, NOVA SCOTIA, &c. and also under BRITAIN; of the Spanish colonies, under the articles BUENOS AYRES, CHILI, MEXICO, PERU, &c. and also under SPAIN; of the Portuguese settlements, under the head of BRAZIL, and also under PORTUGAL.

V. We shall now conclude this article with a brief notice of the different species of history, besides that which is emphatically so styled. History, strictly speaking, relates to the narration of the wars and political events of kingdoms; but besides this species of history, that which relates to the support which Christianity has received from the secular power; together with the benefits or disadvantages resulting from this support; and also to the internal administration of the church, its constitution and discipline, its doctrine and its worship; or, in other words, the history of Christianity, of its corruptions and reformation, and of the influence which its principles, or the conduct of its professors, have had on the political condition and affairs of mankind, may justly be regarded as very intimately connected with the species of history which we have been so fully considering. Ecclesiastical history, therefore, ought to be studied, not merely in its religious, but also in its political point of view. Whoever reflects on the power of the Pope for several centuries,—on the friendly relations or wars between the different states of Europe, which they brought about,—on the wars arising from the Reformation, and on the great and decided change in the political character and power of the mass of the people which that event produced, must be convinced that ecclesiastical history cannot safely be neglected even by the mere statesman. This article, therefore, ought to be carefully perused, both by itself, and in connection with the history of the different states of Europe.

The histories of the different arts and sciences are quite of a distinct class from political and ecclesiastical history; though, to the student of both of these, as well as to the man of science, they must be interesting and useful. The resources and the wealth of states depend mainly on their advances in the arts and sciences; and with respect to the connection of some of the latter with the state of religious knowledge, the history of astronomy is sufficiently explanatory. As one of the principal objects and advantages of history, strictly so called, is to gain an insight into the progress of man in political and individual happiness, surely an acquaintance with the advances which he has made in every species of knowledge, which secures his liberty, or multiplies his means of defence or enjoyment, must be interesting and important. Besides, whoever is desirous of satisfactorily accounting for the difference between ancient and modern nations, as displayed in their respective histories, and for the great and decided superiority of the latter, must look beyond mere political history, to the history of those arts and sciences, which were comparatively unknown to the ancients, and in which the moderns have made such wonderful advances,—advances that will be found, in a great measure, and nearly in every instance, accompanied by, if not really productive of, similar advances in national resources and political power. The copious histories of the arts and sciences, therefore, given in this work, under the respective heads of each art or science, ought by no means to be neglected by such as wish to read political history to advantage; and if they are perused in connection with the statistical account of each country, given along with its history, the causes of the comparative progress of nations in political liberty and power will be very clearly and satisfactorily traced. (W. S.)

HIVE. See BEE.

HOBBES, THOMAS, celebrated as a literary and philosophical character, but chiefly for the peculiarities of his moral and political doctrines, was the son of a plain unlettered clergyman of Malmesbury, Wiltshire. He was born on the 5th of April, 1588, at the crisis when this country was menaced by the formidable armada sent by Philip II. of Spain. His mother, powerfully affected by the consternation then so general over the kingdom, was delivered before the full time, in consequence of which Hobbes was remarkably delicate in his childhood. But he evinced a singular aptitude for learning, and attracted much notice by his proficiency at school. B fore the age of 14, he translated the Medea of Euripedes into Latin iambics. At this age, he went to Magdalene Hall, Oxford, where he distinguished himself by his application and genius. The Earl of Devonshire, wishing to profit by his talents, employed him as a companion and instructor to his eldest son, who was nearly of the age of Hobbes, and that family continued to patronise him as long as he lived. At an early period he was known to the celebrated Lord Bacon, with whom he was a great favourite, and to whom he acted as an amanuensis in translating some of his treatises into Latin. He travelled with his noble pupil in France and Italy, where he cultivated the society of Galileo and other celebrated characters, and studied the customs, institutions, manners, and learning of these two nations.

He now resolved to devote his life to the cultivation of polite literature, and his first publication was an English translation of Thucydides, which appeared in 1628. But his plans were disconcerted by the death of his pupil and friend. He soon after formed an engagement to travel with the son of Sir Gervase Clifton, with whom he remained for some time in France. In 1631, the Countess Dowager of Devonshire renewed his connection with her family, by putting the young earl, then 13 years old, under his care. He went with his pupil to Paris, where he studied mechanics and the laws of animal motion. On these subjects he had frequent conversations with Father Mersenne and with Gassendi, who was then engaged in an attempt to revive the physical doctrines of the Epicurean school. It was at the age of 40 that his attention was first turned to mathematical studies, in consequence of having accidentally looked into a copy of Euclid, where the enunciation of the 47th proposition of the first book arrested his curiosity. "This," he exclaimed, "is impossible!" He then rapidly went over the demonstration, and traced in a retrograde direction the preceding theorems on which the steps of the process were founded. The lovers of the mathematical sciences much regretted that he began these studies so late in life; as he evinced a happy talent for them, yet laboured under the disadvantage of an obstinacy of opinion, which might have been corrected by the more varied views unfolded during the pliant period of youth.

The ardour of his mathematical studies was in a great measure repressed, in consequence of the profound interest which he took in political affairs, in which he did not intermeddle as a busy politician, intriguing with individuals for the establishment of one party on the ruins of another, but conceived the design of producing a general impression by an open exposition of his opinions, which, though new and peculiar, he hoped to render popular, by the force of thought which he could display, and the strong evidences by which they were supported. When the political differences of the age were so strongly marked, it was a fair general conclusion that both parties were as likely to be wrong as any one was to be exclusively right, and that a man of vigorous thinking powers, who devoted much laborious meditation to his subject, might form a more accurate system than any maintained by his contemporaries. Nor was it unnatural for a young author to presume too much on the readiness of mankind to lay themselves open to conviction. These ideas he had cherished for a considerable time, and some represent him as having cultivated mathematics chiefly with a view to habituate himself to a close and steady mode of thinking.

His first political essay was a small tract, which was not not printed, but circulated in manuscript in the year 1640, during the sitting of the parliament in April, which was dissolved the following May, when the parliament and Charles I. differed so widely on the subject of the royal prerogative. This tract strongly asserted the pretensions of royalty, and condemned those of the parliament and the people as unjust encroachments. It occasioned a considerable sensation, and would have involved Hobbes in imminent danger, if that parliament had not been dissolved. This was the harbinger of the noted political works which he subsequently published, his book *De Cive*, and his *Leviathan.* Mainwaring, bishop of St David's, was sent to the Tower for preaching the doctrine of Hobbes; and the latter made a timely retreat to Paris, to prosecute his studies in the enjoyment of personal security. Here he returned to the society of Mersenne and Gassendi, to which was added that of Descartes. Afterwards, however, Hobbes controverted the doctrines of the latter on the subject of innate ideas, which terminated all their friendly intercourse.

In 1642, he published, while at Paris, a few copies of his book *De Cive.* He became acquainted with Sir Charles Cavendish, brother to the Duke of Newcastle, who admired his mathematical talents, and attached himself warmly to him as a friend and patron. In 1647, his fame in mathematics procured for him a recommendation to instruct the Prince of Wales, afterwards Charles II., in this branch of science. His fidelity and care in the execution of his trust secured to him the esteem of that prince, which continued ever after, though on some occasions prevented from being manifested by the obnoxiousness of his principles. In this year, a more complete addition of his work *De Cive*, was published in Holland under the care of Dr Sorbiere, to which two recommendatory letters were prefixed, one by Father Mersenne, and another by Gassendi.

In 1650, his book *De Homine* was published in London, containing a development of his doctines of sensation, particularly as illustrated by the mechanism of vision, with a dissertation on human speech, intellect, appetite, passion, action, and character: also another work, entitled *De Corpore Politico*, or "Elements of Law." In this and the year 1651, he published in London his *Leviathan*, a work in which his opinions on moral and political subjects were more completely embodied. After the publication of this work, he returned to England, though Cromwell was now at the head of the government, and lived at the Earl of Devonshire's country seat in Derbyshire. It is remarked that he lived in communion with a congregation belonging to the church of England, and regularly resorted to their place of worship. His assertion of the royal prerogative was not now construed to his disadvantage, as he had prudently intimated that his doctrine was applicable to any individual possessed of supreme power.

In 1654, he published his letter on "Liberty and Necessity," which occasioned a long controversy with Dr Bramhall, afterwards lord primate of Ireland. He advocated the doctrine of necessity. He sometimes says, he could not help being astonished that those who argue that men can act without constraint, forget that the determination of their actions depends on their will, and that it is not to the actions as separated from the will, but to the laws of the will itself, that our inquiries must be directed. He must be allowed to have added some precision to the nature of the arguments embraced in this controversy. He now began a dispute, on his part not creditable, with Dr Wallis of Oxford, which involved the greater part of mathematical science. Not content with attacking the doctrines of his adversary, he exposes with grovelling minuteness the inaccuracies of his language; and, though afterwards repeatedly refuted, to the satisfaction of all the mathematicians of the age, he persevered with unaccountable obstinacy in asserting his first opinions.

At the restoration of Charles II. in 1660, Hobbes removed to London, where he now reckoned himself safe. In the country, he was possessed of every advantage that books could supply, by the ample library of his patron, which was always enriched with every additional work that he chose to recommend; but he wished to enjoy the advantages of the conversation of the learned, which he found necessary to his habits of enjoyment, and to the full activity of his talents. Soon after he came to London, the king observed him from his carriage, and renewed his acquaintance with him: He fondly cherished his conversation, and settled on him an annual pension of 100*l.* But the personal favour of Charles was not sufficient to screen Hobbes from the censure of the parliament, which, in 1666, was publicly pronounced against his book *De Cive* and the *Leviathan*. This prince, though fond of absolute power, was a tool of the high church party, to which that controul on the part of the sovereign over ecclesiastical affairs, which Hobbes recommended, was extremely obnoxious. They professed the strictest attachment to hereditary monarchy, but certainly exacted it as a condition, that the king should maintain their hierarchy and forms as the established religion of the state; and, if we may judge from subsequent events, would have entertained but feeble objections to any prince capable of being seated firmly on the throne, who would shew himself most cheerful in assenting to this indispensable condition. Hobbes maintained, that the natural ferocity of man renders it necessary to vest the absolute power in one person, to whom the church and the consciences of the people ought to be subjected. Thus, he made the radical truth of any religious system a matter of little importance. To admit this, would be to acknowledge the church to be wholly a plastic mutable engine of government, and to compromise the dignity which she always asserts, of having her principles founded in immutable truth. A bill was also brought into parliament to punish atheism and profaneness, which he considered as aimed at him; for, though neither atheism nor the denial of Christianity were tenets maintained by him, he knew himself to be accused of them by the general voice, and therefore was somewhat uneasy. On this occasion, apprehending that his house would be searched, and his papers seized, he burned some of them, and particularly one which was the most obnoxious of all, a Latin poem on the encroachments of the Romish and reformed clergy on the civil power. The king was now obliged to withdraw from him all public expressions of his personal regard. He continued, however, to live in London unmolested; was held in high esteem among the learned; and was honoured by the visits of ambassadors and other illustrious foreigners, among whom was Cosmo de Medicis, then prince, and afterwards Duke of Tuscany, who procured his picture for his cabinet, and a collection of his writings for his magnificent library at Florence. Hobbes had it in contemplation to publish an elegant edition of his Latin works; but finding it impracticable in London, he had an inferior one executed at Amsterdam in 1668. In 1675, he published his English translation of the Iliad and Odyssey.

About this time, he took a final leave of London to pass the remainder of his days at the Earl of Devonshire's seat in Derbyshire, where he continued to prosecute his studies. In 1676, his dispute with Dr Laney, Bishop of Ely, on liberty and necessity, made its appearance; and, in 1678, his *Decameron Physiologicum*, or ten dialogues on natural philosophy; also, his *Art of Rhetoric*, and his *History of the Civil Wars, from* 1640 *to* 1660, which he entitled *Behemoth*, of the publication of which, however, his friend Charles II. who saw it in manuscript, did not approve.

His mental powers continued vigorous till his last illness, and his great delight consisted in exercising them. In his 85th year, he wrote an account of his own life in Latin verse, which evinced considerable activity of mind, though the execution of his task afforded no bright display of literary taste. In the following quaint conceit, for example, he depicts the circumstances of his birth:

> "Fama ferebat enim, sparsitque per oppida nostra,
> Extremum genti classe venire diem;
> Atque metum tantum concepit tunc mea mater,
> Ut pareret geminos meque metumque simul."

He continued even to study mathematics with great perseverance, and he died at the house of his noble patron in 1679.

The accounts given of his temper and private character are various, according to the channels through which they are communicated. Those whose doctrines he disputed, and whose writings and characters he reviled, drew along with them a number of partisans to stigmatise him as rude, acrimonious, and untractable. Of this temper we certainly perceive some traces in his writings; but we likewise find in them occasional proofs of a spirit of conciliation and candour, together with a sense of the bias which external circumstances gave to his writings. In the following terms he concludes his preface to his book *De Cive*: "If, in this treatise, you find any thing of questionable solidity, or any thing expressed with too great acrimony, remember that they are spoken not from party zeal, but a sincere wish for the peace of society; and by a man whose grief, so justly awaked by the distractions and calamities of his country, entitles him to a share of forgiving tenderness. He therefore craves, that you will, on such occasions, bear with his weakness, and not indulge towards him the extremity of your displeasure." He laid it down as a maxim, that it was unlawful to commence an abusive attack on any writer without provocation, but that, when first attacked in this way, he was entitled to make the severest retorts; and his practice shewed, that on such occasions he knew no bounds. He aspersed with the utmost scurrility the members of the Royal Society as a body, expressing his contempt for their attachment to experimental inquiry, and representing them as abandoning the use of their rational faculties.

At court he was a common object of banter, which he bore with good temper, and was remarkable for the felicity and fecundity of his repartees. To serious questions, however, he never gave a ready reply. If his opinion was asked on any point of philosophy or of political science, he gave a winding, computing, and diffident sort of answer, which, in a less noted man, might have been mistaken by the superficial for a mark of indecision of character, but in reality proceeded from his being aware of the multiplicity of circumstances to be taken into account, and the risk which there always is of running into error. All who cultivated his society pronounced him a delightful companion. Mr Wood, in his *History of the Antiquities of Oxford*, inserted this character of Hobbes: "He was a man, of whom (amidst the varieties of accounts, good and bad, that have been circulated) this may be most truly pronounced, that he had a most comprehensive and well replenished mind on universal science,—a mind which despised riches and secular honours, and was superior to the envy of the world. To his relations and others he was ever kind and beneficent. Among his companions, his conversation was cheerful, open, and free. By strangers he was held in veneration, as the first ornament of his country." This eulogium, however, was struck out of the work by Dr Fell, dean of Christ-

Church, through whose hands all works printed at the university-press were required to pass. The transaction was communicated to Mr Hobbes, who had a pamphlet, containing a full exposure of it, ready for appearing in London and Oxford at the same time with the work of Mr Wood. Hobbes was remarkable for vigour of nerve, and steadiness of intellect. He used to say, that in his most complicated arithmetical calculations he never mistook a figure; and with the same undeviating steadiness he prosecuted all his learned undertakings. The high value which he put on this natural quality, had probably some influence in rendering him impatient of opposition, and gave origin to the harsh features which some parts of his works bear.

According to the account given of him by Dr White Kennet, he was considered in the house of the Earl of Devonshire as a humourist, or unaccountable being; a character very readily acquired by a man who dedicates to study the hours by which those around him have their manners moulded by their general intercourse with others. His amusements, exercises, and social interviews, being subservient considerations, were dictated by his own thoughts; and though not resulting from an unaccommodating temper, appeared capricious, because they were singular. In this nobleman's house he was retained from gratitude and affection, rather than with a view to any sort of services, and he lived in ease and plenty without any official charge. His mornings were spent in violent exercise, such as running and climbing steep ascents, in which he exerted himself to fatigue. After breakfast, he went round the family, to wait on the countess, the children, and the visitors. Thus the time passed till twelve o'clock, when he had a little dinner prepared for him, after which he retired to his study, where he smoked, thought, and wrote for several hours.

Sensible that he was obnoxious to a powerful party, he was haunted with habitual apprehensions for his safety. The pension of the King was chiefly valued by him as a pledge of protection from persecution; and he had Lord Arlington and some other friends engaged to protect him at court whenever there was occasion. He disliked to be left in a house alone, some said for fear of being assassinated by his enemies, while others ascribed it to the workings of an involuntary superstition. When the Earl went from home, he always went along with him, even in his last illness, when he required to be conveyed on a feather-bed to the carriage, and survived the journey only a few days. He avoided all conversation on the subject of death. If, as has been supposed, he scarcely believed in a future state, yet he seems not to have been capable of looking forward to his dissolution with that placid indifference with which men generally look back to the period preceding their birth. He reckoned on the continuance of life when his constitution was too much worn out to justify such expectations; and when, in reply to some anxious inquiries, he was forbid to hope for a recovery, he lay in a state of silence and apparent stupefaction, which was concluded to be in a great measure produced by the state of his mind. The last words which he uttered in the full possession of his senses were, "I shall be glad to find any hole to creep out of the world by," which probably expressed a wish that his last moment should be exempt from pain and disturbance. He conformed to the Episcopal Church of England, and declared that he preferred that religion to all others; yet he had no confidence in the utility of religious services on his death-bed. On one occasion, during his residence in France, when his life was seriously in danger, he resented the solicitations of the Romish priests and the Protestant clergy to submit to some rite which would proclaim him a believer in their respective systems, and told them, that if they did not desist, he would expose the impostures of their whole fraternity, from Aaron downwards.

It is with the writings of Hobbes, and the opinions which he circulated, that the public is chiefly concerned. His writings were fitted to make a powerful impression at the time at which they appeared; but the character of society has subsequently so much changed, that they are now comparatively of little interest. His small treatise *De Homine* is regarded by the philosophical world as the best of his works. In this he, in some degree, advanced the science of optics, then in a rude state. His notions, though crude and inaccurate, are ingenious and interesting. His moral observations sometimes breathe the sage spirit of Aristotle. At one time he, like that author, condenses his meaning in a few words; at another he suddenly deviates into a style of extreme expansion. This chiefly happens when he applies his doctrines to the opinions and transactions of his own times. A celebrated living author (Professor Stewart) justly remarks, that Hobbes, whether right or wrong, never fails to set his reader a-thinking, which is the most indubitable proof of original genius.

To attempt to collect a system of moral, political, and religious doctrine from his works, would now appear ludicrous. In some parts his inquiries are shallow and deficient, most especially in his investigations of our ideas of morality and justice. He considers a regard for personal advantage as the only law of man in a state of natural liberty, and represents all the obligations of justice and good conduct to our fellows as the consequence of civil contracts formed under the influence of individual prudence. The laws, he says, are the foundation of justice; before them justice and injustice are unmeaning words. If this view of things had been advanced only as a general description of the actual condition of man under a total want of laws, as well as the absence of generous or deliberate reflection, and if he had considered pactions and civil institutions as the means by which men agree to execute beneficial ends, he could not have been greatly blamed; but he regards even civil compacts as the sole effect of the regard of each man for his own safety; and such feelings of kindness and compassion, as most loudly proclaim the social virtues to be a part of our original nature, are represented as arising solely from a reflection on the possibility that exists of experiencing in our own persons the evils which we deplore in others.

In forming this, and some other views, he appears to have been led astray by the desire of giving what appeared to him a palpable account of human affairs; but it partakes too much of those gross maxims which sometimes indecently obtrude on our notice, both in conversation and books, which foster our worst passions by boldly representing them as the necessary springs of human conduct. No doctrines can have a more destructive influence on those finer feelings which are connected with just reflection and the encouragement of exalting sympathies, but which require to be delicately cherished if they are to be preserved from pollution and degradation. The same love of palpability seems to have been the origin of that system of materialism, or rather that preference of the language of materialists, which appeared in the explanations which Hobbes gave of the origin and laws of thought. By representing justice as founded on positive law, he overturns the principles of jurisprudence itself, which must precede law, and determine the propriety of institutions. If he acknowledged the preservation of the general welfare to be a valuable end, it was certainly paradoxical to deny that a man, on his first interview with a stranger on an unknown shore, previously to the establishment of any mutual understanding, is under obligations to cultivate personal kindness, and to abstain from violence and domination. The boundaries of these early feelings, and the modes in which they may be best expressed, are not indeed easily defined, especially if we encounter distraction from the circumstance of a numerous population. Therefore it appeared the easiest method to pronounce them arbitrary, and in no degree binding, compared to declared promises, compacts, and promulgated laws. But men may differ both about the formation and the execution of laws, and how are their differences to be decided? "They must," says Hobbes, "choose a sovereign power, and to this their whole interests are at once committed." Such is the origin of regal government; and from this simple fact he draws the monstrous conclusion, that kings can do no wrong; that they must never be resisted; and that to their hands the lives, properties, and consciences of the members of a state must be perpetually and unconditionally entrusted. That such will be the state of mankind, if they are barbarous in their character, jarring in their views, or bereft of spirit; that it will even be worse than this, if they are subjugated by the power of a brutal master, who feels no obligation to consult their welfare, farther than as it is subservient to his imagined interest or the gratification of his caprice, is a fact too often exemplified in the history of the world: but to erect it into a principle that this *ought* to be the case, and that no efforts of mankind should be directed to the formation of any better state of society, is an idea which, in a reflecting mind like that of Hobbes, could only be generated by the miserable dissensions by which he was surrounded. In the days of Cromwell and the Charles's, the spirit of intolerance was active, extravagance contended with extravagance, and there seemed to be no possibility of terminating the scene of violence by a temperate discussion of principles, or a mutual adjustment of views; it was therefore necessary to still the passions by some powerful agent. The agent that occurred to Hobbes as the most suitable, was the exertion of absolute authority in the hands of the chief magistrate, and the perpetual establishment of this power seemed necessary for the prevention of future troubles. As a temporary expedient, he might have been pardoned for advancing such a position, even by those who dissented from him; but when he erects it into a universal principle, he must be regarded as an aggressor of the rights and interest of society, and a deliberate apologist of tyranny.

In theology Hobbes speculated with equal infelicity. Insensible both of the mysterious nature of his subject, and the reverence which it required, he examined it with a minute and daring curiosity, and pronounced his opinions in the same dogmatic spirit which characterises his other discussions. To retail his notions would be superfluous. Let it suffice to mention that, in conformity with his general theory of right and wrong, he asserts that the attribute of justice has no meaning as applied to the divine Being, who possesses uncontrolled power, and is not accountable to any superior. His comments on scripture cannot be read with interest by any class of men. The Christian must regard them as audacious and wild, and the infidel as tedious and unmeaning. Although, with his usual love of palpability, he explodes some mysteries, and attempts to reduce his subject to a few short and easy theorems, these are so repugnant to the conclusions which the slightest farther reflection would suggest, that their only tendency is to unhinge such religious views as his readers may have formerly entertained, without furnishing any thing satisfactory in their stead, or emancipating the mind from the wishes which it may have habitually cherished.

Hobbes will long be pointed to as an eloquent and remarkable writer, but rather fitted to excite wonder than to gain approbation. His intentions, however, are not deserving of that abhorrence which his name excites among many who have never looked into his writings. Hobbes was inconsistent, but he seems never to have seen this, and to have been thoroughly sincere in his doctrines. Though the tendency of his writings is objectionable, there is no appearance of the slightest design of impairing the credit of Christianity, and he evidently thought that the publication of his doctrines would promote the political interests of his country and the world. Notwithstanding his power in exciting philosophical reflection, we are not now in need of his aid, as we possess abundance of literature better adapted to every purpose of philosophy; and we can only turn our attention occasionally to his writings as objects of curiosity, forming a remarkable epoch in the history of human opinions. See Leland's *View of Deistical Writers;* Mosheim's *Ecclesiastical History;* Aubrey's *Letters and Anecdotes;* and Hobbes's *Works.* (*H. D.*)

HODEIDA is a sea-port town of Arabia, situated on the Red Sea. Although the harbour is larger than that of Loheia, yet it will admit only small vessels. The town is large, and is composed principally of huts built in the ordinary style. The mansion of the Dolah, or governor, the mosques, the custom-house, and the houses of the principal merchants, are built of stone. There is a small castle near the sea, but it is not capable of much defence. At the distance of a mile and a half from Hodeida is a well of excellent water, from which the town is supplied, the water nearer the town being very bad. Hodeida is the sea-port of Beetlefackie, a town in the interior, about 30 miles from the coast, and only about half a day's journey from the hills where the coffee grows.

The Dolah of Hodeida is accountable only to the Imam; but his jurisdiction is confined to the city. His revenues consist partly of the duties upon exported coffee. All the mercantile transactions at Hodeida are carried on in Spanish dollars and cavears; 40 cavears making one Spanish dollar. The cavear is an imaginary coin. All foreign coins pass current here. The coffee from Beetlefackie, which is intended for India, Muscat, or Europe, is sent by land to Mocha; but that which is intended for Jidda, is shipped at Hodeida. East Long. 42° 59′, and North Lat. 14° 49′, according to Lord Valentia's chart. See Niebuhr's *Travels through Arabia*, sect. ix. chap. 2.; and Milburne's *Oriental Commerce*, vol. i. p. 95, 96.

HOEING. See Agriculture.

HOGARTH, William, the celebrated painter, was the grandson of a yeoman, who possessed a small tenement in the vale of Bampton, near Kendal in Westmoreland. He had three sons. The eldest succeeded his father in his little freehold; the second settled at Troutbeck, near Kendal, and was remarkable for a talent at provincial poetry;* the

* We trust that it will not be indulging in diffuse or impertinent anecdote, to subjoin a few particulars respecting this poetical uncle of the great Hogarth, whom we find denominated the Mountain Theocritus of his native place by Mr Walker, the lecturer on natural philosophy, who came from the same part of the country. The songs and quibbles, he says, of old Hogarth, had often delighted him in his youthful years. "Those simple strains," he adds, "were composed while he held the plough, or was leading his fuel from the hills."—Who does not recall Burns to his recollection in perusing this circumstance?—"He was," continues Mr Walker, "as critical an observer of nature as his nephew, for the narrow field he had to view her in. Not an incident or an absurdity in the neighbourhood escaped him. If any one was hardy enough to break through any decorum of old and established repute,—if any one attempted to over-reach his neighbour, or cast a leering eye at his wife, he was sure to hear himself sung over the whole parish, nay, to the very boundaries of the Westmoreland dialect; so that his songs were said to have had a greater effect on the manners of his neighbourhood, than even the sermons of the parson himself. But his poetical

third son, who was the father of the painter, after having kept a school in the country, came to London, and pursued the same occupation in Ship Court, in the Old Bailey. William Hogarth was born in the parish of St Bartholomew in 1698, and seems to have received only the usual education of a mechanic. He was bound apprentice to Ellis Gamble, a silversmith in Cranbourn Court, Leicester-fields; and was to learn in that profession only the branch of engraving arms and cyphers on metal. Before his apprenticeship had expired, his genius for drawing began to point to the comic path which it afterwards pursued. Having one day rambled to Highgate with some companions, he witnessed a quarrel in a public-house, in which one of the disputants received a blow with a quart pot, that made the blood stream down his face. Such a subject, one would think, was little calculated for gay effect; but humour is not an over-delicate faculty, and the distorted features of the wounded sufferer, it seems, so much attracted the fancy of young Hogarth, that he sketched his portrait on the spot, with the surrounding figures, in ludicrous caricature. His apprenticeship was no sooner expired, than he entered into the academy of St Martin's Lane, and studied drawing from the life, in which he never attained to great excellence. It was character, the passions, the soul, that his genius was given him to copy. In colouring, he proved no great master; his forte lay in expression, not in tints and chiaro-scuro. It is not exactly known how long he continued in obscurity, but the first piece in which he distinguished himself as a painter, is a representation of Wanstead Assembly. In this are introduced portraits of the first Earl Tylney, his lady, their children, tenants, &c. The colouring of this is said to be better than that of some of his later and more highly finished pieces.

From the date of the earliest plate that can be ascertained to be the work of Hogarth, it may be presumed, that he began business on his own account at least as early as the year 1720. His first employment seems to have been the engraving of arms and shop bills; the next to design and furnish plates for booksellers.* Among these, were designs for Hudibras, with Butler's head. His Hudibras (says Horace Walpole) was the first of his works that marked him as a man above the common; yet what made him then noticed now surprises us, to find so little humour in an undertaking so congenial to his talents.

The success of his plates was sufficient to bring him business as a portrait painter; but it was not permanent, or attended with much reputation. The author of the volume of anecdotes respecting him, affirms with confidence, that though not a portrait painter, who could gratify the self-love of his employers, he drew individual likenesses in his best pieces. One of his most striking scenes of this sort, was the examination of the committee of the House of Commons into the cruelties exercised on the prisoners of the Fleet to extort money from them. On the table of the committee are the instruments of torture. A prisoner in rags, half starved, appears before them, with a good countenance, that adds to the interest. On the other side is the confronted and atrocious goaler, with villainy, terror, and the eagerness to tell a lie, depicted in his features, and expressed in his gesture. This was Bambridge, the warden of the fleet, who, with Huggins his predecessor, were both declared guilty of extortion and cruelty. In 1730 Hogarth made a clandestine marriage with the daughter of Sir James Thornhill, sergeant painter, and history painter, to George I. Hogarth was at this time called in the Craftsman an ingenious designer and engraver; but his father-in-law regarded him as so unworthy of his daughter, and was so much offended by the match being a stolen one, that he was not easily reconciled to it. About the same period our painter began his celebrated Harlot's Progress, some scenes of which were purposely put in the way of Sir James Thornhill, to bespeak his favour. Sir James remarked, that the man who could produce such works could maintain a wife without a portion; but he afterwards relented, and the young pair took up their abode in his house.

By the appearance of his Harlot's Progress, his fame was completely established, and his finances raised, by the rapid sale of the plates that were struck from the pictures. He might be said in this production to create a new species of painting,—the moral comic; and in the furniture, dresses, and details of the scenes, to give a history of the manners of the age. The Rake's Progress, which appeared in 1735, though, in the opinion of many, superior in merit, had not so much success from want of novelty. In

talents were not confined to the incidents of his village. I myself bave had the honour to bear a part in one of his plays, (I say one, because many are extant in MS. in the mountains of Westmoreland at this hour.) This play was called *The Destruction of Troy.* It was written in metre, much in the manner of Lopez de Vega, or the ancient French drama. The unities were not too strictly observed, for the siege of ten years was all represented. Every hero was in the piece, so that the dramatis personæ consisted of every lad of genius in the whole parish. The wooden horse—Hector dragged by the heels—the fury of Diomede—the flight of Æneas—and the burning of the city—were all represented. I remember not what fairies had to do in all this; but, as I happened to be about three feet high at the time of this still-talked of exhibition, I personated one of these tiny beings. The stage was a fabrication of boards placed about six feet high on strong posts; the green-room was partitioned off with the same materials; its ceiling was the azure canopy of heaven; and the boxes, pit, and galleries, were laid into one by the great Author of Nature, for they were the green slope of a fine hill Despise not, reader, this bumble state of the provincial drama. Let me tell you, there were more spectators for three days together than your three theatres in London would hold; and let me add, still more to your confusion, that you never saw an audience half so well pleased. The exhibition was begun with a grand procession from the village to a great stone, dropped by the devil, about a quarter of a mile off, when he tried in vain to erect a bridge across Windermere; so the people, unlike the rest of the world, have remained a very good sort of people ever since. I say the procession was begun by the minstrels of five parishes, and were followed by a yeoman on bull-back. This adept had so far civilized his bull, that he would suffer the yeoman to mount bis back, and even to play the fiddle there."——After detailing an accident that befel the yeoman, from his bull running away with him, the narrator proceeds:—"This accident rather inflamed than depressed the good-humour arising from the procession; and the Clown, or Jack-pudding of the piece, availed himself so well of the incident, that the lungs and ribs of the spectators were in manifest danger. This character was the most important personage in the whole play. He was a compound of Harlequin and Merry-Andrew, or rather the arch fool of our ancient kings. . . . . . . The play was opened by this character with a song, which answered the double purpose of a play-bill and a prologue: for his ditty gave the audience a foretaste of the rueful incidents they were about to behold, and it called out the actors, one by one, to make the spectators acquainted with their names and characters, till the whole dramatis personæ made one great circle on the stage. The audience being thus become acquainted with the actors, the play opened with Paris running away with Helen, and Menelaus scampering after them. Then followed the death of Patroclus, the rage of Achilles, the persuasions of Ulysses, &c. &c. and the whole interlarded with apt songs, all the production of ald (old) Hogarth. The bard, however, had been dead some years; and, I believe, this Fête was a jubilee to his memory. But let it not detract from the merit of Mr Garrick to say, that his at Stratford was but a copy of one forty years ago on the banks of Windermere. Was it any improvement, think you, to introduce several bulls instead of one? But I love not comparisons; and so conclude, yours, &c. ADAM WALKER."—*From Anecdotes of Hogarth.*

* Thirteen folio prints, with his name to each, appeared in Aubrey de la Mortraye's Travels, 1723. Seven smaller prints for Apuleius's Golden Ass, 1724. Fifteen head pieces to Beaver's Military Punishments of the Ancients; and five Frontispieces for the translation of Cassandra, in five vols. 1725 Seventeen cuts for Hudibras, 1726. Two for Perseus and Andromeda, 1730. Two for Milton, the date uncertain; and a variety of others between 1726 and 1733.

the following year, ambitious of distinguishing himself as a painter of history, he finished the Scripture scene of the Pool of Bethesda, and of the Good Samaritan; but the burlesque turn of his mind mixed itself with all subjects, and here with disadvantage. Nor was he more successful in his picture of Danaë, where the old nurse tries the gold by ringing it with her teeth. His fame was however now so high, that Swift complimented him in the Legion Club, and Fielding in his preface to Joseph Andrews. Theophilus Cibber had also brought his Rake's Progress on the stage, in the shape of a pantomime.

His printed proposals, dated January 25, ascertain his Company of Strolling Players, and his Marriage a la Mode, to have been then ready for sale. He had also projected a Happy Marriage, by way of a counterpart to his Marriage a la Mode. The time supposed was immediately after the return of the parties from church. The scene lay in the hall of an antiquated country mansion. On one side the married couple were represented sitting. Behind them was a group of their young friends of both sexes, in the act of breaking bride-cake over their heads. In front appeared the father of the young lady grasping a bumper, and drinking, with a seeming roar of exultation, to the future happiness of her and her husband. By his side was a table covered with refreshments; jollity rather than politeness, was the designation of his character. Under the screen of the hall, several rustic musicians in grotesque attitudes, together with servants, tenants, &c. were arranged. Before the dripping-pan stood a well-fed divine, with his gown and cassock, with his watch in his hand, giving directions to a cook dressed all in white, who was basting a haunch of venison. Among the faces of the principal figures, none but that of the young lady was completely finished. Hogarth had been often reproached for his inability to give grace and dignity to his heroines. The bride was meant to vindicate his pencil from this imputation. The effort, however, was unsuccessful. The girl was pretty, but her features were uneducated. She might have attracted notice as a chambermaid, but would have failed to extort applause as a woman of fashion. The parson and his culinary associates were more laboured than any other parts of the picture. The painter sat down with a resolution to delineate beauty improved by art, but seems, as usual, to have deviated into meanness, or could not help neglecting his original purpose to luxuriate in more congenial ideas. He found himself, in short, out of his element in the parlour, and therefore hastened in quest of ease and amusement to the kitchen fire.

Soon after the peace of Aix-la-Chapelle, he went over to France, and was taken into custody while he was drawing the gate of that town; a circumstance which he has recorded in his picture, entitled *O the Roast Beef of Old England*, published in 1749. He was actually carried before the governor as a spy; and after a very strict examination, committed a prisoner to Grandsire his landlord, on his promising that Hogarth should not go out of the house till he was to embark for England. Previous to this commitment, he had behaved with a sturdiness and sauciness which he thought became an Englishman, but which betray the extreme grossness of his manners. In the streets he was often clamorously rude. A tattered bag, or a pair of silk stockings with holes in them, drew a torrent of imprudent language from him, and which there were Scotch and Irish emigrants on the spot who could interpret to the French. But his pleasantry was extinguished by what happened when he was drawing the gates of Calais; for though the innocence of his design was rendered perfectly apparent on the testimony of other sketches he had about him, which were by no means such as could serve the purpose of an engineer, he was told by the commandant, that had not the peace been actually signed, he should have been obliged to have hung him up immediately on the ramparts. Two guards were then provided to convey him on shipboard; nor did they quit him till he was three miles from the shore. They then spun him round like a top on the deck, and told him he was at liberty to proceed on his voyage without farther molestation or attendance. The slightest allusion to this ludicrous affair used to be offensive to our painter.

In 1753, he appeared in the character of an author, and published a quarto volume, entitled *The Analysis of Beauty*, written with a view of fixing the fluctuating ideas of taste. His intention was to shew that a curve is the line of beauty, and that round swelling figures are most pleasing to the eye. He received assistance in this work from Dr Benjamin Hoadley the physician, and the Rev. Mr Townley corrected the preface. The family of Hogarth rejoiced when the last sheet of his Analysis was printed off, as the frequent disputes he had with his coadjutors in the course of the work, did not much harmonize his disposition. If beauty really did consist in any particular kind of lines, there were few painters less likely to discover them than Hogarth, and he was no metaphysician; but the refutation of an exploded theory would be now superfluous.

About 1757, his brother-in-law, Mr Thornhill, resigned the place of King's sergeant-painter, in favour of Hogarth, who soon after made an experiment in painting that involved him in some confusion. The collection of pictures of Sir Luke Schaub, was sold in 1758, by public auction; and the celebrated painting of Sigismunda, said to be the work of Corregio, (Mr Walpole thought that it was by Furino,) excited his emulation. From a contempt of the ignorant virtuosi of the age, many of whom he had seen bubbled by vile copies, as well as from having never studied the great Italian masters, he persuaded himself that the praises bestowed on their glorious works were only the effects of prejudice. He went farther; he determined to rival the ancients, and unfortunately chose the subject we have mentioned. His Sigismunda is described by Walpole as the representation of a maudlin strumpet, just turned out of keeping, and with eyes red with rage and usquebaugh. Her fingers blood-red by her lover's heart, (the blood was afterwards expunged from her fingers,) that lay before her like that of a sheep for dinner. None of the sober grief; no dignity of suppressed anguish; no settled meditation of the fate she meant to meet; no amorous warmth turned holy by despair; in short, all was wanting that should have been there; all was there that such a story would have banished from a mind capable of conceiving such complicated woe,—woe so sternly felt, and yet so tenderly. Hogarth's performance was more ridiculous than any thing he had ever ridiculed. He set the price of 400*l*. on it, and had it returned on his hands by the person for whom it was painted. This unfortunate picture, which was the source of so much vexation to Hogarth, at least made a versifier of him. He addressed an epistle to a friend, occasioned by Sir Richard Grosvenor (now lord) returning the picture on the artist's hands. The verses are splenetic and conceited, without a particle of wit or humour.

The last memorable event in his life, was his quarrel with Mr. Wilkes. His connection with the court probably induced him to quit the line of party neutrality which he had hitherto observed, and to engage against Mr Wilkes and his friends in a print, September, 1762, entitled *The Times*. He was attacked, in return, in a number of the *North Briton*, which produced his caricature of Wilkes. At an early period of his career, Hogarth had ventured to assail Pope himself in the blaze of his poetical reputation,* and from his exasperation he escaped, either by his obscurity, or by the prudence of the poet. But he was now destined to feel the lash of a writer, inferior indeed in fame, but equal in the talents of vituperation. Churchill avenged the caricature of his patron Wilkes, by his *Epistle to Hogarth*, not, indeed, the brightest of his works, and in which the severest of his strokes fell upon his age. Hogarth retaliated by caricaturing Churchill under the form of a canonical bear, with a club and a pot of porter. Never, as Walpole truly remarks, did two angry men, of their abilities, throw mud with less dexterity.

It deserves to be noticed, that, amidst the bitterest invectives on Hogarth, his enemy, Churchill, conceded a degree of merit to him, with which his warmest admirers may be contented, and a description of his genius, to which they would find it difficult to add a material circumstance.

In walks of humour, in that cast of style,
Which, probing to the quick, yet makes us smile;
In comedy, his natural road to fame,
Nor let me call it by a meaner name,
Where a beginning, middle, and an end,
Are aptly join'd; where parts on parts depend,
Each made for each, as bodies for their soul,
So as to form one true and perfect whole,
Where a plain story to the eye is told,
Which we conceive the moment we behold;
Hogarth unrivall'd stands, and shall engage
Unrivall'd praise to the most distant age.

Hogarth having been said to be in his dotage when he produced his print of the bear, it should seem, was provoked to make the following additions to this print, in order to give a farther specimen of his still existing genius. In the form of a framed picture on the painter's pallet, he has represented an Egyptian pyramid, on the side of which is a Cheshire cheese, and round it 3000l. per annum, and at the foot a Roman veteran in a reclining posture, designed as an allusion to Mr Pitt's resignation. The cheese is meant to allude to a former speech of Mr Pitt's, in which he said that he would rather subsist a week on a Cheshire cheese and a shoulder of mutton, than submit to the enemies of his country. But to ridicule this character still more, he is, as he lies down, firing a piece of ordnance at the standard of Britain, on which is a dove, with an olive branch, the emblem of peace. On one side of the pyramid is the city of London represented by the figure of one of the Guildhall giants going to crown the reclining hero. On the other side is the King of Prussia, in the character of one of the Cæsars, but smoking his pipe. In the centre stands Hogarth himself, whipping a dancing bear, (Churchill,) which he holds in a string. At the side of the bear is a monkey, designed by Mr Wilkes. Between the legs of the little animal is a mop-stick, on which he seems to ride like a child on a hobby-horse. At the top of the mop-stick is the cap of liberty. The monkey is undergoing the same discipline as the bear. Behind the monkey is the figure of a man, but with no lineaments of face, and playing on a fiddle. This was designed for Earl Temple, in allusion to the inexpressiveness of his countenance.

Amidst these disgraceful hostilities, Hogarth was visibly declining in his health. In 1762, he complained of an inward pain, which proved to be an aneurism, and became incurable. The last year of his life was employed in retouching his plates, with the assistance of several engravers, whom he took with him to Chiswick. On the 25th of October, 1764, he was conveyed from thence to his house in Leicester Fields, in a very weak condition, yet remarkably cheerful; and receiving an agreeable letter from the celebrated Dr Franklin, he drew up a rough draught of an answer to it. In the night time, however, he was seized with a vomiting, probably owing to a circumstance of which he had boasted before going to bed, viz. that he had eat a pound of beef steaks to his dinner, and expired about two hours after, aged 67. His corpse was interred in the Church-yard of Chiswick, on a monument which bears a simple inscription on one side, and on the other emblematic ornaments, with some verses by Garrick.

In his private character this celebrated man is reputed to have been hospitable and liberal, as well as accurately just in his dealings, but his manners were coarse and vulgar, and his powers of delighting seem to have been restrained to his pencil. To be a member of clubs of illiterate men was the utmost of his social ambition, and even in those assemblies he was oftener sent to Coventry than any other member. The slightest contradiction is said to have transported him to rage. His genius as a comic painter is of that strong description which breaks down the partition between connoisseurship and the popular taste in the enjoyment of it. It is merit, which his satirist yet ablest panegyrist so well expressed, "which we conceive the moment we behold." The critic Du Bos often complained that no history painter of his time went through a series of actions. What Du Bos wished to see done, Hogarth performed, though probably without knowing that he was so obligingly complying with the critic's request. In his Harlot's Progress he launches out his young adventurer, a simple girl upon the town, and conducts her through all the vicissitudes of wretchedness to a premature death. This was painting to the understanding and to the heart. None had before made the comic pencil subservient to instruction; nor was the success of this painter confined to his persons. One of his excellencies consisted in what may be termed the furniture of his pieces; for as in sublime historical representations the fewer trivial circumstances are permitted to divide the spectator's attention, the greater is the force of the principal figures; so in scenes of familiar life, a judicious variety of little incidents contributes an air of versimilitude to the whole. The rake's levee room, (Walpole observes,) the nobleman's dining room, the apartments of the husband and wife in marriage *à la mode*, the alderman's parlour, the bedchamber, and many others, are the history of the manners of the age.*

For a scientific view of the works of this great artist, we must refer the reader to Walpole's Anecdotes of Painters, which we have already quoted.—A complete list of his prints, at least the most complete that has been made out, will be found in the Biographical Anecdotes, by Nichols. Walpole has made one remark upon them, in his eulogy of Hogarth, against the truth of which his works bear ocular demonstration, viz. that his delicacy is

* In a plate, entitled *The Man of Taste*, 1732, (for a poem of Welsted, we believe,) containing a view of the gate of Burlington-house, with Pope whitewashing it, and bespattering the Duke of Chandos's coach, as well as in a ludicrous picture on the subject of the South Sea bubble.

† Among the small articles of furniture in the scenes of Hogarth, (says the compiler of the anecdotes of his life,) a few objects may speedily become unintelligible, because their archetypes being out of use, and of perishable natures, can no longer be found. Such is the *dare for larks*, a circular board, with pieces of looking-glass inserted in it, hung up over the chimney-piece of the distressed poet; and the Jew's cake, (a dry tasteless biscuit, perforated with many holes, and formerly given away in great quantities at the feast of the passover,) generally used only as a fly-trap, and hung up as such against the wall in the sixth plate of the Harlot's Progress.

superior to that of the Dutch painters, or rather that his indelicacy is less. The illustration of this would be a task more easy than agreeable. Mr Gilpin, in his Essay on Prints, observes, that in design Hogarth was seldom at a loss. His invention was fertile, and his judgment accurate. An improper incident is rarely introduced. In composition, he continues, we see little in him to admire; in many of his prints, the deficiency is so great, as to imply a want of all principle, which makes us ready to believe that when we do meet with a beautiful group, it is the effect of chance. Of the distribution of light, according to the same writer, he had as little knowledge as of composition. Neither was Hogarth a master of drawing. But of his expression, in which the force of his genius lay, we cannot speak in too high terms; in every mode of it he was truly excellent. The passions he thoroughly understood, and all the effects which they produce in every part of the human frame; he had the happy art also of conveying his ideas with the same precision with which he conceived them. (*n*)

HOLBEIN, John, or Hans, an eminent painter, was born at Basle, in Switzerland, in the year 1498. He was instructed in the art by his father John Holbein, whom he very soon surpassed. Holbein was the particular friend of the celebrated Erasmus. At his request he visited London, where he was patronised by Sir Thomas More, to whom Erasmus had introduced him. Sir Thomas employed him in painting the whole of his family, and several of his relations and friends, and he allowed him an apartment in his own house, where he continued for three years. When King Henry VIII. saw these performances, he was so much struck with the talent which they displayed, that he took Holbein into his service, and honoured him with his patronage and kindness during the rest of his life.

It is a singular circumstance, that Holbein always painted with his left hand. He succeeded equally in oil, water colours, and distemper. After he arrived in England, he learned the art of miniature painting from Lucas Cornelii, and carried it to a very high degree of perfection.

In the Florentine collection, are the portraits of Martin Luther, Sir Thomas More, Richard Southwell, and of Holbein, all painted by our author. The "Sacrifice of Abraham," which has been much admired, is in the cabinet of the King of France, along with several portraits executed by Holbein.

In the library of the university of Basle are several of Holbein's works in the highest preservation. A few are preserved, which he painted before he was 15 years old; one of which he drew upon a sign for a writing-master. The portraits of himself, his wife, and children, in the same group, are much esteemed. The other pictures of Holbein in this collection are, the Passion of our Saviour, in eight compartments; the Institution of the Supper; the Body of our Saviour after the Crucifixion; a Lucretia; a Venus; a Cupid; and portraits of Erasmus and Ammerbach. Erasmus is represented as writing his Commentary upon Matthew. In the same library are preserved a copy of Erasmus's *Eloge de la Folie*, which he had presented to Holbein, who ornamented the margin of it with very interesting sketches, done with the pen. An edition of this work was published at Basle, in 1676, by Charles Patin, who got the original sketches copied by Stettler of Berne, and engraved by Merian. A new edition of this work, in Latin, French, and German, with fac-similes of the original designs engraven on wood, was published by M. Haas in 1780. The paintings of Holbein on the organ of the cathedral are still to be seen.

The Dance of Death, on the walls of the cemetery of the Dominicans at Basle, was not painted, as has often been said, by Holbein, but by John Klauber, at the desire of the council, when the plague ravaged that city. These walls were pulled down in 1805. The paintings had been restored in 1558, 1616, 1658, and 1703. Since the year 1792, they have been almost entirely effaced. From these paintings it is probable that Holbein took the idea of composing the famous drawings of the Dance of Death; in which he has shewn so much judgment and imagination, that even Rubens condescended to study and copy them. It consisted of 44 designs, done with the pen, and slightly shaded with Indian ink. These designs were engraved by Haller, and more recently by M. de Mechel, a celebrated artist of Basle. The originals were sold, along with the famous collection of Crozat at Paris, to M. Fleichman of Strasburg. In the reign of the Emperor Joseph II. the Prince Gallitzin, the Russian ambassador at Vienna, purchased them, and carried them to St Petersburg. Holbein died in the year 1554, in the 56th year of his age. See Coxe's *Travels in Switzerland*, vol. i. p. 162.

HOLDEN'S Temperament of the Musical Scale. In 1770, Mr John Holden, in a work on music, in long quarto, recommended a system of tuning, in which each of the fifths, except that on ♯G, should be flattened $\frac{1}{5}$th of a major comma; producing a perfect or untempered major seventh; and a major third and major fifth, alike tempered by the $\frac{1}{5}$th of a major comma, but in contrary directions, as Mr Farey has shewn in the *Philosophical Magazine*, vol. xxxvi. p. 46; and Mr Liston in his *Essay on Perfect Intonation*, p. 22.

The latter gentleman, in p. 23. describes this system as being "nearly what *is in common use*;" and in p. 142, gives it the preference over the scale which Mr Hawkes at last adopted, (viz. V—$\frac{1}{6}$C, see his Temperament); on which account, we shall here present the musical student with a table of the beats of each of the 72 concords in Mr Holden's system, calculated on purpose for our work, viz.

| 1 | 2 | | | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| C | 612.00000 | 12 | 53 | 480.0000 | 0 | 0 | 0 | 0 | 0 | 0 |
| B | 555.00000 | 11 | 48 | 450.0000 | 13.3830 | 42.5792 | 4.4778 | 3.3500 | 8.9330 | 11.2074 |
| ♭B | 512.40315 | 10 | 44 | 428.7920 | 54.0490 | 5.3336 | 4.2664 | 3.1920 | 63.7110 | 10 6802 |
| A | 455.40315 | 9 | 39 | 401.9925 | 11.9550 | 4.9999 | 4.0002 | 2.9923 | 7.9800 | 10.0125 |
| ♯G | 398.40315 | 8 | 34 | 376.8679 | 11.2074 | 35.6605 | 3.7502 | ♯15.6859 | 7.4802 | 40.4365 |
| G | 355.79843 | 7 | 31 | 359.1067 | 10.6802 | 4.4665 | 3.5732 | 2.6733 | 7.1296 | 8.9443 |
| ♯F | 298.79843 | 6 | 26 | 336.6625 | 10.0125 | 31.8555 | 3.3500 | 2.5063 | 6.6830 | 36 1219 |
| F | 256.40315 | 5 | 22 | 320.7960 | 40.4365 | 3.9900 | 3.1920 | 2.3880 | 47 6650 | 7.9902 |
| E | 199.40315 | 4 | 17 | 300 7463 | 8.9443 | 3.7401 | 2.9923 | 2.2389 | 5.9704 | 7.4903 |
| ♭E | 156.59635 | 3 | 14 | 286.5724 | 36.1219 | 3.5648 | ♭15.6859 | 2.1332 | 42,5792 | 7.1380 |
| D | 99.59685 | 2 | 9 | 268.6617 | 7.9902 | 3.3415 | 2.6733 | 2.0001 | 5.3336 | 6.6915 |
| ♯C | 42.59685 | 1 | 4 | 251.8703 | 7.4903 | 23.8325 | 2.5063 | 1.8751 | 4.9999 | 27.0245 |
| C | 0 | 0 | 0 | 240.0000 | 7.1380 | 2.9852 | 2.3880 | 1.7866 | 35.6605 | 5.9775 |
| Notes. | Σ Value of the Notes. | + f | + m | Vibrations in 1″ of time. | *Flat*, of 3d on | *Sharp*, of IIId on | *Sharp*, of 4th on | *Flat*, of Vth on | *Flat*, of 6th on | *Sharp*, of VIth on |
| | | | | | Beats in 1″ of time. | | | | | |

In column 2, the notes are set down in the nearest regular interval in Farey's notation: col. 3. is adapted to the octave above tenor-cliff C; and the beats are expressed in the six following columns, all of them beating *flat* or beating *sharp*, as expressed at the bottom of the several columns, except ♭E in col. 6, and ♯G in col. 7, which are the reverse of all the other fourths and fifths in this system: in which only two of the notes differ from those since adopted by Mr William Hawkes. See Hawkes' *Temperament*.

In a subsequent edition of his work, in octavo, entitled "An Essay towards a rational System of Music," Mr Holden, from having, unfortunately, adopted a defective rule for calculating the *Grave* Harmonics of a consonance, (see that Article), conceived, that he had legitimately introduced the prime number 7 into musical ratios; and thereupon, in the 2d part of his book, grounds a great many unfounded and false rules and conclusions, regarding harmonics: in particular, he gives an ascending and a descending scale, which, when combined, contains 24 notes within the octave, eleven of which involve the number 7 in their numerical ratios. (*g*)

# HOLLAND.

Holland, one of the provinces of the kingdom of the Netherlands, and, before the formation of that kingdom, the most considerable of the united provinces of the Netherlands, is bounded on the west by the German Ocean, or North Sea; on the north by the Zuyder Zee, which separates it from the province of Friesland; on the east, by the same sea, which separates it from the province of Overyssel, and by the province of Utrecht, and part of Guelderland; and on the south by the province of Zealand, and part of Brabant. It is situated between the latitude of 51° 40′ and 53° 10′ north, and the longitude of 3° 56′ and 5° 30′ east of London. Its greatest extent, from south to north, including the isle of Texel, is about 90 miles, and from east to west not above 25 miles in some places, and above 40 in others, it being of a very irregular figure, and extremely narrow towards its northern extremity. According to the calculation taken in the year 1554, there were upwards of 300,000 morgens of land in this province, each morgen being about two English acres. The states of Holland and Zealand, in a remonstrance made soon after this year to the Earl of Leicester, contended, that these two provinces, with all their heath, downs, and grounds delved out, could make in all but about 500,000 morgens; and De Witt, in his work on the true interests of Holland, calculates that there cannot possibly be more than 400,000 morgens of land in this province, down and heath not included.

This province is divided into South Holland, commonly called Ug Holland; and North Holland, generally called West Friesland, and sometimes Waterland; there are also subdivisions, the principal of which will be afterwards noticed. Both South Holland and North Holland contain a great many considerable cities, besides a vast number of large and beautiful villages. In South Holland the principal places are Amsterdam, Rotterdam, the Hague, Leyden, Haerlem, Dordrecht or Dort, Delft, the Briel, Gorcum, Gouda, &c. Rhineland is a subdivision or district in South Holland, the capital of which is Leyden: it contains within its jurisdiction 45 large boroughs and villages. This subdivision is bounded on the west by the coast of Holland; on the east by part of the province of Utrecht, and by Amstelland; on the north by part of the river Y, along the course of the dyke that goes from Haerlem to Amsterdam, and by the shallows and washes as far as Beverwic; and on the south, by a line drawn from Montfort through Oudewater and Gouda to the Hague: it has its name of Rhineland from the middle branch of the Rhine running through it. All the inhabitants of this district are obliged by law, agreed to among themselves, to provide for the maintenance and reparation of the dykes, sluices, and canals within the district; and they have a council which meets every Saturday at the Rhineland House, in Leyden. This council is composed of the Dyke-graaf, and seven assistants, called Heemraden. There are several islands belonging to South Holland: The island of Voornlees, between the mouths of the river Maese; Briel is the capital: This island, along with the small adjoining islands of Goree, and Overslackee, form the territory called Voornland, which was anciently part of Zealand. The isle of Ruggonhill, to the east of that of Voorn, of which Williamstadt is the principal town, together with the isle of Finard, formerly belonged to Brabant.

North Holland is divided from South Holland by the river Y. The principal towns in it are Saardam, Edam, Monikendam, Alcmaer, and Hoorn. Across the mouth of the Zuyder Zee lies a row of islands, belonging to North Holland. The Texel island is separated from the North Cape of North Holland by a very narrow channel; it is about eight miles long and five broad; it is defended from the sea by sand hills and strong banks; there are several villages in it, and a large town on the east side, called Burgh, which enjoys the privileges of a city. As this island lies at the mouth of the Zuyder Zee, and commands the only passage to Amsterdam, the States have built a strong fortress on it, in which a considerable garrison is always kept. The island of Vlieland lies towards the north-east of the Texel; it is about nine miles long, and two broad; it has only two small villages; and is chiefly remarkable for the great quantity of muscles found on it. The island of Schelling lies to the north-east of Vlieland; and is about 10 miles long, and three broad; there are five villages on it. These islands, together with several large sand-banks, break the rage of the ocean, and form two good harbours, or rather roadsteds, at the Texel and the Vlie; the first being a noted station for ships bound to the south, and the other for those bound to the north. The Wierengen, thus called from the great quantity of sea-weed, named in Dutch, as in Scotch, *Wier*, is a number of little islands, which lie more to the south, on the coast of North Holland; the principal of them is five miles long, and two broad, and contains several villages.

The name of Holland, (the hollow land,) sufficiently indicates the nature of the country. The level of a great part of it is, indeed, below the level of the sea, which is kept out only by means of dykes, or natural sand banks. In many parts, the dyke, or mound, is 30 feet above the adjoining land; the width at top is enough to permit the passage of two carriages; and there is a sort of imperfect road along it. In its descent, the breadth increases so much, that it is not very difficult to walk down either side. On the land side, it is strengthened by stone and timber, and covered by earth and grass; towards the sea, somewhat above, and considerably below water-wark, a strong matting of flags prevents the surge from carrying away the surface of the mound. This kind of defence appears to have been discovered in the 17th century; for Sir William Temple, in his observations on the Netherlands, expressly says, it was lately found out. This matting is held to the shore by bandages of twisted flags running horizontally, at the distance of three or four yards from each other, and staked to the ground by strong wooden pins. As this matting is worn by every tide, a survey of it is frequently made. Farther in the sea, it is held down by stones. Above, there are posts at every 40 yards, which are numbered, that the spot may be exactly described where repairs are necessary. The impost, for the maintenance of these banks, amounts to nearly as much as the land-tax. Sir William Temple asserts, that these dykes employ annually more men than all the corn of the province of Holland could maintain. In the time of De Witt, the making of one rood's length of sea-dyke sometimes cost 600 guilders. Besides these sea-dykes, there are other dykes to keep out the waters of the rivers. In the time of De Witt, the annual charges of the district of Rhineland, which contains about 8000 morgens, and has not much communication with the sea, nor with running but only with standing waters, paid as acredge money and inland charges, at least two guilders for every acre; besides for drawing out of the rain water by mills each acre 30 stivers, and towards foot paths, highways, and ditches, at least 20 stivers more. The banks or dykes near Medenblick, in North Holland, near the Zuyder Zee, are stronger, broader, and higher, than any others in the country; for there being nothing to break the violence of the sea from the islands of Schelling and Vlieland to this shore, the water beats most furiously upon it when the northerly winds blow, and at spring-tides the sea rises sometimes as high as the dykes, and would even overflow and break them down, did not the inhabitants stop its fury by laying sails over the dykes, which preserve them in a tempest. Whenever the water of the sea, or the rivers, breaks over upon the lands, they are drained by means of wind-mills, of which there are immense numbers for this purpose. From what has been already said, it may well be imagined, that the general face of the country is that of a large marsh that has been drained, the canals, and even the sea, looking pale, and even discoloured by mud; yet the eye is not unfrequently relieved and delighted by the groves, gardens, and meadows, while the great rivers, and the immense number of canals in this province, leading not only to every great town, but to every village, and almost to every farm-house, present an infinite number of vessels everywhere coursing up and down upon them.

The principal rivers in Holland are, the Rhine. When we come to treat of the progressive geography of this province, the changes in the course of the Rhine, so far as they are connected with it, will be mentioned; at present, we shall confine ourselves to its present state in Holland. According to some geographers, the northern mouth of this river must be sought in the Leck, which joins the estuary of the Meuse, between Dort and Rotterdam; according to others, it runs through Leyden, where it divides itself into two canals, one of which runs into the lake of Haerlem, and the other loses itself, four miles beyond Leyden, in the sand hills between Catwyk on the Rhine, and Catwyk on the sea, where was anciently the mouth by which it emptied itself into the ocean. The Leck, if it be not the ancient Rhine, must be regarded as another river in Holland; its course has been already mentioned. There is another small branch of the Rhine called the Vaert, or Vecht, which falls into the Zuyder Zee at Muyden, about eight miles to the east of Amsterdam. The little Yssel falls into the Maes, a short way to the east of Rotterdam. The Maes, passing before Gorcum, runs to Dort, where it divides itself into two large branches, forming an island called Ysselmonde. The most northern branch runs to Rotterdam; it is called the New Maes, to distinguish it from the southern branch, which is called the Old Maes. They reunite a little before they reach Vlardingen, and enter the ocean, by a wide mouth, a little below Briel. The Amstel is not properly a river, but rather a collection of waters from the Drecht, the Miert, and other rivulets, the waters of which are swelled by their communication with lakes and rivers, by means of canals. The Y, called by some a river, is more properly a branch of the Zuyder Zee, from which it begins, at a sand bank called the Pampus. Its channel here is half a mile broad, which breadth it continues to Amsterdam, but grows soon afterwards twice as broad. It receives the waters from the lake of Haerlem by a large canal, called the Sparen, and from several lakes in North Holland. It afterwards passes northwards to Beverwyk, without discharging itself again into the sea.

From the town of Haerlem, the great lake called the Haerlem Meer, or Sea of Haerlem, derives its name. It is situated between Haerlem, Amsterdam, and Leyden; and is formed by the waters of several rivulets, and of the sea, with which, as has just been noticed, it has a communication by means of the Y, which enters it by a sluice, strongly built with brick-work. From its communication with the sea, the waters of the Meer are brackish. There are canals from its several gulfs to the cities of Amsterdam, Leyden, and Haerlem. On the east side, there is a gulf or branch called the New Meer, from which a canal leads to the suburbs of Amsterdam. Here there is a dyke, over which loaded boats are carried, by means of a wheel and rollers, into another canal. On the north of the lake there is another gulf, where there is a sluice, which opens and shuts itself by the weight of the water. This is the sluice by which the lake communicates with the Y. In one place, the neck of land which separates the Haerlem Meer and the Y is so narrow, that a canal cannot be drawn through it. Both these waters have gained considerably on their respective shores, and if united would be irresistible. At the narrowest part, the neck of land consists of pile-work and masonry to the thickness of about 40 feet. On the south and south-west, Haerlem Meer communicates with several small branches of the Rhine, one of which comes from Leyden. The Haerlem lake is about 12 miles long, and nine broad; and as ground is very dear and valuable in Holland, it has often been proposed to drain it: but the draining of it would probably be productive of great mischief, for it receives the waters when the violent north winds drive them from the German Ocean into the Zuyder Zee and the Y; whereas if, by the draining of the lake, they were confined within the banks of the Y, the city of Amsterdam would be in great danger of being overflowed. Besides this, the lake of Haerlem affords a vast quantity of fish, and the conveniency of navigation not only to the adjoining villages, but also to Leyden, Haerlem, and Amsterdam. There are some small lakes in North Holland, but none deserving of particular notice.

The climate of Holland is humid, cold, and generally unwholesome; the winters are sharp and very long, the rivers being generally rendered unnavigable by the ice for a considerable length of time. In the spring, which is very short, and by no means agreeable, the sharp cold winds frequently blast the blossoms of the fruit trees. The summers are not unfrequently very hot. The climate is also disagreeable and unwholesome, from sudden and extreme changes of temperature. The east wind generally blows nearly the whole of the winter, and is extremely fierce; but it serves to drive away the fogs, with which this country is dreadfully plagued. The moisture of the air is such, especially about Leyden, that all metals are apt to rust, and even the wood to mould. The climate about Williamstadt is particularly unwholesome, from the extreme flatness and marshiness of the ground; whereas, about Naerden, where the country is high and sandy, the air is by no means bad. The soil of Holland is in general uncommonly rich, being in fact alluvial, and consisting of deep fat loam; in some parts, however, it consists of a barren sand. The soil of North Holland, especially in the drained land called the Bemster, is particularly rich. The country near the village of Schagen is reckoned to possess the richest soil in Europe. Land is sold here at double the rate of any other in Holland, there having been trees upon it, one of which, upwards of a century ago, yielded the owner as much fruit in one year as brought him 10*l.* sterling; and a sheep, bred here, was sold, about the same time, for the same sum.

The progressive geography of Holland is so interesting and important, that we have no doubt our readers will pardon us for dwelling on it pretty fully and minutely. It naturally divides itself into what respects the formation or extension of the Zuyder Zee, the alteration in the course, and the diminution of the size of the Rhine, so far as it is connected with Holland, and the changes which the breaking in, or draining off, of the sea has produced in different parts of this province.

From the name of West Friesland, which is given to North Holland, it is highly probable that part, at least of this division of the province of Holland, was formerly united to East Friesland. How much of it belonged to the Frisia Occidentalis of the ancients is not accurately known: some geographers are of opinion, that only that part to the north-east, in which Hoorn, Enchuyzen, and Medenblic are situated, was the ancient Frisia Occidentalis. From the description of Tacitus, it is evident that, in his time, no other distinction was known but that of greater or lesser Frisons; and that distinction arose entirely from the number of the forces which each could respectively bring into the field. He informs us, that among the Frisons were great lakes, evidently implying that they were of fresh water; and this is made yet plainer by the expression *ambiuntque immensos lacus*, which proves that these lakes were inhabited round by these nations. Hence it is probable that the more inland part of what is now the Zuyder Zee, was one of the lakes mentioned by Tacitus, between which and the Texel and Vlie islands, there lay anciently a large tract of land. This opinion is strengthened by several circumstances. These islands lie still in a contiguous line, and like the broken remains of a continued coast. The sea here, too, is remarkably shallow, and the sands through the whole extent very flat. From the inspection of the accurate maps of the ancient and middle geography of Gaul, by D'Anville, it will be seen that part of the present site of the Zuyder Zee was occupied by a considerable inland lake called Flevo. This lay towards the southern part of the present Zuyder Zee. The question then is, By what means, and at what period, were the northern part of the Zuyder Zee formed, and the communication between this Sea and the ocean opened, or at least rendered so wide as it is at present? From the lake of Flevo ran a river of the same name into the ocean. Formerly the Rhine divided itself into two grand branches at Burginasium, the present Schenck, about five miles north-west of the Colonia Trajana, now an inconsiderable hamlet, called Coln, near Cleves. The southern branch joined the Meuse at the town of Meusa, while the northern passed by Leyden into the ocean. From this branch Drusus formed a canal, bearing his name, which originally joined the Rhine to the Yssel, a river which flowed into the lake Flevo. This canal being neglected, the Rhine joined the Yssel with such force, that their waters increased the lake of Flevo to a great extent, by which means it was carried forward to the ocean by a wide gulf, instead of having a communication with it only by means of the river Flevo. It is probable, also, that the entrance of this river into the ocean was much widened by the force of the waves; for, at present, the violent rage of the waves breaking in towards the mouth of the Zuyder Zee, threatens the parts of North Holland about Medenblick and Enchuysen, braving it over the highest and strongest dykes of the province upon every high tide and storm at north-west. The exact period when the lake Flevo was extended into the Zuyder Zee is not positively known; indeed it is probable that the increase took place at different periods. We are informed by an old Dutch chronicle, published by Vossius, that the increase on the south side, by the breaking in of the inlet to the Texel, took place about the year 1170; others say it was so late as the year 1400. The increase of the lake on its northern side was probably at an earlier period, and also gradual. It certainly was about the year 1400 that the river Y became navigable to Amsterdam by large vessels.

In our account of the progressive geography of the Zuyder Zee, we have partly noticed the changes which have taken place in the course of the Rhine. At the same time that the lake Flevo gained its increase, the northern branch of this river was weakened by the division of its waters; and even the canal of Drusus was afterwards almost obliterated by the deposition of mud in a low country. The Rhine seems to have been farther divided and weakened by a canal cut by Civilis, which, according to Cluverius, is the present Leck; though Pinkerton thinks the deviation of the Rhine into the Leck was the work of natural causes. The same author regards the Leck, which joins the estuary of the Meuse between Dort and Rotterdam, as the northern mouth of the Rhine; which, according to him, the Waal continues to be the southern, both being lost in a comparatively small stream, the Meuse. According to other geographers, what falls into the sea near Catwyk is not the Rhine, but a canal bearing the name of that river. In the sea at low tides, are to be seen, near this village, the foundations of an ancient Roman castle, that commanded the mouths of the Rhine. The Maese, running by Dort and Rotterdam, fell, as it now does, into the sea, at Briel, with a powerful flow of water; but the sands, which are gathered for three or four leagues upon this coast, having obstructed the exit of the river, have caused or increased those inundations, out of which so many islands have been recovered, and of which that part of South Holland is so much composed. Towards the formation of these islands, the Scheldt seems also to have contributed. This river anciently formed a mere Delta, with four or five small islands. At what time the irruptions of this river took place, by which the islands of Zealand, and the most southern of those of Holland, were formed, is not accurately known. Pinkerton is of opinion that they happened at the time that the Godwin sands arose: other authors assign them to violent tempests in the years 860 and 1170. A Zealandic chronicler, quoted by Cluverius, says, that the islands of Zealand were formed by violent tempests in the year 938. It is more probable, however, that these great changes made a slow and gradual progress: none of them being so ancient as the time of Charlemagne, and some of them as recent as the fifteenth century.

Of the most recent changes in the geography of Holland, besides the enlargement of the Zuyder Zee already mentioned, that which took place in the year 1421, to the south-east of Dort, is the most remarkable. Dort is the capital of a bailiwick of the same name. In 1421, this Bailiwick was made an island by a violent tempest, which drove the waters up the Maese and the Mereune with such violence, that they overflowed their banks, and swallowed up a large tract of land, with 70 villages, and 100,000 people; a vast lake between Dort and Brabant was also formed. The name of Dordrecht signifies a ferry,on the river Dort, but that river is now swallowed up by the channel of the Maese. The isle of Rugenhil, on which Willenstedt stands, was covered by the sea for some time; it was recovered so late as the year 1654. Naerden is the capital of a district called Goyland: it lies upon the Zuyder Zee, 13 miles to the east of Amsterdam, and 14 to the north of Utrecht. The old town, which stood more to the north, was swallowed up by the sea. The ruins are still to be seen at low water, 200 perches from the present town.

The drained lands in North Holland deserve particular notice under the head of Progressive Geography; they consist of the Zype, the Beenister, and Purmer, the Wormeer, and Schermeer. The Zype was first drained and encompassed by banks, by William Lord of Schagen, and secured by stronger fences in 1552; but the sea broke them down in 1570. After this it was drained again, and secured by a mole of prodigious height and bulk, proof against all attacks of the sea; and it is now, like all the other drained lands, very fruitful soil. The noise made by the waves which break upon it, sounds like the barking of a pack of hounds, from which circumstance it is called the *Hounds-wood*. It is supported by large beams of timber, firmly placed in the ground, and strongly fastened together, the distances between them being filled with very large stones; and the mole is strengthened by a vast bank cast up against it.

Purmer, or Purmeren, and the Beenister, are both drained lakes: the latter is encompassed by a channel from 4 to 8 rods broad, and is joined to the former by a bridge at the south end. Purmer is about 5 miles long, and above 2 broad. The Beenister contains 7090 acres besides the highways, dikes, and canals, which surround and cross it in several places. It lies between Purmer and Edam, and was a lake till the year 1610, when, after four years labour, and vast expence, (the banks, by which the water thrown out by the mills was confined, having been broken, after the work was half done,) it was made dry land; and is now so planted with gardens, orchards, rows of trees, and fertile inclosures, that Sir William Temple says it is the pleasantest summer landscape he ever saw. There were no fewer than thirty mills employed to drain the Beenister.

We come now to the consideration of the agriculture, fisheries, manufactures, and commerce of the province of Holland. The agriculture of such a country, where the soil and climate are so very moist, cannot be expected to be considerable, or to present many instructive or interesting topics: in some respects, however, it deserves notice, particularly in what regards the pasturage of New Holland, and most especially of the drained lands.

In this province, few lands are held in fief, or by homage, and the women being very fruitful of children, and the men generally dividing their landed property among them, estates are for the most part small. The farms are also small: the farm houses are neat, sheltered and concealed by small clusters of trees, and included, together with their gardens and orchards, in a perfect green fence. The fields are separated from each other, and from the road, neither by hedges or walls, but by deep ditches filled with water, over which are laid small bridges, that may be opened in the middle by a sort of trap door, raised and locked to a post, to prevent the intrusion of strangers. The roads, in many places, are made on the dike of the canal, the fields being frequently between five and six feet below the level of the road; but the communication between most of the farm houses and the villages and towns, and also between the several parts of the same farm, is often entirely by means of small canals. The most magnificent public roads in Holland are those in the vicinity of the Hague. The road from this place to Scheveling is pointed out by the Dutch as an object of admiration to strangers: the length of this avenue, for it can hardly be called a road, is nearly two miles, and its breadth rather more than 20 paces: it is a perfectly straight line, so that the entrance of the road commands a view of the whole; and the church of Scheveling, a picturesque object, terminates the prospect. It is shaded on each side by beeches, limes, and oaks, of an astonishing growth, which are so closely and skilfully planted, that they form to appearance an impervious forest. From Delft to the Hague, the road is magnificently grand. It is of sufficient breadth to admit four or five carriages abreast, shaded on both sides by lofty rows of trees, kept in excellent repair, and so level, that not the least inequality of ground is to be perceived.

There is very little land under tillage in the province of Holland, as may be easily imagined from the nature of the soil and climate; and what is under tillage is almost exclusively confined to South Holland. The crops principally cultivated are wheat, madder, tobacco, hemp, flax, clover, &c. The country adjacent to Gravesande, not far from the mouth of the Maese, is reckoned to produce the best wheat, as well as the sweetest grass, in South Holland. Madder of most excellent quality, naturally as well as prepared, in a most superior manner, has long been a productive and famous crop in Holland. Tobacco is not so extensively or carefully cultivated as formerly. Hemp flourishes remarkably well, the depth and moisture of the soil being admirably adapted to the luxuriant growth of this plant. Oudewater, about seven miles to the south of Woerden, upon the lesser Yssel, in South Holland, is noted for good hemp produced on its soil. Flax is grown, not only for the purpose of manufactures, but also for its seed, though some of the other provinces in the Netherlands are more remarkable for this crop than Holland. The same remark applies to clover.

The pastures of Holland, especially as has been already remarked, of North Holland, are perhaps unrivalled for the abundance and luxuriance of the grass they produce. From it they obtain milk, cheese, and butter, all of excellent quality. Mrs. Radcliffe remarks, that on her way from Helvoetsluys to Rotterdam, she passed now and then a waggon filled with large brass jugs, bright as new gold; in these vessels, which have short narrow necks, covered with a wooden stopper, milk is brought from the field, throughout Holland. It is always carried to the towns in light waggons or carts, drawn frequently by horses as sleek and well-conditioned as those in our best coaches. The butter of Holland is of a very superior quality: the greater part of it is salted and barrelled for exportation; Beenister is noted for the excellence of this article. There are several kinds of cheese made in Holland, some of which are rich and highly esteemed, and some made from milk, which has previously supplied the butter, of course very inferior in quality. Leyden, Gouda, Edam, Gravesande, and Hoorn, are famous for their cheese: from the last place, vast quantities both of cheese and butter are exported to Spain, Portugal, and other countries, epecially during their annual fair in the month of May. The cheese made in Holland is of two sorts, red and white; the red is much esteemed, and somewhat resembles the Parmasan ; it is made into large and small shapes ; the former weighs from 18 to 20, and the latter from 6 to 8 libs : the white cheeses weigh from 6 to 7, and the richest kinds are excellent as toasting cheeses. Besides the common Dutch cheeses, there are some called *Kanterkaas* ; these are of various sorts, the principal of which are the green cheeses, the white of Leyden, the cummin cheese of Leyden, and the round cheese. In North Holland, about 18 millions of pounds of cheese were sold in the year 1801 : and at Gouda, in 1803, about two millions were sold. The cattle which produce such large quantities of excellent butter and cheese, are not indigenous, but for the most part are of the Holstein or Danish breed. In the vicinity of Hoorn they have a considerable trade in Danish cattle, which are imported lean, and fattened in the rich pastures round this place, and then driven to the other parts of Holland. The utmost attention is every where paid to the warmth and cleanliness of the milch cows, so that even in summer the animals appear in the meadows clothed with ludicrous care. The horses are principally from England or Flanders. The number of horned cattle in Holland, in the year 1804, amounted to 902,526, of which 252,394 were under two years of age. At that time it was generally believed that there had been a great decrease in the number of horses, sheep, and swine. The ancient race of sheep indigenous to the country, have long been improved by the introduction of foreign breeds ; but the soil and climate of Holland are not favourable to this animal : very little wool is exported, what is obtained from the sheep being chiefly consumed in the manufactures of the country. In some parts of Holland, bees are an object of much attention to the farmer, chiefly on account of the wax which they afford. A vast quantity of this article is annually gathered ; and the bleaching of it forms a considerable branch of industry among the poorer classes : a great deal of white wax was formerly exported to Spain. In connection with the agriculture of Holland, its horticulture must not be passed over : the mode of laying out the gardens is still very ungraceful and artificial ; the trees are bent and cut into a thousand fantastic shapes, and the flower-beds are of every form that can displease and disgust the eye of taste. There are generally abundance of stagnated canals, with puerile bridges thrown over them. But setting aside these points of inferiority, the people of Holland in several respects are excellent horticulturists, especially in what regards the culture and improvement of the most beautiful flowers. The rage for flowers, especially tulips, is not nearly so great or general at present as it was formerly. There is to be seen in the registers of Alcmaer, the record of a circumstance which deserves to be mentioned : In the year 1637, there were sold publicly in this city, one hundred and twenty tulips for 90,000 guilders : one of these flowers, called the Admiral of Enchuysen, with its root and offsets, was sold for 5200 guilders ; two others, called Brabanters, for 3800 guilders ; and one named the Viceroy sold for 4203 guilders. Not only the name and price of these flowers, but also their weight, are particularly set down in the registers of this city. The passion of paying exorbitant prices for flowers at length came to such a height in Holland, that the States were obliged to put a stop to it by severe penalties; many gentlemen having been ruined by that passion. The fruit of Holland, though abundant, is seldom of good quality : the humidity of the climate, as well as its rapid growth, from the richness of the soil, rendering it insipid.

The fisheries of Holland consist of those which are carried on near the coasts, and those which are carried on at a distance. The shores abound with excellent fish, particularly turbot and soals ; but for other fish, in consequence of the shallowness of the sea near the coast, the fishermen are generally obliged to go to the distance of more than five miles. The village of Scheveling is particularly remarkable for the number of fishermen whom it contains ; they are distinguished by their ruddy countenances and athletic limbs. The principal foreign fishery of Holland, formerly, was that of herrings : it was carried on from the ports of Dort, Rotterdam, Delft, Schiedam, Briel, Enchuysen, &c. The time of departure for the fishery was about the 24th of June. The cod fishery, which is still carried on to a considerable extent, commences in October and ends in April. It is carried on upon the Dogger Bank ; what is caught serves not only for the consumption of Holland, but forms one of its chief exports. The city of London consumes immense quantities of cod, caught by the Dutch. The whale-fishery was formerly vested in a company called the Northern Company; it afterwards became open and free ; but, like all the other branches of the fisheries and commerce of Holland, was destroyed by the revolutionary wars, and has not yet revived. It was chiefly carried on upon the coasts of Nova Zembla, as far as Davis Straits, and upon those of Spitzbergen, Greenland, &c. The vessels engaged in this fishery, during its flourishing state, were about 300 in number.

The chief manufactures of Holland are linens, (many of which, however, are made in Silesia) pottery and painted tiles, woollen cloth, leather, wax, snuff, sugar, starch, paper, &c. At Haerlem, there are considerable manufactories for the fabrication of fine linen cloths, dimity, satins, &c. which, though they have fallen off considerably, in consequence of the war and the measures of Bonaparte, still give employment to a number of workmen, and carry on a profitable trade with Brabant and Germany. The bleacheries of Haerlem have long been famous for the delicate whiteness which they give to linen cloths, large quantities of which are annually brought hither from all parts of the Netherlands and Germany to undergo this operation; and before the war between Holland and Britain, and the improvements made in the process of bleaching, by means of the oxymuriatic acid, much was sent from Ireland and Scotland. The principal inhabitants of Amsterdam, and other neighbouring places, also send their linen to be washed and bleached at Haerlem. The superior whiteness of the bleacheries of this town is attributed to some peculiar quality in the water of the lake of Haerlem. Some woollen cloth is manufactured at Delft, and other places, but Leyden is the principal seat of this branch of manufacture: here is a large building for examining and sealing the cloth. This manufacture is at present in a very decayed state; half a century ago, there were annually made upwards of 100,000 pieces : and many thousand industrious workmen were employed. The woollen manufactures, in all Holland, at the beginning of the 18th century, amounted to about 200,000 pieces of broad cloth, serges, baize, stuffs, &c. whereas in the year 1802, they did not exceed 20,000 pieces; and in 1804, the whole manufacture did not amount to 400,000 ells of cloth. The effects of this decay were strikingly evinced at Leyden, the population of which fell from 80,000 to 30,000. The manufactures of this city do not appear, even in their most flourishing condition, to have rivalled, in the fineness of their articles, the looms of England; but their coarse cloths found a ready sale on the continent, and the East and West India companies procured them ready markets in the other quarters of the globe. As the commerce of Holland declined, that of Britain increased; and the manufactures of Yorkshire deprived the manufactures of Leyden of the foreign markets to such an extent, that the Dutch merchants discovered it was for their interest to export English cloths in preference to the manufactures of their own country. The woollen trade of Leyden also received much injury on the continent, from the establishment of extensive looms in various parts of Germany and the Netherlands, which then ceased to draw any considerable supplies from Leyden. In the year 1808, the minister for the interior made a report to the king of Holland, on the state of the woollen manufactures, from which it appears that attempts were then making to improve the Dutch wool, by the introduction of Merino sheep, and to revive the woollen manufactures of Leyden. The manufacturers of this city are extolled for the durability, beauty, and excellent quality of their cloths and kerseymeres; and, from a passage in the report, it appears that Louis had conferred the golden prize of honour on the Leyden cloth. This report also gives some information respecting other branches of woollen manufacture in Holland. Bocking frize, formerly imported from England, seems to have been made at Amsterdam; the blankets of Leyden are mentioned as of excellent quality; and the silver prize of honour seems to have been conferred on the camlet hall of that city.

Delft was formerly famous for its manufacture of earthen ware, which rivalled the porcelain of China, and was generally sought after and esteemed throughout Europe, for its elegance and beauty. In the year 1800, there were scarcely 500 persons employed in the potteries of this place; whereas, in their most flourishing days, they gave subsistence to upwards of 10,000. The principal causes of this astonishing decay, independently of those which have produced a general decay of manufactures and commerce in Holland, are the immense quantities of porcelain, which, for a century and a half, have been imported into Europe from China; and the rival manufactures, which, during that time, have been established in Germany and England. The earthen ware of Staffordshire was some years ago so much approved of in Holland, that the states-general, in order to protect the manufactures of Delft from absolute ruin, were obliged to lay duties on its importation into the republic, which were so severe as to amount almost to an entire prohibition. Glass, especially glass toys, are made in several parts of Holland. The glass-house in Rotterdam was formerly deemed the best in the Seven Provinces. It made a number of glass toys and enamelled bowls, which were exported to India, and exchanged for china ware, and other oriental commodities. From the universal practice of smoking among the Dutch, it may naturally be supposed that manufactures of pipes are by no means uncommon. There is a noted manufacture of them at Gouda; they are remarkably neat, and a very extensive trade of them is carried on. They make also in the neighbourhood of this city a vast quantity of bricks and tiles, the latter principally what are called Dutch tiles. At Enchuysen, salt brought from Brittany is refined.

The breweries and distilleries in Holland are numerous and extensive. Delft, Gouda, and Muyden, are particularly celebrated for their beer. The beer made in Delft is chiefly consumed in that place and the adjacent country. In the 15th century, the town of Gouda had 350 breweries, from which Zealand and a great part of Flanders were furnished with beer. In 1518, they had decreased to 159; in the year 1522, there were 153; in 1588, there were 126; and in the year 1803, there were only two. These, however, make beer of excellent quality; imitating London porter with tolerable success. If, however, it is drank out of the cask, it is very inferior; but after it has been in bottles for some time, its taste is nearly as agreeable as London bottled porter, from which it is difficult to distinguish it. Muyden is noted for good beer, called Flemish physic. The distillation of ardent spirits is the sole manufacture which has increased in Holland. In 1775, there were at Scheidam, particularly noted for its Geneva, 120 distilleries; in the year 1792, 220; and in the whole province of Holland 400; each of these distilleries yielded annually 4492 ankers of gin. The whole distilleries of the seven provinces would produce annually 2,152,672 ankers; but the want of grain renders it necessary to reduce this quantity one-third, which leaves 1,400,000 ankers, of which 456,000 are consumed in the country, and the remainder exported.

There are a great number of sawing mills in Holland, particularly in the vicinity of Rotterdam. They are lofty and rather pleasing objects, the mill generally rising from the top of a substantial building two or three stories high. Some of them are painted in a whimsical taste, and others adorned with grotesque figures. During the flourishing state of Holland, Saardam, where Peter the Great acquired a practical knowledge of the art of ship-building, derived great wealth from that trade; but it is now almost annihilated.

The miscellaneous manufactures of Holland, not yet enumerated, most of which, however, are confined to Amsterdam, are stuffs embroidered with gold and silver, damasks, brocades, mohair, silk, &c. and particularly the preparation of drugs for dyeing, painting, and medicine, such as camphor, vermilion, sulphur, borax, lapis lazuli; likewise pitch, tar, rosin, spermaceti, &c. The oil mills are numerous. The cordage made in Holland is very good; and Dutch paper, particularly cartridge paper, is still exported in very great quantities, even to England, though we now rival or excel them in the manufacture of fine writing paper. The preparation of diamonds, that is, the cutting, polishing, and grinding of them, is confined to Amsterdam, where many artists are employed for that purpose. The manufacture of skates is also of some consequence in Holland.

The United Provinces were formerly pre-eminent in commerce; and the province of Holland, from its greater extent, population, and riches, as well as from its possessing near all the sea-ports, enjoyed nearly the whole of this commerce. Long before the French Revolution, however, the trade of the United Provinces had begun to decline; and the circumstances of that tremendous event may be said to have utterly annihilated the commerce of Holland. While it lasted, it was carried on principally with France, England, Spain, and Portugal, the Levant and Mediterranean states, Russia, Sweden, and Denmark; and with Germany, by means of the Elbe, the Ems, the Weser, the Rhine, and the Meuse. The inland trade with Germany, by the canals and the Rhine, is almost the only branch which has escaped the ravages of war. Of this, the most remarkable feature consists in the vast floats of timber which arrive at Dort from Andernach and other places on the Rhine. The length of these rafts is from 700 to 1000 feet; the breadth from 50 to 90; and 500 labourers direct them, living in a village of timber huts erected on the rafts for their reception. The navigation is conducted with the strictest regularity. On their arrival at Dort, the sale of one raft occupies several months, and frequently produces upwards of 30,000 pounds sterling. The commerce of Holland was either transit or direct. The articles of direct commerce were supplied either by her agriculture, such as butter, cheese, &c. or by her manufactures, as prepared drugs for medicine, dyeing, &c. linen, woollen cloth, paper, &c.; or they were supplied by her East India possessions and her fisheries. In return, Holland received either what was necessary for her own consumption, particularly corn, or those articles which she again distributed over the rest of Europe. In the year 1807, nearly one million pounds of silk were imported into England from Italy through the medium of Holland.

The province of Holland is extremely populous; perhaps more so than any other part of Europe. In the year 1515, it contained only 45,000 houses. In the year 1732, the number of houses was increased to 163,462. De Witt, in his work on the true interests of Holland, informs us, that, in the year 1622, the States laid a poll tax upon all inhabitants, none excepted but strangers, prisoners, and vagrants, and those that were on the other side of the line; yet were there found in all South Holland no more than 481,934, although the instructions of the commissioners appointed for that purpose were very strict. The following are the particulars, as registered in the Chamber of Accounts:

| | |
|---|---|
| Dort, with its villages | 40,523 |
| Haerlem, with its villages | 69,648 |
| Delft, with its villages | 41.744 |
| Leyden and Rhineland | 94 285 |
| Amsterdam, and its villages | 115,022 |
| Rotterdam, and its villages | 28.339 |
| Gouda, and its villages | 24,622 |
| Gornichem, and its villages | 7.585 |
| Schiedam, and its villages | 10,393 |
| Schoonhoven, and its villages | 10,703 |
| Brill, with its villages | 20,156 |
| The Hague | 17,430 |
| Heusden | 1,444 |
| | 481,934 |

De Witt supposes that West Friesland, or North Holland, might have the fourth part of the inhabitants of South Holland, or 120,483, which, added to 481,934, would give 602,417 as the total population of the province of Holland in the year 1622. This, however, in the opinion of De Witt, was far below the truth, and he raises the number to 2,400,000. This must be an exaggeration; and it is given here, only for the purpose of adding De Witt's calculation of the proportions of this number engaged in different employments: according to him, 450,000 were employed, directly or indirectly, in the fisheries: 200,000 were supported by agriculture, inland-fishing, herding, hay-making, turf-making, and by furnishing materials for these operations: 650,000 in manufactures: 250,000 in navigation and trade: 650,000 in miscellaneous employments; and 200,000 gentry, magistrates, soldiers, &c. In the year 1732, the population of Holland certainly did not exceed 980,000. In the year 1796, an estimate of the population of the Seven United Provinces was made by order of the National Assembly, which we shall give entire, for the purpose of comparing the population of Holland with that of the other provinces.

| | | |
|---|---|---|
| Guelderland, in the towns, | 64,994 | |
| in the flat country | 152,834 | |
| | | 217,828 |
| Holland, in towns | 495,017 | |
| in the flat country | 333,525 | |
| | | 828,542 |
| Zealand, in towns | 39,978 | |
| in the flat country | 42,234 | |
| | | 82.212 |
| Utrecht, in towns | 45,204 | |
| in the flat country | 47,600 | |
| | | 92.804 |
| Friesland, in towns | 44,824 | |
| in the flat country | 116,689 | |
| | | 161,513 |
| Overyssel, in towns | 41,805 | |
| in the flat country | 93,255 | |
| | | 135,060 |
| Groningen, in towns | 23,770 | |
| in the flat country | 90,785 | |
| | | 114,555 |
| The country of Drent, in towns | 5,789 | |
| in the flat country | 33.883 | |
| | | 39.672 |
| Dutch Brabant, in the towns | 48,711 | |
| in the flat country | 159.466 | |
| | | 2[illegible]8,177 |

The total is 810,192 in towns, and 1,070,271 in the flat countries, making the entire population of the United Provinces, in the year 1796, to be 1,880,463. The population of the province of Holland, as stated above, in the year 1732, was 980,000, and in the year 1796 it was 828,542, which shews a decrease of 151,458 inhabitants, equal to one-thirteenth of the whole population.

The people of Holland may be divided into the following classes:—the clowns, or boors, who cultivate the land; the mariners, or skippers, who navigate the ships and inland boats; the merchants and traders, who fill the towns; the *renteeners*, or men that also live in towns, upon the rents of their estates; and the gentlemen, officers of the army and navy, magistrates, &c. The boors feed chiefly on herbs, roots, and milk. The other classes drink enormous quantities of tea and coffee, or, more properly speaking, of lukewarm water scarcely coloured. A great quantity of spirituous liquors are also drank; 456,000 ankers of geneva being annually consumed in the province of Holland. The class of gentlemen, or nobles, is very limited; most of the families having been extinguished in the long wars with Spain.

Of the characteristic manners and customs of the people of Holland we can only mention a few. To every house throughout North Holland there are two doors; one of which is never opened but when a corpse or a christening is carried from the house, while the other serves for the ordinary purposes of the family: this custom is peculiar to North Holland. The houses in almost every part of the province have a gay appearance, the windows and doors in general being painted green. The most scrupulous cleanliness is practised respecting them; not only the windows, but the whole front of the houses, in most of the towns, is generally washed two or three times a-week, by engines for that purpose, which are abundantly supplied with water from the canals; and the same care is extended to the pavement of the streets in which the more opulent inhabitants reside. A Dutch house, in the old style of building, such as they are seen in Leyden more particularly, is generally six stories high, the three first of which are of an equal breadth, but of unequal heights; from the third story the roof rises to a point, and the rooms in this part of the house necessarily diminish in size as they approach to the top of the building. The front wall of the upper apartments projects so much from the roof as nearly to hide it, unless viewed in profile; and the exterior of each room diminishes, till that of the attic story is two-thirds less than the basement. To the aperture of the uppermost room is commonly fixed a small crane, for the convenience of hoisting up wood and turf, and these cranes sometimes have grotesque figures carved upon them. In the large and commercial towns, it frequently happens, that apartments that would grace the mansion of a prince have no other views from their windows than the dead walls of a warehouse, used as a magazine for stock-fish, skins, tobacco, &c. so that the eye may turn from the works of Rubens and Titian to these disagreeable and disgusting objects.

The custom of smoking is so prevalent in Holland, that a genuine Dutch boor, instead of describing the distances of places by miles or hours, says, they are so many pipes asunder. Thus a man may reach Delft from Rotterdam in four pipes; but, if he goes on to the Hague, he will smoke seven during the journey. Adjoining to their theatres is a room where refreshments are to be sold, and here the lovers of tobacco resort, to smoke their pipes between the acts. Their rigid attention to cleanliness, and bigoted attachment to smoking, jointly give rise to a most inconvenient and disgusting custom. After dinner, there is placed on the table, along with the wine and glasses, a spitting-pot, which is handed round as regularly as the bottle. All Dutchmen of the lower classes of society, and not a few in the higher walks of life, carry in their pocket the whole apparatus that is necessary for smoking: a box of enormous size, which frequently contains half a pound of tobacco; a pipe of clay, or ivory, according to the fancy or wealth of the possessor; if the latter, he carries also instruments to clean it; a pricker to remove obstructions from the tube of the pipe; a cover of brass wire for the bowl, to prevent the ashes, or sparks, of the tobacco from flying out; and sometimes a tinder-box, or bottle of phosphorus, to procure fire in case none is at hand.

When a woman is brought to bed, a bulletin is daily fixed to her house, for the space of a fortnight, or longer if she recovers slowly, which contains a statement of the health of the mother and child. This bulletin is fastened to a board, ornamented with lace, according to the circumstances of the person lying in; and serves to answer the inquiries of friends, and to prevent unnecessary noise near the house. When a person of consequence is dangerously ill, a bulletin of health is generally affixed to their house; but, unless it is a child-bed case, the board is not ornamented with lace.

The women in Holland, in general, are lovely rather than beautiful; in their persons they are well formed; their complexions are fair, and their features regular, but their countenances are inanimate. Women are shorter-lived in Holland than men; and after twenty-five generally lose all their beauty. The management of children is very absurd and injudicious. The air of the country is regarded as so prejudicial to them, that for the first two or three months they are never taken abroad; and, during this period, the windows of their apartments are kept invariably shut. Their dress consists in flannel rollers, girt very tightly about their bodies, and these rollers are farther covered with a large flannel wrapper, bound three or four times round the body of the infant, and fastened with pins at its feet. The use of water is rigorously denied them. Thus managed, they are sickly, squalid objects. Children, particularly females, are frequently indulged in the pernicious use of *chauffepieds*, or stoves, without which a Dutchwoman could not exist, and this adds to their unwholesome appearance. We may remark, by the bye, that the advances of Britain in civilization and useful knowledge are perhaps in no instance more decidedly conspicuous, than in the improved management of children. Many of our readers must remember the period, when British children were almost universally clothed and treated as Dutch children still are.

The female dress, such as it was generally worn in Holland nearly two centuries since, is not unfrequently still seen on the daughters of the ancient stock of burghers. The hair is bound close to the head, and covered with a small unornamented cap, with large plates of thin gold projecting from each side of the forehead, and a plate in the middle; ponderous ear-rings, and necklaces of the same metal; gowns of thick silk, heavily embroidered, and waists of unnatural length and rotundity; hats of the size of a small Chinese umbrella, gaudily lined within; sometimes these hats are set up in the air like a spread fan; yellow slippers, without quarters at the heel. Children, and women of seventy, are frequently seen in this preposterous dress. The women of rank or fortune are very fond of ornamenting their dress with rare and valuable jewels. These, as well as the gold plates worn by the lower orders, are of great antiquity, and are most carefully handed down from generation to generation.

The Dutch language is evidently of Gothic origin, but it is little known out of the United Provinces. Dutch literature will be more properly considered in the article NETHERLANDS; where, indeed, every thing relating generally to the history and statistics of the Low Countries must be sought for; as, in the present article, we confine ourselves, as much as possible, to the province of Holland. With respect to the encouragement given to literature, this province was formerly very remarkable. Leyden, Amsterdam, and the Hague, may be seen on the title-pages of the most valuable works, in Latin and French, which were printed during the 17th, and the beginning of the 18th centuries. The Elzivers, justly celebrated for the correct and beautiful editions which they have given to the world of the best writers of antiquity, resided in Leyden, and ennobled its press by the elegant specimens of typography, which, for the space of a century, appeared from their press. During the bright period of French literature, when the writings of Voltaire, Rousseau, D'Alembert, &c. were eagerly sought after by the learned and curious of Europe, the booksellers at the Hague and Amsterdam multiplied the editions of these authors, and carried on a lucrative trade with their works. Haerlem is one of the places which lays claim to the honour of the invention of the art of printing; but at present the literary character, as well as the bookselling and printing trade of Holland, are at a very low ebb. There is one university in the province of Holland at Leyden, and an inferior college at Amsterdam.

Though the province of Holland is now only a part of the kingdom of the Netherlands, and of course has lost many of its peculiar privileges and institutions, yet some particulars respecting its government require to be noticed, as they still remain under the constitution of the Netherlands. Deputies of the nobles, and those of the towns and country, are elected for the parliament of the kingdom. There are also provincinal councils of state for South and North Holland. For the administration of justice, there are two courts held at the Hague; namely, the court of Holland, and the high council. The nobles of Holland are subject to the jurisdiction of this court; an appeal lies to it from the sentences of the inferior courts. The high council of Holland judge peremptorily and definitively of all cases brought before them by an appeal from the court of Holland. Among the laws of this province the following deserve notice. No person can be arrested for debt, who has not been summoned regularly three times, with the interval of 14 days between each summons; and six weeks further must elapse from the last official notification and demand of the debt, before the creditor is permitted to arrest or seize the effects of the insolvent person. By this mode of procedure, debtors are generally enabled either fully to settle their affairs, or to compromise with their creditors, so that few are sent to prison. No person can be arrested in his own house in Holland, or even standing at the door of it, though all the previous citations should have been made; and should his wife be lying in, he is privileged, during her illness, to go abroad without molestation.

The religion of Holland is Calvinism. In it there are two provincial synods; one for South Holland, and the other for North Holland. The whole province being divided into a great many classes, composed of the deputies of five or six neighbouring churches; each class sends four deputies to the respective synods, two ministers, and two elders. The synods meet twice a year, and a political commissary attends their meetings. The ministers are paid by the magistrates. Their salaries are small; few, even in the cities, having 200*l.* a-year, while in the country they have generally 60*l.* or 70*l.*

The taxes of the province of Holland are very heavy. They amounted in 1795 to 24,000,000 of guilders, or 2,000,000 sterling, which, on the supposition that the population was 800,000, formed an average of 2*l.* 10*s.* each person; but a large portion of this taxation is, in fact, paid by foreigners, who consume the articles taxed. Among the taxes really paid by the inhabitants themselves are the following: A land-tax of about 4s. 9d. per acre; a sale-tax of 8 per cent. upon horses; 1¼ per cent. upon other moveables; and 2½ per cent. upon land and buildings; a tax upon inheritances out of the direct line, varying from 2½ to 11 per cent.; 2 per cent. upon every man's income; an excise of 3*l.* per hogshead on wine, and a charge of 2 per cent. on all public offices. The excise upon coffee, tea, and salt, is paid annually by each family, according to their number.

The province of Holland, as well as all the countries watered by the Meuse and the Rhine, were for a long time divided into small earldoms; but in the year 923, Theodoric was appointed Count of Holland by Charles the Simple, King of France, and the title became hereditary. The most frequent wars of the counts of Holland were with the Frisons, a part of the old Saxons. There were also frequent contests between the counts of Holland and Flanders, concerning the possession of the islands of Zealand. The counts of Holland, likewise, were frequently opposed by their own nobility. In order to break their power, they not only demolished many of their castles and strong holds, but also, about the year 1200, built several cities, and gave freedom to the inhabitants of the adjacent country; or even to foreigners, who would come and dwell in those cities. They were thus freed, not only from all taxes due to the counts themselves, but also, when they had dwelt in the cities a year and a day, from the vassalage they were under to their own lords. The counts, besides, gave especial privileges to those cities; but the inhabitants were not permitted, though at their own charge, to set up gates or walls to defend their cities, unless they purchased the privilege from the counts. Hence proceeded the difference between walled and unwalled cities in Holland; and also, that the counts being afterwards jealous of the former, destroyed many of them entirely, and pulled down the walls of others. Philippina, daughter of William III. Earl of Holland, was married to the Prince of Wales, afterwards Edward III. of England. This king afterwards contested the earldom of Holland with Margaret, his sister-in-law. In the year 1417, Jacquelin, heiress of Holland, married John IV. Duke of Brabant; but her uncle John of Bavaria, who had resigned the bishopric of Liege, in the hopes of espousing her, contested the succession. A kind of anarchy followed. Jacquelin went to England, where, in 1423, she married Humphrey, Duke of Gloucester; but this marriage having been annulled by the Pope, she married, in 1432, Borselen, stadtholder of Holland. But having no children by any of her husbands, Philip the Good, Duke of Burgundy, who was her first cousin, obliged her to give up the administration and government of her states, and at her death inherited them. Soon afterwards, Holland, with the other large possessions of the House of Burgundy, fell by marriage to the House of Austria. Its history, from this period, must be sought for under the article NETHERLANDS. See *Statistical Account of Holland*, by R. Meterlecamp, 1804; De Witt's *True Interest of Holland;* Sir William Temple's *Observations on the Netherlands;* Mrs Radcliffe's *Journey through Holland in* 1794; *A Tour through the Batavian Republic in* 1800, by R. Fell. (W. S.)

HOLLAND, NEW, an island in the South Pacific Ocean, which some geographers have called a continent, from its immense extent. Its general outline somewhat approaches to that of a spherical triangle. It stretches from east to west above 2600 miles, between Sandy Cape and the entrance of Sharks Bay; and its length surpasses 2000 miles, from Cape York on the north, to Wilson's Promontory in 39° 10′ south latitude. New Holland was originally called the Great Southern Land; its present name was imposed by the Dutch, who navigated the coasts at an early period; but it has lately been proposed to alter its appellation to Notasia by Mr Pinkerton, and to Terra Australis by Captain Flinders, neither of which will probably be adopted. Nothing whatever being known of the interior, and very little with certainty of the skirts of the island, it is only divided into portions, called by the names of their supposed discoverers, and the vessels which they commanded; as, Arnheim's, Van Diemen's, De Witt's, Endracht's or Corcord's, Edel's, and Leuuin's land, on the north and west, and Nuytz's land on the south. The east coast was surveyed generally by Captain Cook, and called New South Wales; and the portion from Cape Howe, the south-east extremity, to Nuytz's Archipelago, where the recognition of that navigator is supposed to have terminated, occupying between 700 and 800 miles, was examined by D'Entrecasteaux, Captain Flinders, and M. Baudin, and also some other officers.

New Holland is begirt with small and sterile islands. A large portion of the coast is inaccessible, either from rocks or shoals, or the precipitous formation of the shores; but the greater part is low and sandy, exhibiting a barren aspect. A few lofty headlands project into the sea; bays and harbours are rarely to be seen, and navigable rivers are scarcely yet discovered. The northern coast is indented by the immense gulf of Carpentaria, stretching 400 miles in width at the entrance, and penetrating 500 miles into the land; which, although it is rudely laid down in the Dutch charts of the 17th century, was first completely explored by Captain Flinders in 1802. Sharks Bay, where Dampier anchored in 1699, was lately ascertained by the French to be 50 leagues deep. And besides these, there are several less capacious on the south coast, as King George's Sound, Port Philip, and Western-port, at the second of which a British settlement was attempted in 1804. On the east coast, Botany Bay is the most important, from the flourishing establishment connected with it; and two other inlets of a different description on the south coast merit notice, from being supposed the entrance to some great river dividing New Holland asunder. One of these, called Bonaparte's Gulf by the French, and Spencer's Gulf by the English, 48 miles wide at the mouth, penetrates the land 185 miles, terminating in a point exactly opposite to the bottom of the Gulf of Carpentaria. The other, separated from it by York's Peninsula, of which the extreme point lies in 136° 52′ East Longitude, is of smaller dimensions. The tide flows 40 miles up Hawkesbury river, falling into Broken Bay near Port Jackson, whither it is navigable by the largest vessels, and still farther by those drawing nine feet water. It is the most important river hitherto seen in New Holland; and, from the floodings above, sometimes overflows those parts of the banks 40 or 60 feet above its ordinary level, thereby committing great devastation. King William's River, on the west coast, is now conjectured to be little more than a creek, whose narrow entrance is obstructed by rocks.

Nothing can be more repulsive than the bleak and dreary appearance of thousands of miles occupied by the shores of New Holland. The earth is parched, vegetation stunted, and animal life seems incapable of being supported, from the universal scarcity of subsistence. Its low, uniform, and sterile aspect is such, that many conceive the whole has only been recently reclaimed from the sea. Nor is it so with the continental part of New Holland alone; for, amidst the numerous islands on the south, "nothing smiles to the imagination; the soil is naked; the heavens burning pure and cloudless; the waves agitated but by nocturnal gales. Man seems to have fled these ungrateful regions; and the navigator, terrified by dangers incessantly renewed, turns aside his weary eyes from the miserable shores." Yet, admitting that the exterior is of later origin, we must reflect on the vast extent of the interior yet unknown, where lofty mountains, wide rivers, and thick forests, may all be frequent. A greater portion is unexplored than equal to the course of the longest river in the world; and possibly its streams may be received in lakes, discharged by subterraneous channels, or absorbed in sandy deserts. We are aware, indeed, that, in the warmer climates, islands, which are the work of an inconsiderable insect, arise in the seas; that they become a resting place for birds; decomposition and fertilization follow; the seeds of plants are conveyed thither, and the deciduous parts of vegetables are not slow in forming a new soil. Neither is it improbable that volcanic eruptions may form a nucleus or substratum for future accessions. Still these accessions are so gradual, that many ages would be required for the formation of so great a country as New Holland. Besides, the appearance of the coast cannot be rigorously applied to the interior; and those minerals supposed to enter the constitution of primitive mountains are discovered here.

We are not enabled to give any specific account of the mineralogy of this country. Wilson's Promontory consists of granite; there are several small islands, some of which are granitic, and some volcanic; and coal is discovered near the surface. Coloured precious stones are also said to have been found in different parts, but we do not know whether their precise quality has been ascertained.

In so far as the country is yet explored, the vegetable creation is diffused more rarely than under corresponding latitudes, and fewer products are convertible to the use of mankind. It is disclosed only in scanty patches, where the soil has undergone amelioration; and there it appears in all possible variety, from the coarsest grass creeping on the ground, to forests consisting of trees of immense girth and altitude. It is said of the eastern parts, that "all the plants of this country are evergreens, and numbers of them are to be seen covered with blossoms at all seasons of the year." M. Leschenault remarks, "that in the districts hitherto visited, and especially the western coast, there have never been found, in great masses, either the majesty of the virgin forests of the New World, the variety and elegance of those of Asia, or the delicacy and freshness of the woods in the temperate countries of Europe. Vegetation is in general dark and sombre; it resembles the shade of our evergreens or copses. Fruits are for the most part ligneous; the leaves of almost all the plants are linear, lanceolated, small, coriaceous, and spiny. This peculiar texture springs from the aridity of soil and climate; and it is doubtless owing to the same causes that cryptogamous plants are so rare." Most of the plants of New Holland constitute new genera; and those belonging to genera already established are almost as many new species. Their numbers and variety are amply described in the works of M. Labillardiere and Mr Robert Brown, to which we shall refer for illustrations. A plant approaching the qualities of coffee has been found, two species of tobacco, and a kind of indigo. Odoriferous gum exudes copiously from a tree abundantly disseminated, which is used for different purposes by the natives, and has gained some credit among the settlers for curing dysentery. Wood of beautiful colours, fit for the finest cabinet work and inlaying, is common; and other kinds have been employed in building vessels. But amidst the great diversity of plants, only some small berries, a few roots, and leaves, have yet been found, which are suitable food. The climate of New Holland is particularly noxious to European fruits, as most of those introduced have speedily perished. Grain, however, succeeds admirably, producing a certain and luxuriant harvest; though the soil for the most part is soon exhausted, and some of what was once brought under culture is now completely abandoned.

A field equally new is presented in the animal world, where an infinity of beings are beheld on this continent, its shores, and islands, that never were seen before. Mollusca are so numerous, that, on one of the latter, the French voyagers collected 180 species. Great shoals of whales and dolphins fill the seas, but in many parts they are rare. The phocæ are so multiplied, that profitable fisheries have been instituted for their skins and oil, though it is so indiscriminately followed, in destroying the young, as to threaten the extirpation of the genera. Among birds, the black swan, cassowary or emu, mountain eagle, and menura, are the most remarkable. The first, which is black as jet, except two or three white feathers of the wings, covers the lakes and rivers in flocks during the greater part of the year. The emu is seen both on the continent and the islands; and there is sometimes found an enormous nest, two or three feet in diameter, belonging to an unknown bird, perhaps of the flamingo kind. Quadrupeds are exceedingly rare, both in species and numbers, compared with the extent of the country. Besides the dog, which is akin to the shepherd's dog of Europe, and never barks, it is supposed that another carnivorous animal of somewhat larger size approaches the coast, which has not been seen. The members of the last French expedition having prepared to pass a night on Edel's land, inform us, that "suddenly a terrible roaring froze us with terror; it resembled the bellowing of an ox, but was much louder, and seemed to come from the neighbouring reeds." Most probably this was an alligator, both from the sound and situation. The greater proportion of the quadrupeds of New Holland, though absolutely new and unknown in other parts of the world, belong to the opossum tribes. Those attracting most attention are the kangaroo of various species; the wombat, and a singularly formed creature, the paradox or duck-billed ant-eater. The first is hunted for the sake of its flesh; the second has been domesticated by the settlers; the third, an amphibious animal, is now found more abundant in the late excursions which have advanced furthest into the interior. Perhaps we should add to the brute creation those introduced into New Holland since the year 1788. Three cows and a bull having strayed into the forests, propagated there, and many thousands of wild cattle are seen in great herds, which it is dangerous to approach. Sheep and swine have succeeded well, but the country proves unfavourable to goats. So little of New Holland has yet been explored, as to admit a strong presumption of many interesting accessions to zoology, in addition to what it has already received.

The most striking peculiarities are beheld in that portion of the human race who inhabit these regions. In stature, the New Hollander is of the middle size; with a large misshapen head, slender extremities, and the belly projecting as if tumefied. The colour of the skin is reddish at birth, and then deepens almost to African blackness; but this is not uniformly so, and some are only of the copper or Malay cast: the hair is long and black, not woolly; the nose flat, nostrils wide, and the mouth immoderately large, with thick lips. These, added to bushy eyebrows, and other characteristics, give the natives a remarkable appearance: Dampier, who says "they are of a very unpleasing aspect, having no one graceful feature in their faces," seems inclined to doubt whether they should be ranked with the human race; and Mr Collins instances "one man, who, but for the gift of speech, might very well have passed for an oran-outang: he was remarkably hairy; his arms appeared of an uncommon length: in his gait he was not perfectly upright, and in his whole manner seemed to have more of the brute and less of the human species about him than any of his countrymen." Yet the physiognomy of the New Hollanders is not disagreeable; nay, it is said, that the delicacy which is to be found among white people may be traced on the sable cheeks of their females. Sustenance being so scanty, and clothing never employed, a decided effect is seen in the want of physical strength, and the consequences of perpetual exposure. In their persons all are filthy; the regular ablutions of many eastern nations are not performed, and the disgust of strangers is heightened by the custom of both sexes rubbing fish oil into their skins, as a protection against the legions of insects swarming around them. Tattooing, so general in the South Seas, is not practised by the New Hollanders; but they have a mode of raising tubercles on the skin, and both sexes ornament themselves with scars on the breast, back, and arms. The incisions, sometimes resembling the feet of animals, being made by the sharp edge of a shell, and kept open, the skin forms a large seam in healing, which is very distinguishable in youth, but is almost totally effaced by age. Men have the septum of the nose perforated to receive a bone, and are subjected to the extraction of some of the front teeth when they attain the age of puberty; and the women are deprived of the first two joints of the little finger of the left hand. Their personal ornaments are not numerous, consisting of the teeth of beasts or mankind glued to their hair, feathers, and the tail of the dog: and certain tribes divide their hair into parcels, matted together with gum into portions like the thrums of a mop. The men also ornament themselves, previous to a dance or combat, with broad stripes of white paint, used entirely according to taste, without any definite fashion. "Some," Mr Collins observes, "when decorated in their best manner, looked perfectly horrible; nothing could appear more terrible than a black and dismal face, with a large white circle drawn round each eye."

All are absolutely naked: Some of both sexes wear the skin of the kangaroo around their shoulders as a defence against the weather, but for no other purpose. A few of the men also go with a girdle about the loins, but the natural state of the whole is absolute nudity, and along with it, neither male nor female entertains any sense of shame. Nevertheless, violations of chastity seem infinitely more uncommon than where a full proportion of clothing is used. Their habitations are of the most miserable description, the best being only very long pieces of bark bent in such a manner, and the ends stuck into the ground, as to resemble the roof of a barn. Many have no other shelter than rocks, or trees, or even holes in the earth. The subsistence of those hitherto seen on the shores, is chiefly fish: they also feed on a kind of larva, or worm, lurking under the bark of trees, which is extremely disgusting to the view, but reputed a great delicacy; and they endeavour to ensnare wild animals. Captain Flinders found a race at King George's Sound, who seemed to live more by hunting than fishing; and there are inhabitants of the woods north-west of Botany-Bay, who make a paste of the fern root and ants bruised together.

The arts are here in the lowest stage: clothing and dwellings being unknown, all the ingenuity of these savages is concentrated in the means of obtaining subsistence and personal defence against their enemies. They construct canoes consisting of pieces of bark glued, or sewed together; and those seen at the bottom of the Gulf of Carpentaria, the largest of all, are thirteen feet and a half long, by two and a half broad. But many of the tribes seem quite unacquainted with them. Some tribes have also scoop nets and common nets for fishing: one of the latter, no less than 80 feet long and three broad, consisting of larger meshes and stronger twine than any English twine, was discovered at Glass-house bay on the east coast. Their arms are wooden lances, wooden swords, and wooden shields. One of their fishing implements is a four-pointed lance.

In regard to social order among these people, there is none: all we can affirm is, that they are divided into families, the oldest member of which claims a superiority over those immediately dependent upon him. There is no acknowledgment of chiefs; nor are any laws, except those of personal strength, recognised. It is by this means that even their marriages are accomplished. Instead of the courtship, suit, and persuasion, employed in other countries, the object of desire, generally of another tribe, is felled to the earth with a club, in some remote situation, and dragged in a state of insensibility to the dwelling, if such it may be called, of the husband. She becomes his wife, and frequently remains attached to him ever after. Sometimes, however, a more favoured lover is found, for whom the husband is deserted; and many of the men do not confine themselves to a single wife. Their offspring is named after some visible object, a quadruped, a bird, or a fish; and females are in the earliest infancy subjected to that mutilation of the little finger above referred to. Women are held in great subservience. They are the victims of all the barbarity which the superior power of savages can inflict, as is too incontestibly proved by the innumerable scars by which their bodies are covered. The New Hollanders either burn or bury their dead; and in general if a mother dies, while suckling her infant, it is buried alive in the same grave. They are utter strangers to religion: they have no images, nor can they be said to entertain any idea of a future state.

These people, however, are acquainted with some remarkable customs, of which the first and most conspicuous is, depriving youths at the age of puberty of an upper front tooth. Many ceremonies precede the operation, which are conceived to bestow the more valuable property of certain brutes upon them, and the operation entitles them to the privileges of men, with whom they are now enrolled. They equip themselves with long tails, in imitation of kangaroos; crawl on their hands and feet, and scrape up the earth like dogs; and remain motionless the whole night before the operation. After some preparation by the incision of the gum, the tooth is struck out by main force, but with considerable dexterity. The object of this custom is altogether uncertain; it has been supposed a tribute which one tribe could exact of another; but there is not sufficient evidence that this is the case. The custom is, however, widely, though not universally, diffused. Dampier affirms of those on the north-west coast, that "the two fore teeth of their upper jaw are wanting in all of them, men and women, old and young." Captain Flinders saw individuals at the south-west extremity, who had preserved all their teeth. However, around the settlements at Port Jackson, there are no exceptions. Here it is the right front tooth which is extracted. On the north coast, it is the left; and in the Gulf of Carpentaria, the men seen by Captain Flinders had lost both. We do not know whether the loss of members be deemed tributary among any nation where it is practised; but it has been lately asserted, that, on the death of the chief of the island of Owhyhee, each of his people must extract a tooth. The cause of mutilating the little finger of the women, according to the natives, is to avoid an embarrassment which would ensue to the fishing lines.

Another very extraordinary custom is the exact measure of retaliation observed for injuries. They have no laws; but blood must always be followed by blood. If children when at play receive a push, they return it by one of equal force; if a man is wounded, the aggressor is compelled to expose himself to the throwing of the sufferer's spear, or that of his friend; and if a man of one tribe should be unmercifully beaten by those of another, some individual of the latter must undergo a similar punishment. Yet there are many treacherous and midnight murders, and as savages sleep extremely sound, this is the moment selected for vengeance. It rather appears also, that the death of every individual, natural, accidental, or intentional, must be followed by shedding some person's blood. The disposition of the New Hollanders, as described by one who should know them well, is revengeful, jealous, courageous, and cunning. "The inhabitant of Port Jackson is seldom seen, even in the populous town of Sidney, without his spear, his throwing stick, or his club. His spear is his defence against enemies; it is the weapon he uses to punish aggression, and revenge insult. It is even the instrument with which he corrects his wife in the last extreme; for, in their passion, or perhaps oftener in a fit of jealousy, they scruple not to inflict death. It is the play-thing of children, and in the hands of persons of all ages. It is easy to perceive what effects this must have upon their minds. They become familiarized to wounds, blood, and death, and are repeatedly involved in skirmishes and dangers. The native fears not death in his own person, and is consequently careless of inflicting it on others." Nevertheless, it does not appear that the savages of New Holland are animated by the same treacherous ferocity as many of the neighbouring islanders. They are not cannibals: Strangers on the east coast, though surprised when asleep, have escaped with impunity. On the north coast they are more ferocious; but the sanguinary disposition of their European visitors may have sometimes excited the desire of revenge.

The New Hollanders consist of tribes inhabiting different districts; but, contrary to what is known among all savages still less barbarous, the right of individuals to territorial possessions, which are transmitted by inheritance, is apparently recognized.

The whole of this vast country seems inhabited only by a single race of people, intimately resembling each other in person, appearance, and manners, and who have not undergone the slightest change since Dampier's visit in the year 1688. In every different part that Europeans have landed, however, a different dialect is spoken; and these general conclusions are deduced from a number of instances comparatively small. Few natives consent to hold intercourse with strangers. Captain Flinders circumnavigated the whole coast of New Holland without having beheld a single woman from the time of leaving Port Jackson until his return. It has been conjectured, on very slight probabilities, that New Holland has been peopled from Papua. The natives of Botany Bay call themselves *Gal*, distinguishing their tribe or family by prefixing the name of the place which they inhabit. There is a tribe in Abyssinia designated Galla; the Highlanders of Scotland are denominated Gaël; therefore, without investigating the source of affinities in name among people so remote from one another, we shall simply suggest, that Gal, Gaël, or Galla, may signify nothing more than *people*. The present race presents a mortifying picture of mankind sunk in the lowest state of degradation, and, were we to judge hastily, we should say, they are incapable of civilization. The South Sea islanders have made wonderful progress in the arts and civilization, from the transient visits of Europeans. The natives of New Holland, who have witnessed the cultivation of the earth, the erection of houses, and the fabrication of apparel, for nearly thirty years uninterruptedly, still go naked, seek a precarious subsistence, and shelter themselves under rocks, or in caves, from the storm. Exceptions may be found, but they are only of a few individuals; nor is any change ever to be expected, but in selecting others in the earliest childhood; for so deeply rooted is their attachment to savage life, that a native carried to England, and supplied with every comfort, soon after his return stripped himself naked, and sought for greater enjoyments among his barbarous countrymen. See Australasia, Botany Bay, and Diemen's Island. (*c*)

HOLSTEIN. See Denmark.

HOLYHEAD, is a sea-port and market-town of North Wales. It is situated on a small island, on the north-west side of the island of Anglesey, and denominated in British *Caer Cybi*, or the fortified place of Cybi. The town consists of one principal street, with detached buildings. The collegiate, now the parochial church, is a handsome embattled cruciform structure, consisting of a chancel, nave, aisles, and transept, with a square tower, which supports a low flat spire. It appears to have been built about the time of Edward III. An assembly-room and baths, and a large new inn and hotel, have lately been opened. There is also here a free-school, established in 1757. This place seems to have been once in the possession of the Romans. On the summit of the mountain called Pen Caer Cybi, stands a circular building, (called *Caer twr*,) 60 feet in diameter, supposed by Pennant to have been a watch-tower. A long dry wall, 10 feet high, in many places faced and quite entire, runs along the side of the mountain. The precincts of the church-yard seem also to be ancient. Three of the sides of the parallelogram consist of massy walls, 17 feet high and 6 feet thick; the fourth is open to the harbour. At each angle is a circular bastion tower, and round the walls are two rows of round openings or oeillets, four inches in diameter, having the inside smoothly plastered.

As the island on which the town stands is the point of land nearest to Dublin, regular packets are stationed here for the accommodation of travellers passing between England and Ireland. The distance between Holyhead and Dublin is 20 leagues, a voyage which is generally performed in 12 hours, though sometimes in six. In stormy weather the packets have sometimes been two or three days at sea. Six packets are in the constant employment of the Post-office. One goes out every day except Thursday, and returns next morning. These packets are well constructed and well manned, so that serious accidents very seldom happen.

The harbour of Holyhead is formed by the cliffs under the church-yard, and a small island called Inys Cybi, on which there is a light. This harbour has been lately much improved. A pier has been built on the eastern side of it, to enable vessels to ride at anchor in four fathoms of water. In connection with this improvement, a new road has been made quite across the country from Cadnant island, near Bangor ferry, to the harbour, which saves seven miles. A new light-house has also been erected on a small island, or rather projecting rock, to the west of the head called the South Stack. The light, which is a revolving one, is about 200 feet above the level of the sea. In order to see the light-house, persons are wafted over by ropes in a kind of basket. The promontory, called the Head, is a huge mass of rocks excavated by the sea into the most magnificent caves, one of which, called the Parliament-house, is peculiarly fine. It is accessible only by boats at half ebb tide, and exhibits grand receding arches of different shapes, supported by magnificent pillars of rock. The promontory consists of lofty cliffs excavated into large caverns, which afford shelter to swarms of birds, such as pigeons, gulls, razor-bills, ravens, guillemots, cormorants, and herons. The peregrine falcon is found on the loftiest crags. As the eggs of many of the above-mentioned birds are considered as delicious food, and are therefore in high request, many of the people of the country earn their subsistence in the dangerous occupation of collecting the eggs. In order to accomplish their purpose, a strong stake is driven into the ground at a little distance from the edge of the cliff, and a rope is tied to it of sufficient length to reach the lowest nests. The adventurer ties the rope about his middle, and, with the coil on his arm, he seizes it with both hands, and gradually descends the cliff, placing his feet against its sides, and shifting his hands with great caution. When he reaches the nest, he holds by the right hand, and with his left seizes the eggs, and places them in a basket slung over his back.

The island on which Holyhead stands is called Holy Island, and received this name from the number of pious persons who were buried upon it. It consists chiefly of bare rocks and sterile sands. In the southern part of it, near *Four Mile Bridge*, is a quarry of serpentine or marble, containing a green amianthus.

The channel, which divides this island from the rest of Anglesea, is narrow, and may be forded at some places at low water. The great Irish road passes over a bridge called Rhyd y Pont.

The following is the population of the town in 1811 :

| | |
|---|---|
| No. of inhabited houses, . . . . . . | 539 |
| No. of families, . . . . . . . . . . | 701 |
| Do. employed in trade and manufactures, | 496 |
| Males, . . . . . . . . . . . . . . | 1317 |
| Females, . . . . . . . . . . . . . | 1688 |
| Total population, . . . . . . . . . | 3005 |

See Pennant's *Tour*; and *The Beauties of England and Wales*, vol. xvii. p. 245—253.

HOLY ISLAND, is an island situated about two miles from the coast of Northumberland, but belonging, in all civil matters, to the county of Durham : (See DURHAM, vol. viii. p. 201. col. 2.) It is situated opposite to the mouth of the brook Lindis, from which it received the name of Lindisfarne. By the Britons it was called *Inis Medicante*, and by the English Holy Island, from being the residence of several of the fathers of the Celtic church, and also from having been the episcopal seat of the see of Durham during the early ages of Christianity in Britain. The church of the monastery is in ruins. Its north and south walls are still standing, though they decline greatly from the perpendicular. The east wall is fallen, but great part of the west still remains. The arches are in general strictly Saxon, and the pillars on which they rest are short, strong, and massy. The pointed windows indicate that the building has been repaired at a subsequent period. The length of the body of the church is 138 feet; its breadth 18 feet, and 36 feet including the two aisles. Mr Selby, the proprietor of the island, has lately repaired the weakest part of the walls. The stones appear red with fire, and are wasted away so as to resemble a honeycomb.

> "A solemn, huge, and dark red pile,
> Placed on the margin of the isle."
> MARMION.

The remains of the priory and offices stand on the south side of the monastery, the inside of the walls being built of whinstone, obtained from the rock, which forms a high natural pier on the south side of the island.

The parish church, situated to the west of the monastery, is a plain but spacious Gothic edifice. The pedestal of St Cuthbert's cross, once highly esteemed, is now called the Pelting Stone.

Holy Island is accessible at low water by all kinds of carriages, though there is considerable danger in crossing the sands without a guide. The island, which is a continued plain, is nine miles in circumference, and contains nearly 1020 acres, about one half of which is sand banks. On the north-east side of the island is a tongue of land, about a mile long, and in several places not more than 60 yards wide. The tide may be here seen ebbing on the east, and flowing on the west. Though the soil is rich, yet, before the enclosure of the common in 1792, only 40 acres were in tillage. In 1790, the rent of the whole island was 320*l.*, and in 1797, 926*l.* The town lies on the west side of the island. It appears to have been once much larger, from the names and ruins of the streets. It is principally inhabited by fishermen. The harbour, which is small, lies between the town and the castle, and it is defended by a battery. The castle stands on a lofty whinstone rock on the south-east part of the island, about 60 feet high, and accessible only by a narrow winding pass. It is generally garrisoned by a detachment of invalids.

The parish of Holy Island is likewise called Islandshire, and contains the chapelries of Kyloe, Lowick, Ancooft, and Tweedmouth.

Holy Island was made a bishop's see by King Oswald in 635. In 652, the church was enlarged, but was only made of timber, and thatched; and, in 698, Eadberct, who was bishop for 10 years, covered the roof and walls with sheets of lead. The Danes landed on the island in 793, and a second time in 875, when Bishop Eardulph, along with the inhabitants of the island, took up the body of St Cuthbert, and left the island, with all their relics and sacred utensils. After a pilgrimage of seven years, they at last settled in Chester-le-street.

According to the returns in 1811, there were in Holy Island—

| | |
|---|---|
| Number of inhabited houses | 132 |
| Number of families | 152 |
| Do. employed in agriculture | 67 |
| Do. in trade and manufactures | 47 |
| Total population | 675 |

See Scott's *Marmion*, canto ii. which contains a fine poetical description of Holy Island; the *Beauties of England and Wales*, vol. xii. p. 228; and Hutchinson's *History of Durham*.

HOLYWELL, or Treffynnon, is a town of North Wales, in Flintshire, which derives its name from a remarkably fine spring, which rises at the bottom of the hill just below the town. Holywell is pleasantly situated on the slope of a hill, abounding in lead ore, which rises beautifully above the town. The place is flourishing and well built, and consists of one long street, which is crossed by another, near its centre, of equal goodness.

The church was built in the year 1769. It is a plain neat building, with a square tower at the west end; but though it is furnished with a bell, yet, from its situation below the town, its sound is so inaudible, that it has been found necessary to summon the congregation by a person, who suspends a pretty large one from his neck by a leathern strap, and fixes a cushion upon his knee. This moveable spire walks along, eliciting sounds from the bell, whenever the cushioned knee strikes the instrument. There are other three places of worship in the town, two for Roman Catholics, and one for Protestant dissenters.

The spring called St Winifred's well is reckoned one of the finest in the kingdom. It was found by one experiment to discharge *twenty-one tons* in a minute, and by another 84 hogsheads. In the course of nearly two miles from the source of the spring to its junction with the Chester Channel, its water drives one corn mill, four cotton manufactories, built in 1777, 1785, 1787, and 1790, a copper smelting-house, a brass-house, a foundry, a large copper smithy, a wire mill, a calamine calcinary, &c. The water boils up with great force into a well of a polygonal shape, covered by a colonnaded cupola, having its groined roof loaded with ornaments. It is supposed, but without much reason, to have been built by the Countess of Derby, mother of Henry VII. Near the well is a chapel in the pointed style, which seems to have been built before the time of Richard III. This building belongs to Mr Leo of Llanerch, and has recently been converted into a charity school. A precipitous hill above the church was the site of a fortress belonging to Ranulph the third Earl of Chester. No traces of the building, however, are now to be seen.

The great mining concern, called the Holywell Level, began in 1774, and till lately was an unprofitable concern. The level is carried horizontally for the length of a mile into the hill, and serves both as a drain to the work, and as a canal for the delivery of the ore. Numerous vertical shafts have been cut from this horizontal archway, some of them in pursuit of the mineral veins, and others for the purpose of ventilating the mines. The products obtained from the hill are, 1. Limestone; 2. Chertz or petrosilex, which is ground for the use of the potteries; 3. Lead ore of two kinds, viz. cubic or dice ore, employed in glazing earthen ware, and white or steel-grained ore, containing some silver; 4. Calamine, or ore of zinc; 5. Blende, another ore of zinc, called Black Jack by the miners. The lead ore sometimes brings from thirteen to fifteen pounds per ton, and at other times not more than seven or eight pounds.

An account of the copper and brass manufactures of Holywell has already been given in our article Flintshire, vol. ix. p. 371, to which the reader is referred.

The following is the population abstract of the town of Holywell for 1811:

| | |
|---|---|
| No. of inhabited houses | 1313 |
| No. of families | 1541 |
| Families employed in trade and manufactures | 752 |
| Do. in agriculture | 117 |
| Males | 2925 |
| Females | 3469 |
| Total population, | 6394 |

See *The Beauties of England and Wales*, vol. xvii. p. 708, &c.

HOMANN, John Baptist, an eminent German geographer and mechanic, and a very excellent engraver of maps, was born at Kamlach, a village of Suabia, on the 20th of March, 1663. His parents, who were Catholics, intended that he should embrace the monastic life; but having repaired at an early age to Nuremberg, he became a convert to the tenets of Lutheranism, and devoted himself to the art of engraving, particularly that of maps, which he executed with a degree of correctness and elegance then very uncommon. His first performances of this kind gained him so great a reputation, that he was summoned to Leipsic, where he was employed in engraving the maps to Cellarius' *Orbis Antiquas*. On his return to Nuremberg, he undertook to execute the maps to Scherer's *Atlas Novus*, which was published at Augsburg in 1710. In the year 1702, he established at Nuremberg a manufactory of maps, from which there issued, successively, specimens to the number of two hundred. In 1719, he published an *Atlas methodicus*, for young persons, in eighteen sheets. Under the direction, and with the assistance of another able geographer, Doppelmayer, he also undertook the execution of an astronomical atlas, which appeared, after his death, along with Doppelmayer's Elements of Astronomy, in 1742. Besides maps, he likewise constructed small armillary spheres and pocket globes, and a very curious and ingeniously contrived geographical time-piece.

The scientific and mechanical talents of Homann were deservedly held in high estimation; and his merit was not suffered to languish unrewarded. He was patronised by the Emperor Charles VI. who appointed him his Majesty's geographer; and also by Peter the Great, of Russia. The Royal Society of Berlin admitted him a member of their institution. He died in the year 1724. The manufactory of maps which he established at Nuremberg subsists to this day, and is still conducted under the auspices of his name.

Homann is chiefly known as an excellent engraver of maps; but he likewise possessed a great deal of geographical and astronomical knowledge; and, with an active and enterprising spirit, he combined an inventive genius and uncommon mechanical skill. (z)

HOMBERG, William, an eminent chemist, was born at Batavia, in the Island of Java, on the 8th of January 1652. His father was a Saxon, who had entered into the

Dutch service, and obtained the command of the arsenal of Batavia. Having left this settlement, and gone to Amsterdam, he sent his son to the principal universities in Germany and Italy, where he successively pursued the studies of law, anatomy, botany, astronomy, and chemistry. He was admitted to the bar at Magdeburg in 1674; but having become acquainted with Otto Guericke of that city, the celebrated inventor of the air-pump, he devoted most of his time to the acquisition of the sciences. He now went to the university of Padua, where he studied medicine, anatomy, and botany. After visiting Rome and Bologna, where he discovered the method of making the Bologna stone luminous, he went through France to England, and laboured for some time with our celebrated countryman Mr Boyle. Returning to Holland, he resumed his anatomical studies under De Graaf, and took out his medical degree at Wirtemberg. His passion for travelling, however, prevented him from settling to the practice of medicine. After visiting Baldwin and Kunkel, and exchanging some of his chemical secrets for their methods of preparing phosphorus, he visited the mines of Saxony, Hungary, Bohemia, and Sweden. He next returned through Holland to Paris, where he remained for some time; and when, at the desire of his father, he was about to leave the metropolis, the great Colbert made him such high offers in the name of the King, that he was induced to settle in Paris. He embraced the Catholic religion in 1682, and in the following year he was disinherited by his father for having renounced the faith of his ancestors. In 1685 he again went to Rome, where he practised medicine for some years with great success. On the 4th February 1699, he was admitted a member of the Academy of Sciences, and was allowed the constant use of the laboratory of the Academy. The Duke of Orleans, afterwards Regent of France, erected a magnificent laboratory in 1702, and put it under the charge of Homberg. He allowed him a pension, and in 1704 appointed him his first physician. In 1708, he married Mademoiselle Dodart, the daughter of an eminent medical practitioner; but being naturally of a weak constitution, he lived only a few years, and was carried off by a dysentery, to which he had been liable, on the 24th September 1715. Homberg was not the author of any separate work; but he published no fewer than 102 memoirs in the volumes of the Academy of Sciences, on various subjects, on chemistry, optics, pneumatics, electricity, anatomy, natural history, and the fine arts. See his Eloge in the *Memoirs of the Academy* for 1715. Hist. p. 82.

HOME, Henry, Lord Kames, one of the senators of the College of Justice in Scotland, and an eminent writer both on professional and other subjects, was born in the year 1696. His father, George Home of Kames, was a gentleman of an ancient and honourable family, though of small fortune, in the county of Berwick; his mother was a daughter of Mr Walkinshaw of Barrowfield.

He was educated privately; and, about the year 1712, he was bound by indenture to attend the office or chambers of a writer to the signet in Edinburgh, as a preparatory step to his entering upon the profession of a writer or solicitor before the supreme court. An accidental circumstance, however, afterwards induced him to change his views; and he determined to abandon the more limited occupation of a writer, and qualify himself for the functions of an advocate. With that view, he resolved to supply, by assiduous application, the defects of his imperfect education; and he accordingly resumed the study of the ancient and modern languages; while, at the same time, he endeavoured to acquire a competent knowledge of the sciences. His attention seems to have been particularly directed towards metaphysical investigations, for which, throughout the whole course of his life, he entertained a decided predilection.

In the year 1724, Mr Home was called to the Scottish bar, which was, at that period, graced with the talents of many individuals, who afterwards rose to the first eminence in their profession. Although his mind was abundantly stored with solid learning and legal knowledge, and he possessed, in a high degree, the talents of an ingenious reasoner, Mr Home was not gifted with those shining powers of oratory, which are calculated to bring a young practitioner rapidly into notice. Accordingly, it was not till after the publication of his first work on the law, that he began to enjoy even a moderate share of practice. That work, which consisted of a folio volume of the *Remarkable Decisions of the Court of Session*, from the year 1716 down to the period of its publication, appeared in 1728. Mr Home's manner of pleading was peculiar to himself. He never attempted to speak to the passions, or to captivate his hearers by the graces of oratory; but addressed himself solely to the judgment of his audience; employing a strain of language only a little elevated above that of ordinary discourse, which, even by its familiar tone and style, fixed the attention of the judge, while it excited no suspicion of rhetorical artifice. It would appear, however, that his ability lay more in the devising of ingenious arguments to support his own side of the question, as an opening or leading counsel, than in reply; for which he seems to have wanted that ready command of copious elocution, which is necessary for extemporaneous discussion. There was one peculiarity attending his mode of replying which is worthy of notice. This consisted in a fair concession and abandonment of all the weaker points of his cause. By yielding these at once to his antagonist, he succeeded in creating a favourable impression of his own candour, and a persuasion of the strength of his cause; while, at the same time, he frustrated all attack on those weak parts, which might have given matter of triumph to his opponents, and had a prejudicial influence on the more solid grounds of his plea. But the feature by which Mr Home was principally distinguished as a barrister, consisted in the faculty which he possessed, in a very eminent degree, of striking out new lights upon the most abstruse and intricate doctrines of the law, and of subjecting to the scrutiny of reason those rules and maxims which had become venerable only from long and inveterate usage, having no solid foundation in any just or rational principle.

In 1732, he published a small volume under the title of *Essays on several Subjects in Law, &c.* These subjects had been suggested to him during the course of his employment as a counsel in several important causes; and they contributed greatly to establish the character of the author as a profound and scientific lawyer. From the period of their publication, accordingly, Mr Home appears to have been engaged in most of the causes of importance which occurred in the Court of Session. While occupied with the duties of a laborious profession, however, he did not neglect the pursuits of literature and science, to which he seems to have been at all times ardently devoted; and a considerable portion of his time was also given to the enjoyments of society, in a numerous and respectable circle of acquaintance. He lived in habits of intimacy with many of the first literary and philosophical characters of the age, and frequently corresponded with them on the subjects connected with his favourite pursuits.

In the year 1741, Mr Home married Miss Agatha Drummond, a younger daughter of James Drummond, Esq. of Blair, in the county of Perth, a lady possessed of an excellent understanding, and an enlightened and solid judgment in the conduct of life, with much sweetness of temper, and gentleness of manners. In the course of the same year he published, in two volumes folio, *The Decisions of the Court of Session, from its Institution to the Present Time, abridged and digested under proper Heads, in the form of a Dictionary*,—a work of great labour, and of the highest utility to the profession of the law in Scotland.

During the rebellion in 1745-6, the course of judicial procedure, in the northern part of the kingdom, was interrupted by the disordered state of the country, and the Court of Session did not meet for a period of eleven months. Mr Home employed that interval in various researches connected with the history, laws, and ancient usages of his country, which he afterwards digested into a small treatise, and published in the year 1747, under the title of *Essays upon several Subjects concerning British Antiquities*. These essays, although they contain some curious and important deductions, and exhibit a great deal of ingenious reasoning, are by no means esteemed among the most valuable of the works of their author.

We have already observed that Mr Home's mind was peculiarly turned to metaphysical speculations, for which he found leisure even amidst the pressure of his professional employment. In the year 1751, he published his *Essays on the Principles of Morality and Natural Religion*. This work, in which he endeavoured to place the great principles of morals on a firm and immutable basis, unaccountably drew upon him, from certain quarters, the reproach of scepticism and impiety; and his opinions, particularly on the abstruse question of *free will*, were attacked with great asperity by various writers. Some of these were of so intolerant a spirit, that nothing less could satisfy their zeal, than the interference of ecclesiastical authority, to repress opinions which they conceived to be contrary to the canons of the established church, and subversive even of the fundamental principles of religion. To his opponents, Mr Home made a formal reply, under the title of *Objections against the Essays on Morality and Natural Religion examined*. This controversy attracted the attention of the General Assembly of the Church of Scotland; and a motion was made in the committee for overtures, which was supposed to be indirectly levelled, among others, against the author of the Essays. The motion occasioned a very warm debate, but was finally negatived. However, Mr Anderson, a clergyman, and one of the most zealous of Mr Home's antagonists, resolved not to let the matter rest here. He gave in a petition and complaint to the presbytery of Edinburgh against the printer and publisher of the *Essays on the Principles of Morality and Natural Religion*, requiring that the presbytery should summon them to appear before them, and declare the name of the author of that work, in order that he might be subjected to ecclesiastical censure. The persons complained against appeared by their counsel, and gave in formal defences; but Mr Anderson died during the course of the proceedings. The defendants, however, waving all objection to the want of a prosecutor, consented that the court should give judgment on the merits of the case; which, after undergoing some discussion, terminated in the rejection of the complaint.

In the month of February 1752, Mr Home was appointed one of the Judges of the Court of Session, by the title of Lord Kames. His promotion gave general satisfaction to the country, as his abilities and knowledge of the laws, no less than his integrity and moral virtues, had raised him high in the public esteem. To the discharge of his duties, as a Judge of the Supreme Civil Court, he brought an acute understanding, an ardent feeling of justice, and a perfect acquaintance with the laws of his country; which, amidst the variety of pursuits in which his comprehensive mind had been engaged, had always received the principal share of his attention. His judgments, which were always formed with deliberation, had deservedly the greatest weight with the Court, especially on all questions of recondite jurisprudence. Towards the bar he uniformly conducted himself with a proper courtesy and respect; listening to the arguments of the senior counsel, who pleaded before him, with patient attention, and animating the diffidence of the younger barristers by kind indulgence and urbanity of demeanour. In his character he occasionally displayed something of the humourist; and, even on the bench, he could not always repress his constitutional vivacity, which sometimes broke out in amusing sallies, when the subject of discussion led to a ludicrous train of thought, or when a happy repartee was suggested by the wit of the counsel.

A society had been instituted in Edinburgh, in the year 1731, for the advancement of medical knowledge, the plan of which was afterwards extended, at the suggestion of the celebrated Maclaurin, to subjects of philosophy and literature. It was now known by the title of *The Society for Improving Arts and Sciences*, but more generally by that of *The Philosophical Society of Edinburgh*. At what period Mr Home first became a member is uncertain; but he appears to have been elected its president about the beginning of the year 1769; and in the volume of the *Transactions* of that learned body, published in 1771, there are three papers of his writing, viz. *On the Laws of Motion; On the Advantages of Shallow Ploughing;* and *On Evaporation*. They exhibit the same ingenuity which is conspicuous in all his productions; but the papers on physical subjects are not built on sound philosophical principles.

In the year 1755, Lord Kames was appointed a member of the *Board of Trustees for the Encouragement of the Fisheries, Arts, and Manufactures of Scotland;* and about the same period, he was chosen one of the commissioners for the management of the forfeited estates annexed to the crown, of which the rents were destined to be applied to the improvement of the Highlands and Islands of Scotland. In the discharge of these important trusts, he was a zealous and faithful servant of the public. He regularly attended the stated meetings of these boards, generally officiating as chairman, and taking a most active concern in all their proceedings. In the midst of his professional and literary occupations, he was at all times easy of access to the meanest individual who had any application to make; and was ready not only to advise, but even to assist the ignorant and needy suitor in bringing his claims fairly into view.

In 1757, he published *The Statute Law of Scotland Abridged, with Historical Notes*, and two years afterwards he gave to the world his *Historical Law Tracts*, each in one volume 8vo. The latter work has undergone several editions, and stands deservedly high in the estimation of the public. It is one of the few works which unite law with philosophy and the study of human nature; and it has accordingly received the praise, not only of juridical authors, but of the writers on politics and morals, both of our own and of foreign countries. In 1760, appeared his *Principles of Equity*, in which he traces historically the origin of the courts of equity in each of the united kingdoms, and endeavours to ascertain those general rules by which a court of equity ought to be governed. The active mind of Lord Kames, however, did not confine its efforts to those studies and researches which were more intimately connected with his profession, but exerted its powers in various pursuits of a generally interesting nature. In the course of the education of his own children, he was led to the composition of an elementary work, suited to the minds of young persons, and calculated at once to improve the understanding, and to cultivate just notions of morality. This little work he published in 1761, in a small volume, under the title of *Introduction to the Art of Thinking*. It is divided into two parts; the former containing a series of moral and prudential maxims, and the latter a regular illustration of those maxims by stories taken either from real history, or fictitious narratives.

It appears from the letters of some of Lord Kames's correspondents, that he had for several years meditated an extensive work on the principles of criticism. This design he afterwards carried into execution by the publication of his *Elements of Criticism*, which first appeared in the year 1762, in three volumes 8vo. In this elaborate work, it was the object of the author to subject the impressions made on the mind by the productions of the fine arts to the standard of reason, by showing, that what is generally called taste is by no means arbitrary, but depends on certain principles or laws of the human constitution; and that a good taste consists in the consonance of our feelings with those laws.

From the period of the publication of the last mentioned work, Lord Kames appears to have devoted himself for a few years exclusively to his professional occupations. On the 15th of April 1763, he was appointed one of the Lords of Justiciary, that is, one of the Judges of the supreme criminal tribunal in Scotland. The duties of that situation he continued to discharge, to the end of his life, with equal diligence and ability. In the year 1766, he received a very large addition to his income by the succession to the estate of Blair-Drummond, which devolved on his wife by the death of her brother. The seasons of vacation were now spent at Blair-Drummond, where he began to execute a variety of agricultural improvements on an extended scale, which, while they set a great example for the imitation of the neighbouring landholders, have proved of the most solid and permanent benefit to the proprietor and his heirs. Among these plans of improvement was one of a nature so extraordinary, as to be generally regarded at first as chimerical, but which ultimately succeeded far beyond the most sanguine views of its contriver. We allude to the operations commenced and carried on by his lordship on the moss of Kincardine; of which we shall have occasion to take some notice in the article MOSS in this work. With these substantial improvements he combined many plans of embellishment, suggested by those great features of natural beauty which the surrounding scenery exhibits.

Towards the end of the year 1765, Lord Kames published a small pamphlet on the progress of the flax husbandry in Scotland, of which the principal object was, to show the expediency of encouraging the culture of flax of the native growth of the country. At the same time his lordship, availing himself of a most extensive acquaintance with the principal landholders in Scotland, endeavoured, with a laudable zeal, to stimulate their exertions in diffusing a spirit of industry among their cottagers and dependents, by the introduction of such species of domestic manufactures, suited to both sexes, as, without any considerable expence on the part of the proprietors, would ameliorate the condition, and multiply the comforts, of the lower orders, and thus lay the solid foundation of an increase of their own revenues. Among those patriotic plans of national improvement, in which Lord Kames, as a member of the board of trustess for the encouragement of arts, took a most active concern, was the great and useful project of a navigable canal between the rivers Forth and Clyde, which was begun in 1768, and from which, since its completion, the internal commerce of the country has derived the most essential benefit.

In the year 1766, Lord Kames published his *Remarkable Decisions of the Court of Session, from 1730 to 1752*. The reports contained in this volume consist of 130 cases, comprehending the most important causes which had occurred in the course of his own practice while at the bar.

For many years Lord Kames had been employed, during his leisure hours, in collecting materials for a *History of Man*. The design of this great work, however, as at first conceived, was found to be too vast; and he afterwards wisely determined to confine his plan within narrower limits. The work was at length published in the year 1774, under the title of *Sketches of the History of Man*, in two volumes 4to. Although published in the form of separate essays or dissertations, it is digested with a considerable degree of systematic regularity, and is valuable, not only from the great variety of important objects which it embraces, but on account of the genius and ability displayed in their discussion.

In the year 1776, he published his *Gentleman Farmer*; a work of great utility at the period of its publication, and which affords a singular specimen of the undiminished vigour of his mind at the advanced age of eighty. Even at this late period of his life, his constitution appeared to have suffered nothing from the attacks of old age. There was yet no sensible decay of his mental powers; and, what is still more extraordinary, he possessed the same flow of animal spirits, the same gaiety and vivacity, and the same ardour in the pursuit of knowledge, for which he had been distinguished in his early years.

In 1777, he published his *Elucidations respecting the Common and Statute Law of Scotland*, in one volume 8vo; and in 1780, his *Select Decisions of the Court of Session*, in one volume folio. The latter publication contains 264 reports of the most important cases decided by the court, between the years 1752 and 1768, and forms a supplement to the cases formerly published under the title of *Remarkable Decisions*. The last work of Lord Kames was his *Loose Hints on Education*, published at Edinburgh in the year 1781, when the author was in the 85th year of his age.

Although apparently by no means of a robust frame of body, Lord Kames had hitherto enjoyed an uncommon share of good health; but in the beginning of the year 1782, when he had nearly completed his 86th year, he was seized with a disorder of the bowels, which, being attended with no pain, gave him, for a considerable time, very little apprehension. Finding, however, after some months, that the disease had not yielded to medicine or regimen, he began to regard it as likely to terminate fatally. During the summer term of the year above mentioned, he regularly attended to his official duty in the courts of session and justiciary, and at the end of the term, he went as usual, with his family, to Blair-Drummond. He also attended the autumn circuit; but, on his return, his strength decreased daily, although the serenity and cheerfulness of his temper remained unabated. He left Blair-Drummond in the beginning of November, and continued, for some little time, to attend the meetings of the court of session; but he soon became sensible that his strength was not equal to the effort. On the last day of his attendance, he took a separate and affectionate farewell of each of his brethren. He survived that period only about eight days, and died on the 27th of December 1782, in the 87th year of his age.

In his person, Lord Kames was very tall, and of a thin and slender form. His countenance was animated, and strongly marked with the features of intelligence and benignity. At every period of his life he had a high relish for the pleasures of society; and it was usual for small and select parties to meet at his house in the evenings, during the winter and summer sessions, without invitation. In these parties, the discussion of literary topics was agreeably blended with innocent sallies of mirth and pleasantry; and the graver conversation of a Smith, a Blair, and a Fergusson, was relieved or enlightened by the native wit and polished manners of a Cullen, or the sprightly fancy and whimsical eccentricity of a Boswell. The artless and ingenuous disposition of Lord Kames led him, at all times, to express his feelings and opinions without reserve or disguise; and this propensity, combined with a certain humorous playfulness of manner, might frequently convey to strangers the unfavourable idea of a bluntness and levity, derogatory from that dignity and attention to decorum, which one so naturally associates with talents and eminence. But this impression was soon effaced by that vigour of intellect, that frankness, integrity, and candour, which his conversation never failed to display. He engaged with interest in the discussion of almost every topic that occurred, whether of ordinary life, literature, or science; and, although naturally communicative, he was always as ready to listen to the opinions of others as to deliver his own sentiments. To the introduction of political subjects, however, in common conversation, he had a strong dislike; and when the conversation happened to take that turn, he either took no part in it, or endeavoured to divert it by some timely pleasantry, or guide it with address into a different channel.

To the distinguishing features of Lord Kames' character, as a laywer, a judge, an author, and a man, we have had frequent occasion to allude in the course of the preceding narrative. He certainly contributed, more than any other individual, to explain, illustrate, and define the origin, progress, and character of the laws and institutions of his country; his unwearied attention to agriculture and internal improvement, and his zealous encouragement of every useful project, bear sufficient testimony to his public spirit; and, however widely he might occasionally err in his speculations on subjects of strict science, his many and valuable publications, on literary and philosophical subjects, will prove a lasting monument of his genius and industry. See Lord Woodhouselee's *Memoirs of the Life and Writings of Lord Kames*. The writer of this article has also been favoured with the perusal of the MSS. of John Ramsay, Esq. of Ochtertyre, in which there are many interesting particulars, illustrative of the characters of Lord Kames and other individuals, whose talents contributed to elevate the literary reputation of their native country during the eighteenth century (*z*)

HOME, John, a clergyman of the church of Scotland, but best known to the public as author of one of the most classical tragedies in the English language, was a descendant of one of the ancestors of the Earl of Home. It was once reported, that he had some pretensions to the title of the Earl of Dunbar, but upon what grounds we have never been able to learn. His father was clerk, or, as it might be termed in England, recorder of the town of Leith.* Our poet was born at Leith in September 1722. He received the elementary part of his education at the parish-school of his native place; after which he went to the university of Edinburgh, and there went through the customary course of the languages and philosophy, with the reputation of a respectable and diligent student. At the university he was the intimate companion of several of those eminent men, who, like himself, afterwards contributed so highly to raise the literary reputation of Scotland about the middle of the eighteenth century. Among these were, Drs Robertson and Blair, and Professor Adam Ferguson. The circle of his intimate friendship afterwards included David Hume and Lord Kames. Being educated for the church, he had passed through the divinity-hall, and was about to enter upon the duties of the clerical profession, when he was suddenly called to forsake his studies by the rebellion that broke out in Scotland in the year 1745. On the approach of the rebels, the citizens of Edinburgh assembled, and formed themselves into an association for the support of their sovereign, and the defence of the city; and in this association Mr Home was appointed to be lieutenant of a company of volunteers. In the first crisis of alarm, it became a question among those who had taken up arms, whether they should wait for the approach of the rebels within their walls, or march out to meet them, and act with the king's army. Mr Home, with the more active spirits, was in favour of the latter plan; and while the bulk of the volunteers remained in the Scottish capital, he was one of a much smaller number, who solicited and obtained permission to follow the army of Hawley into the field. At the unfortunate battle of Falkirk, he was taken prisoner by a party of Prince Charles's troops, and was for some time confined a prisoner in the castle of Downe. From thence, however, he soon afterwards contrived to effect his escape; and public tranquillity having been restored by the victory of Culloden, he resumed his studies, and was licensed to preach. In the same year, 1746, he was presented to the living of Atholstaneford, in the county of East Lothian. It gives a poetical interest to the name of this parish, that it had successively for clergymen two poets of respectable names, Mr Home having succeeded in that living to Blair, the author of *The Grave*. In this retired situation, however, we cannot suppose the dramatic muse of Mr Home to have found herself so congenially situated as the more sombrous genius of his predecessor. Accustomed to the sweets of literary society, and elegant in his pursuits, he probably felt the life and duties of a country parish priest far from being delightful. To a mind teeming with dramatic conceptions, the offices of visiting, catechising, and spiritual rebuking, must have been somewhat irksome. He appears, however, to have sometimes taken the recreation of a visit to England; and on one of those occasions he met with Collins the poet, whose mind immediately felt a pleasing congeniality with that of Home. In his *Ode on the Superstitions of the Highlands*, we have almost the only record that Collins has left of his personal friendship, when he says,

> Go not regardless, while these numbers boast
> My short-liv'd bliss; forget my social name,
> But think far off, how, on the southern coast,
> I met thy friendship with an equal flame.

The tragedy of Douglas, though the first play of Mr Home's that was brought upon the stage, was not the first of his composition. He had before written *Agis*, a tragedy, of which we shall have occasion to speak hereafter. The plot of the tragedy of Douglas, as few will probably need to be told, was suggested by the ancient ballad of Gill or Child Morrice. Hearing a part of that beautiful old

* It should be observed, however, that the English recorder's office is of higher dignity than that of the Scottish clerk, who does not sit, like the former, on capital cases.

song sung by a lady one evening after a supper party in Edinburgh, Mr Home remarked, that he thought it contained the germs of a tragedy; and very soon made good his opinion, by commencing to dramatise the story. Douglas made its first appearance on the Edinburgh theatre, which was then in no unflourishing condition, in the year 1756. When the managers received the MS. they readily accepted it, put it into rehearsal, and prepared for giving it a magnificent representation. The transaction, however, coming to the knowledge of the elders of the kirk, they, in their great zeal, first remonstrated with the author on the heinous sin he was committing. Failing in this remonstrance, they endeavoured to terrify the performers from representing it; but with no better success. Author and actors remained equally incorrigible, and nothing remained for the incensed elders to do, but threaten to expel, and for ever disqualify for the ministry, not only their disobedient poet, but even such of his clerical friends as had been wicked enough to go to see his piece performed at the theatre. In pamphlets and advertisements, they thundered their anathemas against those implements of Satan, the actors, who had led aside, or at least abetted in his wandering, the lost sheep of their flock. The presbytery of Edinburgh published an admonition and exhortation against stage-plays, which was ordered to be read in all the pulpits within their bounds, on a Sunday appointed. In this proclamation, there was no mention of Mr Home or his play, though it was evidently against him that this spiritual artillery of obsolete laws and fanatical prejudices were levelled. To avoid a formal expulsion from the church, Mr Home, in 1757, resigned his living, and with it the ecclesiastical profession, and wore for ever after a lay habit. Similar as the Puritans of England and the Scottish Calvinists might have been half a century before, this ejection of an amiable and accomplished clergyman from the Scottish Kirk, for the crime of writing a tragedy, which did honour to the genius of the nation, excited among the more liberal part of the Scotch, and much more generally in England, a sense of indignation at the injustice, and ridicule at the absurdity of the procedure. That leaven of bigotry happily is now far extinct; we believe the last mark of it is to be found in the article Home, in the Biographical Dictionary of Mr A. Chalmers, the writer of which article gravely denies the treatment of Mr Home to have been unjust, since the constitutional laws of the Kirk of Scotland denounced stage-plays. If the writer of this luminous opinion were at present flourishing in Spain, he might argue with equal justice in favour of the burning of heretics, on the grounds of the ancient laws of the Catholic Church—as if an enlightened age were for ever bound to follow the dead letter of primitive barbarism. Happily, in Protestant communities, such an example of clerical hostility to the cause of literature stands alone: for parallels to it we must go back to times of Paganism and Popery. It may remind us of the persecution of Æschylus, in consequence of the clamour of the Athenian priests, or of the influence of the monks in Spain, when neither the patronage even of Philip IV. nor the orthodoxy of Lope de Vega's works, were sufficient to screen him from the personal virulence of the ecclesiastics. At no very distant period, indeed, during an epidemical disorder, the inhabitants of Seville renounced the amusement of the theatre, as the surest mode of averting Divine vengeance. To return, however, to our author. His tragedy of Douglas was extolled, on its first appearance, by the literary circles of the North, in terms that were perhaps rather unqualified. David Hume gave it as his opinion, that it was one of the most interesting and pathetic pieces ever exhibited on any theatre; he even gave it a preference to the *Merope* of Maffei, and that of Voltaire. The rest of the philosopher's panegyric on our author, in which he alluded to Shakspeare, may, for the credit of his taste, be left unquoted. The poet Gray, in one of his letters to a friend, renders an homage to the play of Douglas, that is perhaps not much lessened by his fastidious allusion to its defects. "I am greatly struck," he says, "with the tragedy of Douglas, though it has infinite faults. The author seems to me to have retrieved the true language of the stage, which had been lost for these hundred years; and there is one scene between Matilda and the old peasant, that strikes me blind to all its defects." Jackson, in his *History of the Scottish Stage*, informs us, that when this tragedy was originally produced in Edinburgh, the title of the heroine was Lady Barnard. The alteration to Lady Randolph was made on its being transplanted to London. Its success at the Edinburgh theatre induced Mr Home to offer it to the London managers, where, notwithstanding its rising celebrity, and all the influence used in its favour, it was refused by Mr Garrick. Mr Rich, however, accepted it, and it was acted for the first time at Covent Garden, March 14, 1757, with some applause, but by no means such as indicated the future celebrity which it was to obtain.

On resigning his living, Mr Home repaired to England, where the munificent patronage and unremitting friendship of the Earl of Bute made him ample amends for the abandonment of his profession. Lord Bute having become first minister on the accession of his present majesty, appointed him, in March 1763, a commissioner for sick and wounded seamen, and for the exchange of prisoners of war; and in the next month of the same year, he was nominated conservator of the Scotch privileges at Campvere in Zealand. From the period of the exhibition of Douglas, down to the year 1778, Mr Home brought five other tragedies before the public. Of these, *Agis*, as has been already mentioned, had been composed before that of Douglas. Mr Garrick had formerly refused this piece as well as Douglas; but as it was now considerably altered, and the author's reputation established, the manager brought it forward at Drury Lane in 1758. The play is founded on a story in Spartan history. It is pretended that the author has kept up in the character of Agis a continued allusion to the misfortunes of Charles the First; and the figurative retrospect of the conduct of the Scots towards their sovereign was charitably ascribed, by the conjectures of English criticism, to the author's vindictive feelings towards his countrymen. The allusion was in all probability either casual or imaginary—the imputed motive is inconsistent with all that is known of the character of Home. Agis was certainly heard with impartiality, and even with that partial disposition which the author of Douglas had a right to expect. It had the additional advantage of good acting, and of two solemn musical processions. But the intrinsic merit of the piece could not secure to it a lasting popularity. On perusing it, the poet Gray writes this melancholy sentence to Dr Warton, "I cry to think that it should be by the author of Douglas. Why, it is all modern Greek. The story is an antique statue, painted white and red, frigid, and dressed in a negligée, made by a mantuamaker of Yorkshire." Mr Home's third tragedy was the *Siege of Aquileia*. It was acted with indifferent success at Druly Lane, in 1760. From the title, we should expect that the author would have adhered, with general fidelity, to the circumstances, as they are recorded in history, of the defence of that city by the legions of Gordianus, against the gigantic tyrant Maximin; but, in reality, the incidents of the play agree much nearer with the history of the Siege of Berwick, defended by Seton against the arms of Edward III.; and it was conjectured, with some appearance of plausibility, that Mr Home had received his first hint from the latter story; but disliking to bring Edward the Third before an English audience, in the light of a brutal tyrant, in which the siege of Berwick too strongly exhibited him, he thought proper to preserve the circumstances, only under the disguise of more ancient names. This play is regular in its structure, and the language in some passages is fine; but, on the whole, the incidents are too few, the distress too unvaried, and the catastrophe too clearly anticipated. Mr Home's muse cannot be said to have prospered beyond the time when she was rich enough to lend images to Ossian. The shrieking of the spirit of the waters was an admired expression in the description of the tempestuous night in Douglas, which seems to anticipate much of the spiritual imagery of Macpherson. Gray the poet puts a query in one of his letters, whether Home borrowed this from Macpherson, or Macpherson from Home. Without pretending to enter on the wider question of Ossian's authenticity, we shall only notice, that the play of Douglas appeared some years earlier than the fragments ascribed to Ossian. The latter, as we have seen, was acted in 1757; Macpherson did not come before the world till 1760. By the *Fatal Discovery*, Mr Home's next tragedy, it would seem that our author was willing to be reimbursed for whatever hints of fancy he had lent to the Gaelic muse, and accordingly he supplied himself in this piece with much of the famed phraseology of Fingal. But whatever might be the real demerits of the *Fatal Discovery*, the London public seems not to have been disposed to receive it with an equitable judgment. To such a height, we are told in the *Biographia Dramatica*, had party prejudice risen against Mr Home, on account of his enjoying the patronage of the Earl of Bute, that it was found necessary to conceal the author's name during the first nights of its representation; and, after the twelfth night, Mr Garrick was threatened with having his house burnt down, if he continued it: an injunction with which the managers thought it advisable to comply. *Alonzo*, Mr Home's next tragedy, was more successful than any other of his productions, *Douglas* alone excepted. It had a considerable run on its first appearance, and added much to the rising reputation of Barry as an actor; but it never obtained the rank of what is called a stock play, nor was afterwards performed, except at provincial theatres. The language of the tragedy of *Alonzo* possesses considerable force and purity, though the cadence of its versification is, like all the blank verse of that period, too little varied in the pauses, and monotonously concludes the rhythm with every line. The story is also romantic and lucidly brought out, but it is rather too much like an echo of *Douglas*. Ormisinda brings us back Lady Randolph. She is not indeed a widow; but has been forsaken for eighteen years by the husband of her early love, who had groundlessly suspected her virtue. They had married unknown to her father, and their meetings were in a solitary place; where a confidential servant, in order to give the semblance of protection to Ormisinda, assumed the plume and vesture of a brother. Deceived by this appearance, Alonzo had abandoned her, wandered in foreign countries, and returned only in disguise to fight with the Moors in behalf of Spain. In his absence Ormisinda has secretly reared his son at a distance from her, and unconscious of his birth. Like Douglas, he bursts from obscurity into martial reputation, and offers to become her champion without knowing that she is his parent. Alonzo conquers the Moorish champion, throws off his disguise, declares his marriage with her from whom he has been eighteen years separated, and, in a scene which is pretty striking, demands, as the reward of his services, that the king shall sentence her, his own daughter, to die. The conscious innocence of Ormisinda,—the agony of her wrongs,—the bursts of her affection towards Alonzo,—and her maternal feelings at the sight of her boy rushing to combat with his unknown father,—compose a strong situation of terror and pity; and the moment when she throws herself between their swords, is one of rivetting interest. It may be questioned, however, if the effect would not have been much better, had the termination been fortunate. In plots where a happy denouement would not be merely satisfactory, but joyous and exultingly triumphant, the policy of killing the tragic victims is very doubtful. Ormisinda was not like Lady Randolph, who, though her son was restored, had only a second and apparently not a distractedly beloved lord to be reconciled with; she had all the pledges of filial, maternal, and conjugal love to redeem, as well as honour, and the inheritance of a throne; and the catastrophe that severs her from all those blessings, seems to depend more on the tragical resolution of the poet, than on that overawing *fatality which gives dignity to dramatic slaughter.*

*Alfred*, our author's last tragedy, was acted in Covent Garden in 1778, but was only performed for three nights.

It is impossible to follow this detail of Mr Home's dramatic career, without a melancholy reflection on the power of genius itself being included in the sentence of mutability which is passed on all earthly blessings. With *Alfred* he took his leave of the stage, and retired to Scotland, where he continued to reside during the greater part of his remaining life. In 1778, when the late Duke of Buccleugh raised a regiment, under the name of Fencibles, Mr Home received a captain's commission, which he held till the peace. A few years before his death, he published the *History of the Rebellion in Scotland in* 1745: a work of which great expectations were formed; but whether he delayed it until his powers of mind had lost their vigour, for he was now seventy-eight, or did not feel himself at liberty to use all his materials, the public was not satisfied. For a considerable time before his death his mental faculties were impaired, and his health was much affected by a dangerous fall from his horse. He died at Merchiston house, on the 4th September, 1808, at the advanced age of eighty-five. (*n*)

HOMER, (the Grecian poet.) Without leaning to the faith of those who have denied the existence of Homer, we cannot avoid noticing the remarkable circumstance of his existence having been called in question. Both learning and ingenuity have been employed in attempting to prove, that neither the Iliad nor the Odyssey were the production of a single genius, but composed by the rhapsodists, who recited those poems in detached parts; and that the name of Homer, which in the Eolian dialect of Greek, signifies "blind," was either applied to some personage wholly fanciful, or, by way of eminence, to some strolling declaimer of the Iliad, who may have executed parts of the poem, but cannot be supposed to be the author of the whole. It may seem a paradoxical way of annihilating an individual to multiply his existence; but yet, by proving a diversity of Homers, if such a thing could be proved, our homage to the single author of the Iliad would be shaken, and the reputation of a sacred name would fall with its loss of unity. Annius of Viterba pretends to give the authority of Archilochus, an author to whom he ascribes the most remote antiquity, for the existence of eight different authors of the Iliad, among whom are gravely registered Apelles the painter, and Phidias the statuary. But for the comfort of those who may feel alarmed at the threatened dismemberment of the Homeric existence, it must be mentioned, that this Annius of Viterba, who was a Dominican friar, and master of the sacred palace under Pope Alexander VI., was an impostor, who had not even skill to palm upon the world the MS. page of this ancient Archilochus, which he pretended to find, and stands upon record as one of the most impudent and clearly convicted of literary forgers. The book, which he called the Genuine Remains of Sanconiathon Manetho, &c. brought him the same species of reputation that accrued to the younger Ireland, from his Shakespeare MSS., or to Mr John Pinkerton from his execrable additions to Hardyknute.

By far the most formidable opponent of the unity of the author of the Iliad is the learned German Professor Wolff, who supposes Homer to be either an imaginary being, or, at most, one of the earliest of the rhapsodists. In the works which he prefixed to the works and remains of Homer and the Homerides, there are several false inferences, deduced from admissible facts, brought forward with a boldness that might indeed have been expected from a writer who arrogantly pronounced his work to be above all critical objections, and who predicted, that no Grecian scholar should attack it with impunity.

In opposition to all scepticism regarding Homer, every candid mind will agree, that the settled and prevailing belief of antiquity is not to be made light of in such a question. It is true that Homer's birth-place, as well as his age, are disputed, but such controversies are not apt to be started about imaginary beings. It is unreasonable to say, that a poet so illustrious as Homer, if he had been the acknowledged author of the Iliad, must have been known to his own contemporaries. Only a few scattered anecdotes of Shakespeare himself have reached the present day. In an age, such as the probable age of Homer, had a man of genius a better chance of finding contemporary biographers? When Massinger was buried, all that could be told of him, in the inscription upon his tomb, was, "Here lies Philip Massinger, a stranger." To adduce all the proofs that could be given of great poets being neglected by their contemporaries, would unhappily be to write the history of the greater part of them. In forming our opinion of narratives that exceed the accustomed phenomena of nature, we cannot be sufficiently cautious of making the creed of a past age the standard of our own belief. But tradition that is free from the marvellous is fairly entitled to confidence, and the tradition which assigns a single author to the Iliad, a tradition which Lycurgus and Aristotle believed, has surely nothing in it so incredible, as that a work, so remarkable for simplicity of design, should have been the work of fortuitous and successive composers. Great works of science may, indeed, be thus built up by accumulation, but great poems and pictures are not usually constructed by a multiplicity of artists. Nor, if the Iliad had been the work of successive rhapsodists, is it easy to conceive by what poetical effort of modesty those authors suppressed their respective rights upon the gratitude and admiration of posterity.

We must distinguish, however, between the credit that is due to the general tradition of Homer having been a wandering reciter of his own poetry, and the more specific facts that are pretended to be given as the history of his life. The most ancient work of this kind is the life of Homer attributed to Herodotus. Whether this be the genuine production of Herodotus, we are far from pretending to decide. The opinion of Professor Heyne, which was apt to be deliberately formed, is unfavourable to its authenticity, as he pronounces it impossible to ascertain either the age or country of Homer. The learned Vossius also rejected its authority, on the ground that no writer makes mention of the work, previous to Stephen of Byzantium and Suidas. This argument, though it comes from a great name, is certainly not quite conclusive. By far the most important objection to it is, the different calculations of chronology exhibited in Herodotus the historian of Greece, and the Herodotus to whom this life of Homer is assigned. The former, in his Euterpe, speaks of himself as posterior to Homer by only 400 years; while the latter computes a period of 622 years, and the expedition of Xerxes across the Hellespont, a difference of nearly 200 years. On this account, Eustathius wishes to assign the life of Homer to another Herodotus, surnamed Olophyscius, instead of the historian of Halicarnassus. Admitting the above objections in their full force, it cannot be affirmed that they amount to a demonstration of the biography itself being either spurious, or fraught with internal marks of falsehood. On the contrary, the birth-place, which it gives to the author of the Iliad, corresponds with an inference most plausibly drawn by an enlightened traveller from the poet's descriptions of external nature, that he paints them with the very circumstances that would occur to a native of Chios or Smyrna. If Homer was born at the latter place, the vicinity of Herodotus's birth-place would naturally make him anxious to collect every tradition respecting him; and in the wandering life and disastrous voyages which those traditions describe, there is every thing which the state of society in such an age renders probable. It cannot well be doubted that the author of the Iliad and the Odyssey was a traveller, as they are both the evident offspring of a mind which had contemplated nature and human life in a full variety of aspect and manners, and of one who had felt much from the opposite dispositions of good and bad in his own species; who, according to the circumstances then existing in society, had

> "Walked in every path of human life,
> Felt all its passions, and to all mankind
> Doth now, will ever, that experience yield,
> Which his own genius only could acquire."
>
> AKENSIDE, *Inscription for the Bust of Shakespeare.*

Our ingenious countryman Wood* had a higher opinion of the authority of the work in question; and although some allowance may be made for the gratification of the traveller, in finding that theory respecting Homer's history, which he had himself so plausibly deduced from his landscapes and similes, confirmed by a work ascribed to so venerable a name as that of Herodotus, yet Wood's remarks are worth attending to: "It may be here requisite," (he says, p. 189, *Essay on Homer*,) "that I take some notice of the ancient life of Homer, handed down to us, and ascribed to Herodotus. The life of Homer is supposed by several not to be the genuine production of that historian. As it is impossible to imagine a collection of circumstances which have less the appearance of fiction, I do not see why we should not suppose that this was the last and most probable account that the historian could get. As for the observation that they belong to the lowest sphere of life, I fear it is suggested by modern distinctions of rank unknown in those times. When we are told, by way of depreciating this written life, that it is conducted with the spirit of a grammarian; that there is nothing in it above the life which a grammarian might lead himself; nay, that it is such a one as they commonly do lead, the highest stage of [illegible]s to be master of a school; we are treated with objections which arise much more out of a knowledge of modern than ancient times. The character of a grammarian was unknown, not only to Homer, but to Herodotus;

* *Essay on Homer.*

and when it did appear, was much more respectable than of late, when, by an easy transition, it is connected with the name of schoolmaster, as in the present case, and conveys very false ideas of the state of knowledge and learning. Of the same sort is the stricture upon the extempore verses of this treatise, which, far from being an argument against it, I take to be the most genuine mark of the age to which it pretends. When in a written composition, the distinction of prose and verse was of a short standing, what we here call extempore verses, which are so often interspersed in the works of Herodotus, and the oldest of the Greek writers, I suppose to have been quotations from that period of knowledge previous to the common use of writing, when prose was confined to conversations, and all compositions were in metre, that they might be more easily remembered." In this life of Homer, attributed to Herodotus, the name of the poet's mother is said to have been Critheis, a native of Smyrna: he was the offspring of illegitimate love.

> "No sickly fruit of faint compliance he,
> Stampt in the mint of Nature's ecstacy."
> Savage.

Critheis had been left an orphan. Her tutor, whose name was Cleanax, having disgraced her for her frailty, she was obliged to fly from her native place, and after wandering for some time, arrived at the banks of the river Meles. There she was delivered of the infant, who, from the place of his birth, was called Melesigenes, a name which he bore till it was changed to Homer after his blindness. Phemius, an inhabitant of Smyrna, who taught music, took the unfortunate mother into his house, married her, and adopted the child Melesigenes. The youth for some time assisted them in the school of music, but after their death was seized with a desire of seeing foreign countries, and embarked with a Phenician shipmaster. Among other places, he arrived at Ithaca, where he learnt the adventures of Ulysses; but his stay was unfortunately prolonged till he was struck with ophthalmia, which the ignorance of a pretender to the healing art soon made incurable. Already he had been a poet, and he now consoled his blindness by composing the Iliad. With this treasure in his memory, he wandered from place to place, and subsisted by reciting it. Universal tradition thus exhibits to us the greatest genius of antiquity as wandering about in blindness, and supported by the spontaneous kindness of those whom he visited. But the idea of such mendicity must not be confounded with the repulsive and squalid associations which the word beggary brings to the mind in our own artificial state of society, when disgrace covers the supplicant, and when the feeling of compassion carries contempt, and not kindness, along with it. In simple times, the traveller went abroad, and sought protection and food with the assurance, that, whenever he saw the human countenance, he should meet with the natural charity of the human heart. He made his way with confidence, for hospitality was the virtue and the point of honour of primeval society. A picture of such hospitality is given in the Odyssey, when Mentor and Telemachus arrive at the dominions of Nestor. The King, who knows nothing of the visitants, invites them to the royal table, and, not until he has feasted them, puts the question, "*Strangers, what are you?*" But Homer did not visit foreign countries with merely the common claims to hospitality, religiously respected as those claims were sure to be. He travelled in the character of bard and reciter, of which an image was renewed in modern Europe among the minstrels and the troubadours. Of the latter description of poets, we know that many held an honourable place at the most splendid courts, were the inmates of palaces, and the suitors of noble dames. The Greek itinerant bard, in times when books and writing were unknown, must have been a character not coldly respected as a stranger, but esteemed and beloved for his powers of entertainment. Poetry was then not only the ornament of sentiment and beautiful fiction, but embraced all that was the mental amusement, and all that could be called the knowledge of mankind. It taught them what they believed to be their history; celebrated their mythology; gave them romantic conceptions of the past and the present world; and gave additional pleasure to the heart, by the charm which it afforded to the ear. Such was the profession of the ancient poet; but which, nevertheless, though immeasurably removed above the contempt of contemporary society, must have been exposed to many incidental calamities. The very virtue of hospitality arose out of a state of society, that rendered travelling and navigation fatiguing and perilous. When the poet could only recite his works, the honours and caresses due to genius and originality alone might often be lavished on the least inspired of the profession, who drew their stores of entertainment from a memory tenacious of the compositions of others; and hospitable as the times might be, the general partiality of the undistinguishing multitude for impudence and flattery might often favour the mere pretenders to poetry, while the lofty mind of the true poet could not stoop to canvass for popularity. In the life of Homer, already mentioned, we find the prince of poets encountering adversity in many shapes. At several places it tells us of his applying to the rulers of the state for maintenance at the public expence, and promising to immortalize their history by his compositions. If the author of the life, whoever he was, contrived those traditions, it is singular that he has told by anticipation a story so nearly resembling the fortunes of Tasso and of Dryden. Among the Phocians it is also related, that a perfidious brother poet, Thestorides, after having received Homer in his house, drew from him the story of the Iliad, and passed it off for his own. Homer, it is added, followed him to Chios, where Thestorides was reciting his works, and obliged the plagiary to fly from his presence. His kindest reception is said to have been at Chios, where, assuming gaiety from his easy circumstances, he composed the mock heroic of the Frogs and Mice. There, also, he married, and had two daughters, one of whom died a virgin, and the other is supposed to have perpetuated his race in the Homerides, who, for many generations, lived by reciting the Iliad and the Odyssey. On this account of Homer's residence in Chios, whether fabulous or true, are founded all the local traditions of places consecrated by his name. Among others, that of the hollow in the rock, which bears the name of his school, but which Tournefort and Chandlers have so entirely discredited.

It is not known what separated Homer from his family, but he quitted Chios, according to this account, at an advanced age, to recommence his wanderings. Those were principally at sea; and the knowledge which the poet displays of all the rude art that was known to the shipwright and seamen of ancient times, sufficiently evince that Homer had witnessed a considerable deal of navigation. Many of his voyages are said to have been disastrous; a circumstance which we can well believe, when we consider that the only ships which his experience enabled him to describe were destitute of anchors, and built without a nail of metal to secure them. An illness, which at last seized him, obliged him to stop at the island of Jos, and there he died. Strabo, Pliny, Pausanias, Aristotle, and Aulus Gellius, agree with this account of the place of his death and interment. A tomb in that island was long celebrated as the depository of his venerated remains, to which the states of Argos sent a solemn deputation every five years to offer libations.

Such are a few of the traits of his life which are given in the work attributed to Herodotus. Among the places that have laid claim to the honour of his birth, Antimachus thinks that he was born at Colophon; Aristarchus, at Athens; Pindar, at Smyrna; Aristotle supposes that he was born, as well as that he died, in the island of Chios. Suidas assigns him to Cyprus, others to Pylos, Rhodes, Mycæne, Ithaca, Salamis, and Argos. In fact, the guesses at his birth-place lead us pretty nearly over the whole map of Asia Minor, the Peloponnesus, and the Archipelago. Even Egypt has had its advocates for this distinction; so that the whole ancient world may be said to have claimed him. The poet Martial, when called upon for his opinion on the subject, could only reply in an epigram, that such a genius belonged to the world at large; and it is true that genius, like the light, belongs to all that can enjoy it; but unfortunately epigrams will not settle points of history. The Emperor Adrian applied to the oracle to solve the question, and was told that he was certainly born in Ithaca; but the oracle seems to have converted few to its opinion. The opinion of antiquity seems generally to lean towards either Chios or Smyrna having been his birth-place. Wood, who, after describing Balbec and Palmyra, travelled through Greece with the works of Homer in his hand, has adopted, as we have already mentioned, an ingenious mode of inferring, from the landscapes and natural similes of the poet, the place in which Homer first received his impressions of the scenery of nature. "If we survey," says that traveller, "the map of the world with attention, I think we may discover that his first impressions of the external face of nature were made in a country east of Greece, at least as far as we may be allowed to form a judgment, from his describing some places under a perspective, to which such a point of view is necessary; as, for example, when he places the Locrians beyond Eubœa. This piece of geography, though very intelligible at Smyrna or Chios, would appear strange at Athens or Argos. His description of the situation of the Echinades beyond sea, opposite to Elis, has something equivocal in it, which is cleared up, if we suppose it addressed to the inhabitants of the Asiatic side of the Archipelago. But if, with Mr Pope, we understand the words 'beyond sea' to relate to Elis, I think we adopt an unnatural construction to come at a forced meaning; for the old Greek historians tell us, that those islands are so close upon the coast of Elis, that in their time, many of them had been joined to it by means of the Achelous, which still continues to connect them with the continent, by the rubbish which that river deposits at its mouth. I think I can discover another instance of this kind in the 15th book of the Odyssey, where Eumæus, the faithful servant of Ulysses, is described entertaining his disguised master with a recital of the adventures of his youth. He opens his story with a description of the island of Syros, his native land, and places it beyond or above Ortygia. Now, if we consider that Ithaca was the scene of this conference between Ulysses and Eumæus, it will appear that the situation of Syros is very inaccurately laid down; for in reality this island, so far from being placed beyond or farther from Ortygia, should have been described as nearer to it. An ingenious friend thinks that καθυπερθεν may relate to the latitude, and that Homer meant to describe Syros as north of Ortygia; but I cannot help thinking that the application of high to northern latitudes is much later than Homer.

"As therefore the same description would have been perfectly agreeable to truth had it been made in Ionia, is it not reasonable to suppose that the poet received his early impressions of the situation of Syros in that part of the world, and had upon this occasion forgotten to adapt his ideas to the spot to which the scene is shifted? If my conjecture is thus far admitted, I beg leave to proceed to a farther use of it, in attempting to throw some light on this obscure expression ὀθιτροπαι ηελιοιο. It is important to that part of the poet's character now under consideration, to have his sense of these words restored, if possible; for they have been urged as an argument of his gross ignorance of geography, by those who think they relate to the latitude of Syros, and that this description places that island under the tropic * * * * *. I beg leave to carry the reader for a moment to the Asiatic side of the Archipelago, in order to examine whether a view of the landscape under that perspective offers any appearances to which those words can be naturally applied without violence to their literal meaning. No part of our tour afforded more entertainment than the classical sea prospects from this coast and the neighbouring islands, where the eye is naturally carried westward by the most beautiful terminations imaginable, especially when they are illuminated by the setting sun, which shows objects so distinctly in the clear atmosphere, that from the top of Ida I could very plainly trace the outline of Athos on the other side of the Ægean Sea, when the sun set behind that mountain. This rich scenery principally engaged the poet's attention; and if we consider him as a painter, we shall generally find his face turned this way. In the infancy, and even before the birth of astronomy, the distinct variety of this broken horizon would naturally suggest the idea of a sort of ecliptic to the inhabitants of the Asiatic coast and islands, marking the annual northern and southern progress of the sun. Let us suppose the Ionians looking south-west from the heights of Chios at the winter solstice, they would see the sun set behind Tenos and towards Syros, the next island in the same south-west direction; and having observed, that when he advanced thus far he turned back, they would fix the turnings (τροπαι) of the sun to this point. I submit it as matter of conjecture, whether this explanation does not offer a more natural interpretation of the passage than any which has yet been suggested. In pursuance of the same method of illustrating Homer's writings, I shall draw some conjectures with regard to the place of his birth, or at least of his education, from his similes. Here we may expect the most satisfactory evidence that an enquiry of this obscure nature will admit. It is from these natural and unguarded appeals of original genius to the obvious and familiar occurrences of common life, that we may not only frequently collect the customs, manners, and arts of remote antiquity, but sometimes discover the condition, and, I think, in the following instances, the country of the poet." After enumerating several similes to support his theory, the essayist proceeds to the following: "When the formidable march of Ajax is compared to a threatening storm coming from the sea, I must observe, as an illustration, not of the obvious beauty of the simile, but of the poet's country, that this can be no other than an Ionian, or at least an Asiatic storm; for it is raised by a west wind, which, in those seas, can blow on that coast alone. When, again, the irresistible rage of Hector is compared to the violence of Zephyrus buffeting the waves, we are not immediately reconciled to that wind's appearance, in that rough appearance so little known to western climates, and so unlike the playful Zephyrus of modern poetry. But before we condemn Homer as negligent of nature, we should see whether he is not uniform in this representation, and whether this is not the true Ionian character of Zephyrus. The very next simile of the same book is as much to our purpose, where the numbers, tumult, and eagerness of the Grecian army collecting to engage, are compared to a growing storm which begins at sea, and proceeds to vent its rage upon the shore. The west wind is again employed in this Ionian picture, and we shall be less surprised to see the same allusion so often repeated, when we find, that of all the appearances of nature, of a kind so generally subject to variation, there is none so constant upon this coast. For at Smyrna, the west wind blows into the gulf for several hours, almost every day during the summer season, generally beginning in a gentle breeze before twelve o'clock, but freshening considerably towards the heat of the day, and dying away in the evening. During a stay of some months in this city, at three different times, I had an opportunity of observing the various degrees of this progress, from the first dark curl on the surface of the water to its greatest agitation, which was sometimes violent. Though these appearances admit of variation, both as to the degree of strength, and the precise time of their commencement, yet they seldom entirely fail. This wind, upon which the health and pleasure of the inhabitants so much depend, is by them called *inbat*. The Frank merchants have long galleries running from their houses, supported by pillars, and terminating in a chiosque or open summer-house, to catch this cooling breeze, which, when moderate, adds greatly to the oriental luxury of their coffee and pipe. We have seen how happily the poet has made use of the growing violence of this wind, when he paints the increasing tumult of troops rushing to battle; but in a still, silent picture, the allusion is confined to the first dubious symptoms of its approach, which are perceived rather by the colour, than by any sound or motion of the water; as in the following instance. When Hector challenges the most valiant of the Greeks to a single combat, both armies are ordered to sit down to hear his proposal. The plain thus extensively covered with shields, helmets, and spears, is, in the moment of this solemn pause, compared to the sea, when a rising western breeze has spread a dark shade over its surface. When the reader has compared the similes I have pointed out with the original materials, which I have also laid before him, I shall submit to his consideration, as a matter of doubtful conjecture, whether the poet, thoroughly familiarized to Ionian features, may not have inadvertently introduced some of them in the following picture, to which they do not so properly belong. When Eidothea, the daughter of Proteus, informs Menelaus; at Pharos, of the time when her father is to emerge from the sea, the circumstance of Zephyrus, introduced in a description of noon, darkening the surface of the water, is so perfectly Ionian, and so merely accidental to the coast of Egypt, that I cannot help suspecting the poet to have brought this image from home."

That the Iliad displays abundance of geographical knowledge is certainly no internal proof, either for or against its being the work of one individual; but if we suppose it to be the work of a single genius, upon the grounds of that mind alone which had conceived so lofty a plan being able to accomplish its magnificent execution, we shall find in the geography of its author unquestionable proofs of his having been an extensive traveller. Strabo has left a commentary on the geographical parts of the Iliad and Odyssey; and others, such as Apollodorus and Menogenes, wrote on the same subject, though unfortunately only the titles of their works have reached posterity. Homer, in the midst of all his splendid machinery, was regarded as so faithful a painter of real existence, that his catalogue of the Grecian forces was respected as a valuable record in ancient Greece, and appealed to by its jurisprudence. In some cities it was enacted by law, that the youth should get the catalogue by heart. Solon, the lawgiver, appealed to it, in justification of the Athenian claim against the pretensions of the Megareans, when the right to Salamis was so warmly contested by Athens and Megara. And the decision of that matter was at last referred to five Spartan judges, who, on their part, admitted the nature of the evidence, and the affair was accordingly determined in favour of the Athenians. Three other litigated cases of property and dominion are said to have been determined by reference to Homer's geography. In Homer's age there was no other way of acquiring knowledge but by travelling. To the curiosity respecting his own species, which must have possessed the ardent mind of the poet, and impelled him to brave the dangers of sea and land, the veracious Strabo adds another very probable motive of his travels, which was the wish to make his fable accord with the mythology of the people whom he introduced on his scene of action. For this purpose, says Strabo, he consulted the religious records and the oracles that were suspended in the temples. At that period there were hardly any other historical monuments known. The priests held the sceptre of public opinion, and all history was consigned to the oracles. Diodorus says, that Homer visited the isle of Delphos. After the second sacking of Grecian Thebes by Alcmeon, the propheteess Manto, daughter of the famed Tiresias, had been sent to Delphi as making part of the spoils, where she acquired great renown by her talent for composing oracles. The meeting of Homer with such a lady is interesting to the imagination. Homer, says the historian, borrowed some striking verses of the oracle, either as ornament or authority to give weight to his works.

It would be curious to ascertain in what state Homer found the poetry of Greece when he commenced his career; but the question is involved in almost impenetrable obscurity. While he is hailed as the father, he was certainly not the inventor of poetry. According to the Greek library of Fabricius, there were seventy Greek poets anterior to him. The greater part of them were musicians. Among these Linus is cited, who, it is said, rehearsed the first expedition of Bacchus and Orpheus, who sung the Argonautic expedition. The assertion of Suidas, that Homer drew his story of the Iliad from that of Corinnos, who composed it during the Trojan war, seems to be only the dream of a lexicographer. Tzetzes, a versifier of the 12th century, who made a commentary upon Lycophron, and a bad poem called the Chiliade, would have us believe that Homer borrowed his Iliad from Dictys Cretensis, a writer to whom a manuscript, certainly most ancient, but not original, was ascribed, which was found in the reign of one of the Cæsars, in a tomb that was thrown open by an earthquake. When we are told that Dictys followed Idomeneus to the seige of Troy, and wrote a history of it in prose, we have quite enough of this phantom gazetteer. The story of Homer's purloining a manuscript poem from the priestess of Delphi, which is gravely repeated by Ptolemy Ephaestion, is almost too ridiculous to be worth noticing; and we are almost ashamed to mention another hypothesis, which has found an advocate in the absurdity of modern times, viz. the theory of Bryant, which supposes Homer to have found the materials of his Iliad in a temple of Egypt, and to have allegorized the contents under the fiction of Grecian names. According to this reverie, for it merits not the name of a theory, Menelaus, Agamemnon, Helen, &c. were all fantastic personages drawn from Egyptian theogony, and naturalized in Greece. Menelaus is evidently the Pharaoh Menes; Agamemnon is the Turkish word Aga prefixed to Memnon, whose harp resounded at the touch of the rising day. The wealthy Mycene never existed but in the vanity of Thucydides, and the credulity of Herodotus. Troy never existed but on the shores of the Nile. The historical part of this hypothesis is quite upon a par with its etymology, which, with its Agas and Memnons is not so diverting, but equally credible with Swift's derivation of Hector, Ajax, and Alexander.

The epoch of Homer has been not less a subject of disputation than his country. Herodotus says in his Euterpe, that he lived 400 years before his own (the historian's) time. In the chronicle of the Parian marbles, Homer is said to have been in his highest renown at the year of the chronicle 675, which would place the date of the Iliad 2707 years from the beginning of the present century; but venerable as the authority of the Parian marbles may appear, they seem to assign a later date to the great poet than his writings, and the manners of society which he describes, render probable. It is more consistent with his writings to suppose, that he was born not long after the siege of Troy, and that he had finished both his poems half a century after the town was taken. As the first interesting stories he heard when a boy were those of the exploits performed in the Trojan war, in his riper years he had still an opportunity of conversing with the old men who had been engaged in it. Their immediate descendants would, according to this supposition, be his contemporaries; he might know their grandchildren, and live to see the birth of the fourth generation. It is true, that this hypothesis makes the birth of Homer prior to the Ionian migration, which Thucydides places 80 years after the siege of Troy; but in this there is no solid objection, as we know that there were Ionians in Asia prior to the colony of that name being brought thither. The circumstance of Homer ascribing double the strength of modern men to one of the heroes of the Iliad, is no decisive proof that he looked back to a very distant period. Such fanciful exaggerations of the strength of men's immediate ancestors may be found in many romances of the middle ages, that must have been composed within fifty years of the lifetime of those personages to whom the poet ascribes a size and strength surpassing sober belief. The account which Homer gives of the family of Æneas continuing to reign over the Trojans after the Greeks had demolished Troy, though at variance with Virgil's fable, (a circumstance of no great consequence as to its credibility,) has all the air of having been drawn from contemporary information. Such an account of the family of Æneas it would have been difficult, as well as useless, for Homer to have forged. Now the succession of Æneas's great-grandchildren to the kingdom of Troy is the latest fact which the poet has left on record. The Æolian migration most probably disturbed that very generation in their possessions; and from Homer, who is ever minute in his historical accounts, being silent respecting such a disturbance, it may be inferred, that he did not live to be acquainted with it. The other and later era which has been assigned to our poet, makes him contemporary with Lycurgus; and, connected with it, there is a tradition of Homer and the law-giver having met in the island of Chios. But the picture of society which Homer exhibits, does not accord with this tradition. When we look to the verisimilitude of his descriptions, we must believe that he painted the natural world and all its manners from the life. There is no trace of his affecting to give it an antiquated air, or of wishing, as a modern poet would probably be inclined to do, to study simplicity of objects for picturesque effect; on the contrary, whenever he luxuriates in description, it is in painting artificial objects. Those who bring down Homer, therefore, so low as the time of Lycurgus, seem to forget that such a poet and such a legislator belong to different states of society. It has been questioned, and indeed it appears more than questionable, if the art of writing was known in the days of Homer. If we consult the poet himself upon this question, we shall find that in all his comprehensive picture of civil society, there is nothing that decidedly conveys an idea of letters, or of reading. The words Σηματα λυγρα, it is true, in the letter mentioned in the Iliad, which Bellerophon carries to the king of Lycia, have been quoted as a proof of alphabetical writing; but the generality of the term has much more the appearance of merely symbolical signs, or hieroglyphics, than of what we call writing. That such symbolical marks of thought were known in the rudest ages, there can be no doubt; and what has been already alluded to in the travels of the poet as a possible and even probable fact, namely, his consulting the records of different temples, must be taken with this understanding, that such records were, in all probability, also symbolical or hieroglyphical. The introduction of prose writing into Greece took place at so late a period, as to leave it by much the more probable supposition, that alphabetical writing was unknown to Homer; for when prose writing is of recent date, the alphabet cannot have been long in use. Homer, therefore, there is every reason to think, could neither read nor write; he recited his own works from memory, and hence it is little wonderful that he addresses the Muses as the daughters of that faculty of the mind. In modern times, when the memory is at once distracted by so many pursuits, and obliged to lean on so many artificial assistances, we are apt to under-rate its powers when employed upon a single object, and trained by habitual exercise upon that object. To an ancient poet like Homer, his memory was not only the mother of his muse, but his constant and indispensable guardian. The rhapsodists also preserved his works by oral tradition; and if their subsistence depended in a profession where there were rivals to detect the errors of each other, upon the accuracy with which they recited those poems, they were perhaps more safe from corruptions and interpolations, or at all events from omissions in recitation, than we might be apt to imagine, by ascribing the same lax exertions of memory to those reciters, which arise in modern times from the constant reliance upon writing. It may be doubted whether the rhapsodists made such havock in the sense of Homer, as the perverted ingenuity of *writing* commentators has made in that of Shakespeare.

Lycurgus, the legislator of Sparta, is said to have been the first who collected the fragments of Homer's poetry, during his travels in Asia Minor, and on his return by the island of Chios. Three hundred and seven years afterwards, Pisistratus, who erected at Athens the first public library that is mentioned in Grecian history, gave directions to a body of the learned for preparing an edition of the poet more correct than that of Lycurgus, and Solon and Hipparchus are said to have assisted in the undertaking.* At the destruction of Athens, in the invasion of Xerxes, the Iliad and Odyssey were taken from thence, and conveyed to Persia; and the despot himself seems to have respected this monument of taste and genius, since a part of the collection was found at Susa during the conquests of Alexander. It is perhaps to this epoch that we may assign the edition of the Odyssey which was rectified by Aratus, and which bears the name of the Aratæan edition. Alexander's enthusiasm for the memory of Homer is one of the noblest traits of his character. He charged Anaxarchus and Callisthenes to revise the copies of Lycurgus and Pisistratus; and Aristotle put the last hand to this precious edition, called the edition of the casket. After the battle of Arbela, when the conqueror had found, in the tent of Darius, a casket of gold, enriched with stones of inestimable value, he there deposit-

* Diog. Laert. Plut. in Hipparcho.

ed the two poems of Homer, and laid the treasure along with his sword every night under his pillow. After the death of Alexander, Zenodotus of Ephesus was charged, by the first of the Ptolemies, with the task of revising the edition of the casket. The last edition belonging to this period of high antiquity is that which Aristarchus, the greatest critic of his age, published under the auspices of Ptolemy Philometer, about nineteen centuries and a half ago, and which has served as a model for all collections of the works of Homer both in the middle ages and modern times.

The first edition of Homer since the invention of printing, was that of Demetrius Chalcondyles of Athens, and of Demetrius of Crete. It is entirely in Greek, is very magnificent, and now exceedingly scarce. It appeared at Florence in December 1488, in one folio, and had been collated with the commentaries of Eustathius. It was not till half a century after, that the works of Homer appeared again in Greek, with the entire commentaries of Eustathius.* This edition, the only complete one of the commentary of Eustathius, had long been regarded as a *chef d'œuvre* of sound criticism and correctness, till the learned discovered innumerable faults in it, by comparing it with MSS.; and the improvement of taste at last threw contempt on the barren prolixity of the commentary. Six years after the Roman edition of Eustathius, there appeared at Leyden the first esteemed edition of the prince of poets that had a Latin version. It contained also the scholia of Didymus, a commentator assigned to the age of Augustus. We notice here only those editions which may be said to form an epoch in the illustration of Homer. Joshua Barnes brought out at Cambridge the Greek and Latin texts of Didymus, with his own commentaries. The edition of Samuel Clarke appeared at London in 1734; that of Ernesti at Leipsic in 1764. Villoison, who was sent to Venice by the French government to collect ancient relics of literature, found in the library of St. Mark, an unique copy of the Iliad of the 10th century, with the remarks of sixty of the most famous critics of antiquity, such as Aristarchus and Zenodotus. It appeared, that this manuscript had been made from a copy in the library of the Ptolemies that was burnt by the barbarian Omar. Villoison remained two years at Venice to copy it with his own hand, and printed it in a folio volume, entirely Greek. As the original possessor of this literary treasure had joined to it many various and lost editions of the poet, this publication of Villoison may be called the *Homeri variorum* of antiquity. Wolff and Heyne are the two latest editors of Homer. Their merits have been so frequently treated of in the reviews and literary journals of our own time, that we forbear to descant upon them.

The memory of the great poet has received not only the homage of commentators and editors of his works, but of travellers, who have carried the reader's imagination to the scene of his action. Among these may be noticed Tournefort, the French naturalist, who understood the classical as well as his favourite vegetable world. Richard Pococke also carried his researches into Greece, though with less satisfaction to the public curiosity than into other quarters. Lady Mary Montague visited the Troad, though somewhat hastily, and saw, or imagined that she saw, the tomb of Achilles. Doctor Chandler visited Asia Minor and Greece in 1764-66, and made some conjectures that have not received much credit. In conjecturing the exact situation of Troy, and of the scene of Homer's travels, modern travellers have not been more successful than the ancients. Wood, who, on many points, makes ingenious and probable conjectures, is far from having settled the controversy of the Troad; and Chevalier and Gell, who succeeded him in the same attempt, have been less learned and much more gratuitous in their suppositions. To the real admirer of Homer, the controversy will probably appear of less importance than it has been made. For the difficulty of finding, at the end of 3000 years, the site of a town, of which an ancient poet says, that, in his own time, the very ruins had disappeared, (*etiam periere ruinæ*,) there is surely an apparent and sufficient reason in the changes and ravages which 30 centuries can produce. By such a difficulty, no sober mind would consider itself bound to adopt the wild idea, that no such war as the Trojan ever existed; although that supposition would render the Iliad a much more astonishing production than it really is.

The critical judgments that have been passed upon Homer would fill entire libraries. Horace assigns him a place as a moral teacher above Chrysippus and Crantor, the leaders of the two most famous schools of philosophy. Porphyry, in later times, composed a treatise on the philosophy of Homer. On the other hand, Pythagoras has condemned him to Tartarus, for having imparted false notions of the Divinity, and Plato banished him from his ideal republic. Yet, amidst the abstracted and elevated ideas of the latter philosopher, it is easy to perceive the most forced and sophistical reasons in his motives for condemning the poets, and he even redeems our opinion of his taste by the manner in which he ordains this banishment to be put in force. Plato, it should be recollected, admits in nature only two existences, the original idea, and the being which is the resemblance of or copy of that idea. By the original idea he understands God, or the Divine thought, and by the other existences all the forms which God created conformably to his own conceptions. All objects being then only copies of this first model, the arts which imitate them produce only copies of copies, which can serve for no good purpose. If then, says Plato, (speaking of his own ideal republic, which can hardly be called even the copy of a copy,) a poet should present himself amongst us who knows how to express every thing in nature by imitation, we should testify our veneration for him as for a sacred person, who deserves to be admired and cherished; but we should tell him that our political economy did not admit of such persons among us, and we should send him to another city, after having sprinkled him with perfumes, and crowned his head with flowers. It must be owned, that even the vanity of a poet could hardly be offended with such a sentence. When Plato comes to speak of Homer himself, it is with the deepest reverence for his genius. He owns that the respect and love which he has felt since his infancy for his writings almost arrests his tongue from condemning him, and that he considers him as the maker of all poets who have succeeded him, particularly those of the drama. After this apology, he demonstrates at great length that the gods of the Iliad are calculated to give us unworthy notions of divinity, a fact which, *philosophically* considered, it is not very difficult to prove. To exculpate Homer from this heavy charge, both his ancient and modern admirers have recourse to allegory; and in this system of explaining the Iliad, have mixed a vast deal of absurdity with a very small portion of truth. It is true that there was allegory and emblem both in ancient religion and philosophy; and some of the fictions of Homer carry their allegorical meaning in their appearance. But to see nothing in the whole Iliad but

* With the following title, *Homeri Ilias et Odyssea, Græce, cum Commentariis Græcis Eustathii, Archipiescopi Tessalonicensis; Romæ, apud Bladum et Giuntum,* 1542 and 1550, 4 vols. in folio.

moral abstractions personified, is an idea as intolerable to common sense as to poetical feeling. Such a forced explanation of the Iliad would after all leave the poem quite as immoral as it is in its plain interpretation. Suppose we take Jupiter for the power of God, Destiny for his will, Juno for his justice, Venus for his mercy, and Minerva for his wisdom, we shall still find the theology of Homer as defective as if we take things as they are in the Iliad; that is, if we understand his deities to be influenced by the passions of men. Homer painted the gods just as the vulgar belief represented them. It was impossible for him to have done otherwise, for he could not create a new religion; but if we could suppose it possible for him to have surpassed the limits of human intelligence, and to have anticipated the higher notions of Plato respecting the divinity, it would not have been his interest as a poet to have refined his mythology into the pure theism of the philosopher. The moment that he had ceased to consider the inhabitants of Olympus as impassioned beings, there was an end to all our interest in their actions. Divinity, in its true attributes, is not a subject for romantic fable.

The touch-stone of more recent refinement in sentiment and manners has been applied with the same absurdity to his heroes, as the standard of pure theology has been to his divinities. In the times which he described, the power of a man's body constituted the greater part of his estimation in society. He who could support the heaviest load of armour, and who could give and take the hardest blows, was a formidable man or a hero. When this superiority was once recognised, it established his rank in exact comparison with others; and hence it is so common in Homer's heroic descriptions to hear a warrior of acknowledged bravery confess that another is superior to him. At present the equality of arms and the principle of honour would make a man ashamed of such a confession. But in Homer, Æneas says without shame to Achilles, "I know that thou art more valiant than me," which is, in other words, "I know that thou art stronger." Æneas adds, "*but, however, if some god protects me, I shall be able to conquer.*" And this is a general principle, which to a certain extent may be said to constitute all the morality of the Iliad, namely, that power, success, and wisdom, all come from the gods. When Agamemnon excuses his outrage upon Achilles, he says that some god had disturbed his reason. It is the protection of this or that divinity that gives the Greek and Trojan heroes each a triumph in his turn; it is the gods who spread consternation among the armies, or inspire them for the combat; but we must not regard this intervention of the deities as diminishing the glory of the successive warriors. We see clearly that Homer does not lessen their importance on that account. On the contrary, the epic spirit of the piece is heightened by this machinery; because it is clearly perceived, that the heroes thus favoured of heaven, rise in the opinion of their associates and adversaries on that account. Achilles excepted, there is not a hero of the Iliad who does not at some time or other retire before another. What distinguishes the bravest, such as Ajax and Diomede, is, that they fight as they retreat. And it may be observed, to the glory of Homer, that, in spite of this divine intervention, which we might expect to confound all distinctions of human bravery, he still preserves the distinctive character of greatness in his heroes, even when yielding to supernal influence.

It is a singular trait in the Iliad, that the sullen rest of its hero Achilles should form the main-spring of the action. His absence appears to be the cause of the disasters of his countrymen, which prolong the contest. This, so far from being a defect in the plan of the action, is an artifice which carries internal evidence of the whole plan being the invention of one great mind; all the prowess of the successive agents that are described, ministers to the ultimate triumph of him by whom Hector is to fall. In the fire and spirit of this ancient hero, Homer has not certainly left what it would be absurd to seek for in ancient poetry, a model of pure morality; but he has consummated the picture of all that must have commanded the respect of warlike and barbarous times, and has in fact pourtrayed a being that would, under different circumstances, in all ages predominate over the rest of his species, by his pride and energy. It may be necessary to notice the vulgar tradition of his being invulnerable all over but in the heel; but Homer does not debase the courage of his hero by such a fable: nor is his character of stern pride unrelieved by circumstances that touch us with an interest in his fate. His youth, his beauty, his maternal descent from a goddess, the certain prediction that, while he could find no conqueror, he was one day to perish in the Trojan war, prepare us for the part of no vulgar hero.

To enter on a minute criticism of the Iliad would far exceed our limits. The most superficial readers are probably acquainted with the hackneyed objections that have been made to its prolixity of speeches and military details; to the minuteness and surgical description of wounds; the ferocity of its manners, and the abusive epithets which the heroes exchange when they quarrel. The French criticism of La Motte and Perrault has gone even so far as to blame the simplicity of its manners, and to throw contempt on Achilles for cooking his own dinner. The majority of those objections are frivolous. It is true that the primitive abundance of expletives, and the Greek loquacity of Homer, may at times be excessive; but the dramatic air which the constant dialogue gives to the Iliad, would be ill exchanged for the conciseness of mere narrative. The diversity of Homer's battles, as an eminent critic has observed, shews an invention next to boundless; the technical terms of the wounds that are described appear technical to us, only because the language of science is derived from Greek; and the fastidious taste that is offended with the bold simplicity of ancient manners, would with equal propriety find fault with Salvador Rosa for not having adorned his mountain scenery with terraces and gravel-walks. Achilles cooking his dinner is certainly a considerably more poetical personage than Louis the XIV. would have been, if La Motte had made him the hero of an Epopee, treading on a velvet carpet, and commanding the maitre d'hotel to prepare his fricasees.

The excellencies of the Iliad, independent of the beautiful and sonorous language to which it belongs, may be summed up in the vastness and variety of the picture of existence which it spreads before us; the spirit and perpetual motion of its agents; the relieving interchanges of an interesting inferior world, and a heaven of voluptuous and gay mythology; the progressive swell and importance of the story; and the art with which the very rest of Achilles is made subservient to the evolution of his grandeur; the full physiognomy of human character displayed in every age and situation of life; the unstudied strength of his circumstances in description; and the contagious spirit with which he seizes the mind to sympathy with his martial passion: Such an apocalypse of life, from its sublimest tumults to its minutest manners, was never communicated by another human imagination.

If Homer has erred at all, it is from the wealth, or rather from the pathos, of his genius, in giving so strong a countervailing interest to the character of Hector. This unquestionably diminishes our exultation in the triumph of Achilles. Yet who would wish that fault undone? Here is the generosity of genius, even in the poet, scorning the bigotry of national hatred that would depreciate the heroism of an enemy. It is, perhaps, repeating superfluously, what few have to be told, that the character of Achilles, so unlike the *inexorabilis acer* of Horace, has a relief of the noblest traits of compassion and generosity amidst the fury of his savage passions. The concluding book of the Iliad teems with the most touching circumstances of his generosity. He receives King Priam; joins him in his tears at the recollection of their respective losses; perfumes the body, and orders it to be kept out of the father's sight, lest it should shock the grief of the king; places it himself in a litter, fearing that Priam might burst into a fit of exasperation, and should exasperate himself also; and, finally, refreshes him with food and sleep in his tent, and takes him by the right hand as a friend. In recognizing such traits of compassion in the proverbially savage Achilles, one is tempted to believe, that humanity is not so modern a virtue as some would have us believe.

The Odyssey speaks less to the imagination than the Iliad, but it introduces us to a still more minute and interesting view of ancient manners, and it awakens with deeper effect the softer passions that appear but rarely in the other poem. It is strange, that La Harpe, who redeems much of his bad French taste by an apparently sincere enthusiasm for the genius of Homer, should say, that the Odyssey is devoid of the eloquence of sentiment. If by sentiment we mean the sickly misanthropy, or the rampant enthusiasm which distinguishes so many modern productions, there is certainly nothing of the kind in the Odyssey; and the difference of circumstances in which human nature was then placed must be fairly estimated,* before we can even pardon many maxims of moral conduct which Ulysses practically avows: but if by sentiment we mean the unsophisticated feeling of the heart, where, it may be asked, shall we find it, if it is not found in the pathetic situations of Telemachus, the conjugal love of Penelope, and the return of Ulysses to his home, with all the circumstances that attend it, his aged dog expiring with joy at his feet, and his father relating to him, while he retains his disguise, all the little circumstances of his childhood that could awaken his tenderest associations?

Besides the Iliad and Odyssey, Homer is said to have composed another poem, entitled *Margites*. It is now lost. It is said by some to have been a comedy; but, from some verses in the contest between Homer and Hesiod, it may be rather conjectured to have been a piece of mockery and satire. Margites is the name of a person in a verse that is preserved by Plato, who is described as knowing many things, and knowing nothing well. Such a character may have been the original hero of Homer's satire, and been thus damned to everlasting memory, like the Mac Flecknoe of Dryden. The little mock heroic of the *Battle of the Mice and Frogs*, is well known, from Parnell's translation, to the English reader. Professor Heyne supposes it spurious, because he finds scarcely any verses in it that breathe the spirit of Homer; but this is no decisive argument, as Homer might be the worst of all parodists, though the best of original poets. The hymns attributed to him deserve more attention, as, along with those of Callimachus, they form a curious historical monument of the popular superstitions of antiquity. Unfortunately, in the numerous collection of them which Clarke's *Homer* exhibits, there is only one, perhaps, viz. the *Hymn to Apollo*, which is not apocryphal; and the scholiast of Pindar throws doubts even upon that one. But Thucydides recognised in that ode the touch of Homeric genius, and the suffrages of a scholiast has certainly no right to be put in competition with that of so elegant a writer. As to the epigrams that have been occasionally ascribed to him, they carry internal proof of their spuriousness. (*z*)

HOMICIDE, (*Homicidium*,) in law, is the killing of any human creature. This act is of three kinds, according to the circumstances in which it is perpetrated, viz. *justifiable*, *excusable*, and *felonious* or *culpable*.

Homicide is *justifiable*, when the act is committed under some unavoidable necessity, and infers no degree of guilt or blame; as, for instance, by virtue of such an office as obliges one, in the execution of public justice, to put to death a malefactor, who hath forfeited his life by the laws and verdict of his country. This act is also considered justifiable in some cases, either for the advancement of public justice, or for the prevention of some atrocious crime.

Homicide is *excusable*, when a person engaged in a lawful act is, without intention, the cause of another's death. Excusable homicide is of two kinds; either *per infortunium*, by misadventure, or *se defendendo*, in self-defence, including homicide upon *chance-medley*, whereby a man kills another, who assaults him, in the course of a sudden brawl or quarrel.

*Felonious* or *culpable* homicide has different degrees, which distinguish the offence into *manslaughter* and *wilful murder*; in the last of which, the act, being committed from malice and forethought, admits of no defence, and subjects the criminal to the highest punishment of the law. See Blackstone; Erskine; and Hume *on Crimes*. (z)

HOMOLOGOUS Sides and Angles. See Geometry.

HOMOPHONI, in music, denotes the unison whose ratio is 1=1, and whose expression in Farey's notation is 0. See First *Minor*.

HONAN. See China.

HONDURAS, or Hibueras, a maritime province of the Spanish kingdom of Guatimala in America, which the Spaniards calculate to extend 185 leagues from north to south, and 50 from east to west. The surface is in general mountainous, and is intersected by deep vallies, conducting numerous rivers down to the sea; but part of the

* Many Oriental countries retain to this day manners of society nearly similar to those described in the Odyssey. There is nothing more remarkable in those manners than the degree of refinement to which profound dissimulation is carried in all ranks. The stranger accommodates his language much less to his own sentiments, than to his hopes and fears, or the countenance of those he meets. The arts of disguise are, in those countries, the great arts of life; and the character of Ulysses would form a perfect model for those who wish to make their way with security and respect. Cruelty, violence, and injustice, are also so evidently the result of defective government, that it is unnecessary to look for any other general cause of the scenes of this sort with which Homer abounds, in common with other ancient writers, and agreeable to the present manners of those countries. For, when every man is, in a great measure, judge in his own cause, vices of this class are not only more frequent, but, in *foro conscientiæ*, less criminal than in a civilized state, where the individual transfers his resentments to the community, and private injury expects redress from public justice. Where the legislature does not engage for our personal security, we have a right to use such means as are in our power to destroy the aggressor who would destroy us. In such cases, bodily strength and courage must decide most contests, while, on the other hand, craft, cunning, and surprise, are the legitimate weapons of the weak against the strong. In the heroic times, homicide was so common, that we see the poet alluding to a fugitive murderer taking shelter under the roof of a stranger, (to escape, not public justice, but the revenge of the relations of the deceased,) as a familiar occurrence in life.

coast is extremely low and marshy. A hot and humid atmosphere renders the province unhealthy, unless on the shore, where regular breezes refresh the inhabitants; and here epidemical diseases rarely prevail. Thunder showers are frequent during the warmest season, sometimes raging with great violence. This province is penetrated by a large bay, called the Bay of Honduras, to which our notice shall be more particularly directed: the coast abounds in dangers to the mariner from rocks and shoals; and all along its margin are keys, that is, peninsulas or promontories, between creeks and the mouths of rivers. These keys are known by different names, as St George's key, Turneff key, Ambergrease key, and the like; and some of the islands pass by the same denomination.

Some authors affirm, that gold and silver are found in Honduras; but, according to the late traveller Humboldt, it scarcely presents any metallic mines. Vegetation is in remarkable luxuriance, and the plants numerous and diversified. Grapes are produced twice a year from the vines; sugar canes, coffee, cotton, and indigo, are abundant, and also grain of several kinds; but the inhabitants are too indolent to avail themselves of the benefits of nature. The most important plants, in a commercial view, are mahogany and logwood; the former is employed for all descriptions of furniture in Britain and America, and the latter for dyeing. Chiefly for the purpose of obtaining these two commodities, a British settlement has long been established in the Bay of Honduras; and a vast quantity of the former is exported annually. The mode of procuring it, is to dispatch a skilful negro to climb the highest trees on lofty places, for the purpose of discovering mahogany in the woods, which is generally solitary, and visible at a great distance, from the yellowish hue of its foliage. A gang of from ten to fifty slaves is then sent out to erect a scaffold around each tree that is selected, and to cut it down about twelve feet from the ground. When felled, the logs are, with much labour, dragged to the banks of the streams, and being formed into rafts, sometimes of 200 united, are floated as many miles, to places where the rivers are crossed by strong cables, and then the owners separate their respective shares. It is said that the boughs and limbs afford the finest wood, but in Britain mahogany is more valued on account of size; and none is allowed to be exported to the United States of America exceeding 20 inches in diameter. The logwood, on the other hand, affects low swampy grounds, growing contiguous to fresh water creeks and lakes, on the edges of which the roots, the most valuable parts of the wood, extend. It is sought in the dry season, and the wood-cutters having built a hut in the vicinity of a number of trees in the same spot, collect the logs in heaps; and afterwards float up small canoes in the wet season, when the ground is laid under water, to carry them off. This is considered a very unhealthy employment.

Many wild animals inhabit the province, among which are two kinds of tiger, as generally described; but they are more probably of the leopard species, the Brasilian and black tiger. Both of them are fierce; they are said sometimes to attack man; but their depredations are chiefly confined to cattle. The tapir, which is nearly the size of a small cow, is reputed to inhabit the thickest parts of the forests, in the neighbourhood of creeks and rivers, and is very rarely to be seen by day. There are different kinds of wild hogs, three species of the armadillo, and numerous monkeys. Of birds may be named the turkey, concerning whose native country naturalists have expressed doubts; but here it lives in pairs in the most sequestered recesses of the woods, and cannot easily be taken alive. It never survives in captivity, and the young hatched from eggs, generally wander away to the original haunts of the mothers. The toucan, oriole, macaw, and pelican, are common. A great quantity of honey and wax are obtained from the bees of this country, which construct their combs in holes of the earth. The rivers abound in fish; and the manati and turtle are the constant objects of pursuit on the shores.

In regard to the inhabitants of Honduras; the total population of the province, consisting of natives, Americans, Spaniards, and English, with African slaves, is said to have diminished. We are quite ignorant of any calculations as to its amount; but that of the British settlement in the Bay of Honduras is computed at about 3700, or somewhat more, of which there are 200 white inhabitants, rather more than 500 people of colour and free blacks, and 3000 negro slaves. Neither are we acquainted with the precise geographical limits of the settlement, or the number, extent, and position of the towns belonging to the Spaniards. Formerly the principal English establishment was at St George's Key, which is a healthful and agreeable situation, still containing a number of good houses, but now it is at Balize, a town at the mouth of a river of the same name, called Wallix by the Spaniards. It consists of about 200 houses, many of which are spacious and well finished; all are built of wood, and for the most part raised 8 or 10 feet from the ground on mahogany pillars. An agreeable and picturesque effect is produced by groups of lofty cocoa trees, and the foliage of the tamarind thickly interspersed, while they afford to the inhabitants a grateful shelter from the fervour of the sun. This town is accessible to an enemy only from the sea; for it is totally environed behind by a morass, extending many miles into the country, which, during the rainy season, is nearly covered with water. A strong fort lately erected in a commanding situation guards the channel of approach; and the inhabitants have formed a militia as a farther means of defence.

The principal trade of the British settlement consists in the export of mahogany, logwood, and tortoise shell; while the articles of import are chiefly for the consumption of the settlers, being those of British manufacture, and salted provisions for the slaves. They also obtain cattle from the Spaniards, who, besides, carry on considerable traffic in cotton bed-covers, which are much esteemed in that province. The Bay of Honduras is reckoned a very favourable situation for trade; and the preservation of the settlement occasions no expence to government, as the revenue somewhat exceeds the expenditure.

During the last and preceding century, the coast and islands of Honduras were a great resort of pirates, who found sufficient subsistence and concealment to enable them to commit their ravages against defenceless vessels. On the largest island, called Ruatan or Rattan, about 30 miles long, rich and fertile, there is a small Spanish outpost; but, according to Philip Ashton's *Memorial*, it was uninhabited in 1723. Previous to the year 1763, English mercantile adventurers had established themselves on the coast, at which time the court of Spain admitted them to remain, on condition that their fortifications should be demolished. However, all were taken prisoners or dispersed in 1782; and having been enabled to return in 1784, under a treaty with the Spanish government, they finally settled at Balize. Here they remained undisturbed until the year 1798, when the Spaniards, having fitted out an armament, made an attempt to capture the town. They were speedily repulsed, and the colony has never since had to dread any enemy. See Alcedo *Diccionario*; Uring's *Voyages and Travels*; Ashton's *Memorial*; and Henderson's *Account of the Settlement of Honduras*. (c)

HONEY is a saccharine vegetable secretion, most abundant in the nectarium of flowers. Some authors consider it an elementary principle of all vegetables without exception: They suppose that it exists in every part of plants, and that their life is dependent on its presence. We do not know, however, that the saccharine matter of plants is universally convertible into honey. It is much more copiously diffused in certain flowers than in others, both of the same and of different species: in some it cannot be recognised, and the weather has always a powerful influence on its secretion. A hot and sultry atmosphere, charged with electricity, is considered most favourable to the production of honey. Honey seems to be of various quality, sometimes of a grateful taste and odour, sometimes pungent and bitter, or even of a deleterious nature, which probably originates from the flowers.

This substance appears in its sensible shape when collected by bees, a tribe of insects which may almost be considered as reduced under the dominion of man. But naturalists are not agreed whether honey undergoes a particular elaboration in their bodies, thence deriving its flavour and consistence, or whether it is merely collected, and is still seen in its pristine state. A bee having entered a flower, apparently absorbs the liquid nectar by its proboscis, whence it is conducted to an intestinal sac exclusively appropriated for its reception, commonly called the honey bag. The animal is then plump and cylindrical, and returning to the hive, disgorges the contents into cells selected for that purpose. By repeated accumulations the cell is filled, and then sealed by concentric circles of the thinnest wax, begun at the circumference and closed in the centre. There it is kept, as is supposed, for winter store; at least no other use is assigned to it: but we cannot be sufficiently reserved in classing distant anticipations among the instincts of animals. It is principally in the more civilized countries that bees are confined in hives. In many places, they form their combs in trunks of trees, and also in cavities of rocks, and the earth. In India, there is a species which constructs a single comb of very large dimensions, attached to the under part of the bough of a tree well sheltered. During winter, a great portion of the honey thus preserved is undoubtedly consumed; and it is understood that the safety of an ordinary hive is endangered, if there be a smaller quantity than twelve pounds at the end of autumn. Honey is supposed by some of the most acute naturalists, as Huber, to contain the principles of wax, whence the bees are enabled to build their combs without collecting it from vegetables; and he describes a method of arranging a hive, whereby they may be forced to work in this substance. The relative proportions of honey and wax in a hive are not ascertained; the latest observations allot about three or four pounds of wax to one hundred of honey.

The finest honey is collected by swarms leaving the parent hive, and it always becomes darker and coarser in proportion to the age of the combs. Its quantity and quality, both depend very much on the nature of the surrounding vegetation; hence in cultivating bees, particular attention should be paid to the abundance of flowers. Honey and wax are very considerable articles of traffic, and profit may undoubtedly be derived from bees with little trouble and trifling expence. Most part of the honey imported into Britain comes from Germany, Russia, and America, with which we could very well dispense by a little more attention to bees. Probably ten times the number of hives now existing could be subsisted in the country. Mr Huish, a late author, by a moderate calculation, endeavours to show, that in the year 1817, the profit from one hive purchased in 1812 should be 57*l.*: 15: 4, while ten remain to carry on the stock. He considers the chief obstacle to the culture of bees to centre in the use of the common hive; and that, on the whole, it is better that they should be destroyed at the end of the season.

The combs being withdrawn from the hive, are to be laid on a fine sieve above a vessel, into which the best honey will be received: gentle heat will disengage the next in quality; and the whole remaining mass may be then subjected to a press, whereby the remainder will be extracted. A certain quantity of wax and other impurities always pass over, which renders it necessary to expose the honey contained in the vessels again to heat, and this admits their rising to the surface, when the whole can be removed. The purification of honey is conducted after a different process, according to the country wherein it is practised: and premiums have been offered for the best mode of doing so on the continent. Honey should be chosen of an agreeable odour, sweet, clear, and new; but it may be preserved a year or longer in the comb, still retaining most of its properties. See Huber, *New Observations;* Huish, *Treatise on Bees;* Reaumur, *Memoires sur les Insectes;* Bonner *on Bees;* and our article Bee. (*c*)

HONITON, a burgh and market town of England, in Devonshire, is situated in a delightful vale, upon a gentle eminence, on the south side of the river Otter, commanding a fine view of the surrounding country, which is extremely beautiful. It consists chiefly of a spacious and handsome street, running from east to west, through which passes the high road from Exeter to Chard. Two other streets cross this at right angles, one on the north-west leading to Cullumpton, and the other on the north leading to Taunton. Through the principal street flows a stream of pure water, which the inhabitants receive from a dipping-place opposite almost every door. The buildings, which are almost all modern, were covered with slate, in consequence of the town having been twice destroyed by fire in 1747, when three-fourths of it were reduced to ashes, and, in 1765, when nearly 180 houses were consumed. In 1790, and 1797, it suffered considerably from fire. There is a chapel in the town, called All-Hallows chapel, which is a neat structure, with a square embattled tower of flint. It was built in 1765. The church is situated on a high eminence, about three quarters of a mile from the town, and contains some ancient monuments. There is here a small free-school for boys, and a school of industry for girls; and three meeting-houses for the Presbyterians, Baptists, and Independents.

The town is governed by a portreve and bailiff, who are chosen annually. It sends two members to Parliament. The number of voters is 350. The chief articles of manufacture here are broad lace and edgings, which are principally sent to London. A great trade is carried on in butter, which is also sent to the London market.

The following is the population abstract of 1811, for the burgh and parish:

| | |
|---|---|
| Number of inhabited houses | 581 |
| Number of families | 581 |
| Do. employed in manufactures | 349 |
| Males | 1280 |
| Females | 1455 |
| Total population | 2735 |

See Polywhele's *History of Devonshire;* and the *Beauties of England and Wales*, vol. iv. p. 299.

HOOF. See Veterinary Medicine.

HOOGHLY, a river in Bengal, and the port of Calcutta, is formed by the junction of the Cossimbazar and Jellinghy, the two westernmost branches of the Ganges.

The Hooghly, though by no means the largest branch, has the deepest outlet to the sea, and is considered by the Hindoos as the true Ganges, or most sacred part of that river. It is the only branch which is commonly navigated by large vessels; but its entrance and passage are nevertheless extremely dangerous, not so much from the shallowness of the channel, as from the number of the sand-banks which project into the sea. At its junction particularly with the Roopnarrain, there is a large sheet of water formed, which is full of shoals; and, as the bed of the Hooghly turns to the right, many vessels are lost, by being carried, with the force of the tide, up the Roopnarrain, which more directly faces the approach from the sea. There is also, at this bend of the Hooghly, a dangerous sand, named the James and Mary, around which the channel seldom continues the same for eight days in succession, and requires very frequent surveys. The bore, which commences at Hooghly point, where the river first contracts itself, is perceptible above the town of Hooghly, nearly seventy miles distant; and so rapid is the progress of the tide, that it passes through this extent in four hours. It does not run on the Calcutta side; but proceeds along the opposite bank, from which it crosses at Chitpoor, about four miles above Fort William, and rushes with great violence past Barnagore, Duckinsore, &c. At Calcutta, it sometimes occasions an instantaneous rise of five feet, and, upon its approach, it is necessary for boats to quit the shore, and go for safety into the middle of the river. (*q*)

HOOGHLY, a district in the province of Bengal, extends along both sides of the river Hooghly, and is situated principally between the 20° and 23° of North Latitude. It is bounded on the north by the districts of Burdwan and Kishenagur; on the south, by the sea; on the west, by Midnapoor; and on the east, by Jessore, and the Sunderbunds. It consists entirely of low, flat, and fertile land; but, though one of the earliest of the East India Company's acquisitions, and immediately adjoining to the town of Calcutta, where a constant market is found for its produce, three-fourths of it still remain in a state of nature, the habitation of alligators, tigers, and reptiles. The division nearest to the sea, particularly, is covered with jungle, and is remarkably unhealthy, and thinly inhabited. Salt of an excellent quality, (and possessing, in the opinion of the natives, a peculiar sanctity, because extracted from the mud of the most sacred branch of the Ganges,) is manufactured on the coast of the government. The whole district is intersected by rivers, so as to render it capable of complete inland navigation; but these remote streams are greatly infested by river pirates, who rob in gangs, and frequently apply torture for the purpose of extorting the discovery of concealed property. (*q*)

HOOGHLY, an ancient town in the last mentioned province, situated on the west side of the river of the same name, about twenty-six miles above Calcutta, in North Latitude 22° 54′, and East Longitude 88° 28′. It was a place of considerable importance under the Mogul government, and was the seat of their custom-house for collecting the duties of merchandize carried up the western branch of the Ganges. It is now comparatively of little note, but still tolerably flourishing, and well inhabited. The French, Dutch, Portuguese, and Danes, had originally factories at Hooghly; and, in 1632, while in the possession of the Portuguese, it was the scene of the first serious quarrel between the Moguls and Europeans. After a siege of three months and a half, it was carried by assault by the Mogul army, and the greater part of the Portuguese were put to the sword, or taken prisoners. In 1640, the English were permitted to build a factory at this place; but their trade was greatly restricted, and subject to continual exactions. In 1686, they were involved in hostilities with the native powers. in consequence of a quarrel between some of their soldiers and those of the nabob; and though peace was speedily restored, they withdrew their settlement to Chittanuttee, or Calcutta. See Bruce's *Annals of the East India Company*; Rennel's *Memoir of a Map of Hindostan;* Lord Valentia's *Travels;* and Hamilton's *East India Gazetteer.* (*q*)

HOOKAH is the name of a pipe for smoking, in great use among eastern nations. It consists of a globular vessel of glass, nearly filled with water, in which two tubes are inserted; a perpendicular one which holds the tobacco, and an oblique one to which the mouth is applied. The smoke is thus rendered peculiarly agreeable, by passing through the water.

HOOKE, Robert, an eminent natural philosopher, was born at Freshwater, on the west side of the Isle of Wight, on the 18th July 1635, and for the first seven years of his life was in a very infirm state of health. His father, who was the minister of the parish, educated him under his own roof, as he had been such a sickly child that he was not expected to live. He was at first intended for the church; but after beginning the Latin grammar, his health became so weak, and he was so much subject to headache, that his parents despaired of making him a scholar. Being thus left to the direction of his own genius, he amused himself in the formation of toys, and he even succeeded in the construction of a wooden clock, that exhibited in a rough manner the hours of the day, and in the formation of a full rigged ship, about a yard long, which had a contrivance for firing some small guns as it sailed across a piece of water. This circumstance led his parents to the resolution of putting him an apprentice to a watch-maker, or a painter; but by the death of his father in 1648, neither of these plans were adopted. He was placed, indeed, for a time under the celebrated painter Sir Peter Lely; but he soon found from experience, that he had chosen a profession which the state of his health would not allow him to prosecute. He was therefore sent to Westminster school, and was kindly taken into Dr Busby's house, where he made great progress in Latin, Greek, Hebrew, and other oriental languages. He made also considerable progress in Euclid, and, as Wood informs us, he invented and communicated to Dr Wilkins *thirty different modes of flying!*

In the year 1650, according to Mr Wood, and 1653, according to Mr Waller, he went to Christ's Church, Oxford. In 1655 he was introduced to the Philosophical Society there. He was employed to assist Dr Willis in his chemical experiments; and he afterwards laboured several years in the same capacity with Mr Boyle. He received instructions in astronomy from Dr Seth Ward, Savilian professor of that science in Oxford, and was henceforth distinguished for the invention of various astronomical and mechanical instruments, and particularly for the air-pump which he contrived for Mr Boyle.

In consequence of perusing Ricciolus's *Almagest*, which Dr Ward put into his hands, he was led, in the years 1656, 1657, and 1658, to the invention of the balance or pendulum spring, one of the greatest improvements which has been made in the art of horology: (See Horology, chap. iii. p. 137.) He mentioned this discovery to Mr Boyle, who, as Dr Hooke remarks, "immediately after his Majesty's restoration, was pleased to acquaint the Lord Brouncker and Sir Robert Moray with it, who advised me to get a patent for the invention; and propounded very probable ways of making considerable advantage by it. To induce them to a belief of my performance, I showed a pocket-watch, accommodated with a spring applied to the arbor of the balance to regulate the motion thereof. This was so well approved of, that Sir Robert Moray drew me up the form of a patent; the principal part whereof, viz. the description of the watch so regulated, is in his own hand-writing, which I have yet by me. The discouragements I met with in the management of this affair, made me desist for that time." In the agreement between Dr Hooke, Mr. Boyle, Lord Brouncker, and Sir Robert Moray, which seems to have been drawn up about 1663, it was provided, that out of the first 6000*l.* of profit, Dr Hooke was to have three-fourths; of the next 4000*l.*, two-thirds; and of the rest, one half: but the other partners in the patent very improperly insisted upon the insertion of a clause, giving to any of themselves the sole benefit of whatever improvements they might make upon his invention.

About the same time Hooke contrived the circular pendulum, which was shewn to the Royal Society in 1663, and which was afterwards claimed by Huygens. This pendulum, which is described in Hooke's Animadversions on the *Machina Celestis* of Hevelius, does not vibrate backwards and forwards, but always in a circle, "the string being suspended above at the tripedal length, and the ball fixed below, as suppose at the end of the fly of a common jack. The motion of this circular pendulum is as regular, and much the same with those mentioned before; and was made to give warning at any moment of its circumgyration, either when it had turned but a quarter, a half, or any lesser or greater part of its circle. So that here you had notice not only of a second, but of the most minute part of a second of time." See Derham's *Artificial Clock-maker*, p. 97.

The establishment of the Royal Society in 1660, afforded to Dr Hooke numerous opportunities of extending his reputation. He published in 1660, a small tract on the ascent of water in small tubes by capillary attraction, in which he shewed that the height of the water was in a certain proportion to their bores. A debate arose on this subject in the Royal Society in April 1661; but Hooke's replies were considered so satisfactory, and raised him so high in the estimation of the Society, that in 1662 he was appointed curator of experiments to that distinguished body. He was also one of the 98 persons who were declared members of the Royal Society, at a meeting of the council held May 20th, 1663, by virtue of the power given them by the charter for two months. He was admitted to the society on the 3d of June, and was peculiarly exempted from all payments. In the same year he took his degree of Master of Arts, and the Repository of the Royal Society in the White Gallery of Gresham College was committed to his care. About this time he drew up a list of enquiries for the use of those who might have occasion to visit Greenland or Iceland. Those which respect Iceland are numerous and interesting; and one of them is particularly deserving of notice: "Whether spirits appear; in what shape; what they say and do; any thing of that kind very remarkable, and of good credit?" In May 1664, he delivered the astronomical lecture at Gresham College for Dr Pope, who was absent in Italy; and in the same year, Sir John Cutler gave him a salary of 50*l.* per annum, for reading a course of mechanical lectures, under the direction of the Royal Society. These lectures were afterwards published in 4to, in 1679, under the title of "*Lectiones Cutlerianæ*, or a collection of lectures, physical, mechanical, geographical, and astronomical, made before the Royal Society on several occasions, at Gresham College; to which are added divers miscellaneous discourses." On the 11th January 1664, the Royal Society settled upon him a salary of 30*l.* per annum for life, for his labours as curator of experiments; and on the 20th of March of the same year, he was appointed to succeed Dr Dacres as professor of geometry in Gresham College. In the year 1665, Hooke published his "*Micrographia*, or some physiological descriptions of minute bodies, made by magnifying glasses, with observations and enquiries thereupon." All the figures in this work were drawn with his own hand, and many of them are a kind of standard representations, which have been copied by succeeding authors. The best are those of the common mite, flea, louse, gnat, and ant. A new edition of it with abbreviated descriptions appeared in 1745, in which the baroscope, the hygroscope, and the engine for grinding optic glasses, were wholly omitted. During the recess of the Royal Society, on account of the plague in 1665, he accompanied Mr. Wilkins and other ingenious authors into Surry, where they continued their philosophical labours. In 1665, at one of the first meetings of the Royal Society, Dr Hooke produced a very small quadrant for observing the minutes and seconds, by means of an arm moved with a screw along the limb of the quadrant. His explanation of the inflection of a direct into a curvilineal motion, was read to the Society on the 23d May 1666.

On the 19th of September 1666, he laid before the Royal Society a model for rebuilding the city of London, which was destroyed by the great fire; but though his plan was not executed, he was appointed one of the surveyors under the act of parliament; a situation in which he realized a considerable sum of money, which was found after his death in a large iron chest, that appeared to have been shut up for 30 years. The irritable temper of our author now involved him in several quarrels, in all of which he conducted himself with impropriety. In our life of Hevelius, we have already given an account of his controversy with that astronomer respecting the comparative merits of plain and telescopic sights. In 1671, he attacked Newton's theory of light and colours; and in 1675 he had a warm dispute with Mr Oldenburg, the secretary to the Royal Society, in consequence of his pamphlet, entitled "A Description of Helioscopes, and some other Instruments, made by Robert Hooke," in which he complains that Oldenburg had not done him justice respecting his invention of pendulum watches. The dispute terminated by a declaration of the Royal Society, who took the part of their secretary. In 1676, he published his "Description of Helioscopes, and some other Instruments," a work which contains many curious inventions, some of which are described in anagrams. Upon the death of Oldenburg in 1677, Hooke was appointed to the vacant office of secretary; and while he held that situation, he published between 1679 and 1681 the seven numbers of the *Philosophical Collections*, which have always been regarded as a part of the Philosophical Transactions.

About this time the natural peevishness of his temper began to become quite intolerable: He claimed as his own the inventions and discoveries of every other person; and he became so reserved in communicating his own labours to the public, that though he read his Cutlerian lectures, and exhibited new inventions to the Royal Society, yet he never left any account of them to be entered in the registers. When the *Principia* appeared in 1686, he laid claim to the discovery of the doctrine of gravitation, a claim which was warmly resented by Sir Isaac Newton. Hooke, no doubt, had the merit of stating, that gravitation was the power which kept the planets in their orbits, and he even made some experiments to determine the law by which it was regulated; but what a vast interval is there between this conjecture, happy as it is, and the splendid discoveries of Newton!

In the year 1687 he suffered a severe loss by the death of his brother's daughter, Mrs Grace Hooke, who had lived several years with him; and the distress of his mind was still farther increased by a Chancery suit with Sir John Cutler respecting his salary. In 1691, Archbishop Tillotson employed him in contriving the plan of the hospital near Hoxton, founded by Robert Ash; and out of gratitude for his services, that distinguished prelate obtained for him the degree of M. D. When the Chancery suit with Sir John Cutler was determined in his favour in 1696, he was so overjoyed, that he left an account of his feelings in his diary, expressed in the following manner. "DOMSHLGISSA, that is, *Deo, optimo, maximo, sit honor, laus, gloria in sæcula sæculorum, Amen.*" "I was born on this day of July, 1635, and God hath given me a new birth; may I never forget his mercies to me! while he gives me breath may I praise him!" In order to induce him to complete some of his inventions, the Royal Society requested him in 1696, to repeat most of his experiments at their expence, but the infirm state of his health prevented him from complying with their request. During the two or three last years of his life he is said to have sat night and day at a table, so much engrossed with his inventions and studies, that he never undressed himself or went to bed. Emaciated with the gradual approach of old age, he died in Gresham College on the 3d March 1702, in the 87th year of his age, and was buried in St Helen's church, Bishopsgate street, his funeral being attended by all the members of the Royal Society who were then in London.

Besides the works which we have mentioned, he published in 1677 his *Lampas*, or *Descriptions of some mechanical improvements in lamps and water poises*.

The most important of Dr Hooke's inventions, was undoubtedly the method of regulating watches by the balance spring, which has since his time been carried to the highest perfection. Huygens has commonly been considered as the author of this invention, but there is no doubt that Hooke had invented it about 14 years before. The posthumous works of Dr Hooke, collected from his papers by Richard Waller, secretary to the Royal Society, with a life of the author prefixed, were published in 1705. Another life of Hooke was published in Ward's *Lives of the Gresham Professors*, p. 109. Lond. 1740. The papers which Hooke contributed to the Philosophical Transactions, will be found in volumes i. ii. iii. v. vi. ix. xvi. xvii. and xxii. of that work.

The following list of Dr Hooke's inventions is taken principally from a MS. of the late Dr Robinson, professor of natural philosophy in the university of Edinburgh.

1655. Hooke discovered that the barometer indicated changes in the atmosphere, and was connected with the weather. Before the year 1652 the same discovery was made by the Rev. Mr. Gregory of Drumoak. See our Life of JAMES GREGORY.

1655. Contrived the clockmakers' cutting engine.

1656. Contrived a 'scapement for the small vibrations of pendulums.

1656. Invented the spiral spring for regulating the vibrations of a watch balance.

1658. Contrived the Boilean or double barrelled air-pump.

1660. Used the conical pendulum for procuring a minute division of time.

1660. Explained capillary attraction by affinity.

1660. Found that the catenarian curve was the best form for an arch.

1663. Invented his marine barometer and sea gage, and also the method of supplying air to the diving bell.

1664. Invented a quadrant by reflexion, and a clock for registering the weather.

1664. Proposed the freezing of water in a fixed temperature; and in 1684 the boiling of water as another fixed point.

1664. Applied a screw for dividing astronomical instruments.

1665. Proposed to find the earth's parallax by means of a zenith telescope, also by observing the moon in distant places, and in a solar eclipse.

1666. Nov. 28. Invented the spirit level.

1668. Proposed his theory of combustion. See his *Micrographia* and *Lampas*.

1669. Proposed a pendulum, or a drop of water, as a standard measure. Proposed a camera obscura with a lamp.

1674. Invented the areometer.

1674. Tried the famous experiment with Newton on the inflexion of light.

1678. Proposed a steam engine on Newcomen's principle.

1679. Shewed that the path of a falling body compounded with the earth's motion is an ellipse.

1680. First observed the secondary vibrations of sounding bodies; that a glass touched with a fiddle bow threw water into waves at four points, and that the fundamental sound was accompanied with its harmonics.

1682. Observed the separability of heat and light by a glass plate.

1687. Observed the rapid propagation of sound through solid bodies.

Hooke appears also to have been the first who explained the rise of vapour by a dissolving power in the air, and who took a just view of the arrangement of iron filings round a magnet. See HEVELIUS and HUYGENS. ($\pi$)

HOOKER, RICHARD, an eminent English divine, was born at Heavitree, near Exeter, in the year 1553, or, according to Wood, in 1554. His parents, who were by no means in affluent circumstances, intended to educate him for some mechanical trade; but his schoolmaster at Exeter, having discovered his natural endowments and capacity for learning, prevailed with them to allow him to continue at school. His uncle, John Hooker, who was then chamberlain of the town, recommended him to Jewel, bishop of Salisbury, who, after examining into his merits, took him under his protection, and got him admitted into Corpus Christi College, Oxford, of which he was chosen fellow in 1577. Before this last period, however, Hooker had the misfortune to lose his patron; but his talents and excellent disposition soon procured him other valuable friends in Dr Cole, then president in his college, and Dr Sandys, bishop of London. The bishop placed so much confidence in Hooker's character, that he entrusted his own son to his care.

In 1577, Mr Hooker took his degree of M. A., and in the same year he was elected fellow of his college. In 1579, he was appointed deputy-professor of the Hebrew language in the university: but for some cause, which cannot now be ascertained, he and some others were expelled the college by the vice-president, to which, however, they were again restored in the course of two or three weeks. In 1581, he entered into orders, and was soon after appointed to preach at St Paul's Cross in London. Through the great simplicity of his character, he was, about the same time, entrapped into a foolish and unfortunate marriage with a woman who had neither beauty nor portion to recommend her, and who has been represented by Wood as "a silly clownish woman, and withal a mere Xantippe." In consequence of this imprudent step, he lost his fellowship, and was obliged to quit the university before he had obtained any preferment. He was therefore obliged to support himself as well as he could, until the latter end of the year 1584; when he was presented by John Cheney, Esq. to the rectory of Drayton-Beauchamp, in Buckinghamshire, where he led a most uncomfortable life with his wife Joan. In this situation he received a visit from his friend and pupil Sandys, in company with another pupil, Mr Cranmer, a grand-nephew of the celebrated Archbishop Cranmer. These young men found their learned and respected tutor in a common field, with a Horace in his hand, tending a small flock of sheep, in the absence of his servant, who had been called away to assist his mistress in some domestic business. When released from this duty, his friends accompanied him to his house, where they had an opportunity of witnessing the vexation and misery to which he was constantly subjected, from the churlish and capricious conduct of his wife. Upon their return to London, Mr Sandys acquainted his father with Hooker's deplorable situation, who took a warm interest in his concerns, and got him appointed master of the Temple, in 1585. Although this was a fine piece of preferment, Hooker soon discovered that London was not a place that suited his temper and disposition; and several circumstances conspired to excite in him the desire of obtaining the retirement of a country living. At the time when he was chosen master of the Temple, he got involved in a controversy with Travers, an afternoon lecturer there,—a man, it is said, of learning and good manners, but zealously attached to the Geneva government. This controversy led Hooker into a serious examination of the form and principles of church-government, which terminated in his celebrated work *Of the Laws of Ecclesiastical Polity*, the foundation and plan of which were laid while he was at the Temple. But in this residence he found himself incapable of carrying on the work to his own satisfaction; and he therefore entreated the archbishop, Whitgift, to remove him into some more quiet situation, in a letter which exhibits an interesting picture of that union of piety, simplicity, the love of learning and retirement, which formed the predominant feature of his character. "My lord," says he, "when I lost the freedom of my cell, which was my college, yet I found some degree of it in my quiet country parsonage. But I am weary of the noise and oppositions of this place; and indeed God and nature did not intend me for contentions, but for study and quietness. And, my lord, my particular contests here with Mr Travers have proved the more unpleasant to me, because I believe him to be a good man; and that belief hath occasioned me to examine mine own conscience concerning his opinions. And to satisfy that, I have consulted the Holy Scriptures, and other laws, both human and divine, whether the conscience of him, and others of his judgment, ought to be so far complied with by us, as to alter our frame of church-government, our manner of God's worship, our praising and praying to him, and our established ceremonies, as often as their tender consciences shall require us. And in this examination I have not only satisfied myself, but have begun a treatise, in which I intend the satisfaction of others, by a demonstration of the reasonableness of our laws of ecclesiastical polity. But, my lord, I shall never be able to finish what I have begun, unless I be removed into some quiet parsonage, where I may see God's blessings spring out of my mother earth, and eat my own bread in peace and privacy; a place, where I may without disturbance meditate my approaching mortality, and that great account, which all flesh must give at the last day to the God of all spirits."

In consequence of this application, he was presented, in 1591, to the rectory of Boscomb, in Wiltshire; and in the same year, he obtained other valuable preferments in the cathedral of Salisbury. At Boscomb he finished four books of his *Ecclesiastical Polity*, which were entered at Stationer's hall in the month of March 1592, but not printed till 1594. In the following year he quitted Boscomb, and was presented by Queen Elizabeth to the rectory of Bishop's Bourne, in Kent, where he resided during the remainder of his life, discharging the duties of his office in the most conscientious and exemplary manner. In this place he composed the fifth book of his great work, which was dedicated to the archbishop, and published by itself in 1597. He also finished the 6th, 7th, and 8th books, but did not live to publish them; and it has been much disputed whether we have these books genuine as he left them. In the year 1600, he caught a severe cold, in a passage between London and Gravesend, which produced a lingering and painful illness, that at length put a period to his life, in the 47th year of his age. He died on the 2d of November 1600. Notwithstanding the severity of his indisposition, he persevered in his studies to the last. A few days before his death his house was robbed. When informed of that circumstance, he enquired whether his books and written papers were safe; and being answered that they were, "then," said he, "it matters not, for no other loss can trouble me."

The personal character of Hooker may be gathered from the preceding narrative of his life. As an author, the church is indebted to him for the most profound and ingenious defence of ecclesiastical establishments that has ever appeared. His treatise on *Ecclesiastical Polity*, indeed, has been admired both at home and abroad, as a work of deep and extensive research, and of acute and sound reasoning: and the author has been universally distinguished by the honourable titles of "the judicious," and "the learned." Of this valuable work, Pope Clement VIII. is reported to have said, that "there were in it such seeds of eternity as will continue till the last fire shall devour all learning." When King James I. ascended the throne of England, he is said to have asked Archbishop Whitgift for his friend Mr Hooker; and being answered that he had died a year before the queen, who expressed great concern when she received the news, he replied, "And I receive it with no less, as I shall want the desired happiness of seeing and discoursing with that man, from whose books of church polity I have received such satisfaction." He afterwards added, "though many others write well, yet in the next age they will be forgotten; but doubtless, there is in every page of Mr Hooker's book the picture of a divine soul; such pictures of truth and reason, and drawn in so sacred colours, that they shall never fade, but give an immortal memory to the author."

Besides the eight books of *Ecclesiastical Polity*, and his answer to Travers's *Supplication*, Hooker left some sermons, which were collected and published with his works in folio. An octavo edition has also been printed at Oxford. (z)

HOOQUANG. See CHINA.

HOO-TCHEOO-FOO. See CHINA.

HOPS. See AGRICULTURE, and BREWING.

HORACE, QUINTUS HORATIUS FLACCUS, one of the most celebrated of the Roman poets, was born at Venusium, a town in the confines of Apulia and Lucania, in the consulship of Aurelius Cotta and Manlius Torquatus. His father was the son of a freedman, and followed the employment of a tax-gatherer. This was the poet's own account, and most likely to be true. Some of his enemies, however, reproached him with his father having been a fishmonger (*Salsamentarius*,) and one of them said to him, *Quoties ego vidi patrem tuum bracchio se immungentem.* His father, however, though of humble origin, appears to have been a man of liberal sentiments, and to have given his son an excellent education, as the son has recorded in these lines, so honourable to the memory of both:

> "Causa fuit pater his:* qui macro pauper agello
> Noluit in Flavi ludum me mittere, magni
> Quo pueri magnis è centurionibus orti
> Lævo suspensi loculos tabulamque lacerto,
> Ibant octonis referentes Idibus æra:
> Sed puerum est ausus Romam potare docendum,
> Artes, quas doceat quivis eques, atque senator
> Semet prognatos: vestem servosque sequentes
> In magno ut populo si quis vidisset; avita
> Ex re præberi sumptus mihi crederet illos.
> Ipse mihi custos incorruptissimus omnes
> Circum doctores aderat, quid multa? pudicum
> (Qui primus virtutis honos) servavit ab omni
> Non solum facto, verum opprobrio quoque turpi.
> * * * * *
> *Nil me pœniteat sanum patris hujus.*"
>
> Sat. vi. lib. 1.

At the age of eighteen, Horace was sent to Athens, for the purpose of finishing his education, by the study of philosophy and Greek literature. Whilst he was in that city, Marcus Brutus, in his way to Macedonia, stopped at the university, and, being pleased with Horace, took him along with him on his journey. Brutus afterwards entrusted a legion to his care as military tribune. As the poet, in his writings, freely confesses, that he had no great genius for fighting, it may be suspected, that it was by his wit and companionable talents that he had ingratiated himself with Brutus. At the battle of Philippi, he describes himself, with some humour as throwing away his shield, to be disencumbered in his flight. By the victory of the opposite party his property was forfeited, but his life was spared. In his indigence he wrote verses, and so recommended himself to Virgil and Varius, that, with the generosity of true poets, they recommended him to Mæcenas. At the first interview with that noble patron, as he tells us in the satire already quoted, he behaved with diffidence, and simply told Mæcenas what he was. The nobleman, as was his custom, said little in reply, and did not send for him again till nine months after, when he admitted him among the number of his friends, and made him easy in his circumstances. Horace proved so agreeable to Mæcenas, that he made him his familiar companion, in which capacity he accompanied him to Brandusium, in that journey which the poet has so agreeably described in verse. He also introduced him to Augustus, who delighted in his society, and used to call him *homuncio lepidissimus*. When seated between Virgil and Horace, the emperor used to say, that he was between sighs and tears; alluding to the uneasy respiration which afflicted Virgil from a chest complaint, and to Horace's tender eyes. Horace was certainly a courtier, and he did not lay on his flattery in faint colours; nor does he seem to have troubled his patrons with any recurrence to those maxims of public liberty, which he must have learned with Brutus, and which had led him into the field of Philippi; but, on the other hand, he makes allusion to great republican names with the spirit of a Roman and of a poet; and he lived among the great with *personal* independence, for he declined the post offered him by Augustus, of being his private secretary.

The incidents of his life are few. His person is described as short and inclined to corpulence, and his temper as easy and obliging. He passed his time between Rome, his Tiburtine or Sabine villa, and the soft climate of Tarentum, to which he fled in winter. Though an Epicurean enjoyer both of society and of sensual pleasures, his writings breathe a fondness for rural retirement, and he seems often to have returned from the satiety of vice to the calm of virtue and repose. He died in his 59th year, and was interred near his patron Mæcenas. Horace is the only one of the Latin lyric poets who has come down to posterity; a circumstance for which the judgment of Quinctilian may console us, who assures us, that they were scarcely worthy of perusal. In Horace have been supposed to be united, if not individually surpassed, the gaiety of Anacreon, the majesty of Alcæus, and the fire of Pindar. We must leave it to the lovers of voluptuous literature to decide, whether the revelling of the Teian bard possess not a lighter grace of ecstacy than that of the Roman? The soul of pleasure is in both; but Horace's moral reflections (Epicurean as his philosophy was) are often like a drapery to his luxuriant images, that encumbers their joyousness without communicating decorum. In the parallel with Pindar, he presents a clear and rapid brilliancy of thought, more pleasing, if less astonishing, than the vague and obscure sublime of the Theban poet, as well as a richer variety in his subjects. He may be called, perhaps without a rival, the master of expression; and such is the harmony and diction of his odes, that an apt quotation from them always sparkles like a gem, when it illustrates the most eloquently expressed thought in the page of any language. Of all poets he is the most frequently quoted. To the merits of style, harmony, and fancy, must be added his knowledge of human nature, and of the principles of human manners, exhibited in that part of his writings where the tone of fancy and poetical diction is purposely relaxed; in his satires, to wit, where we take him to our bosoms for his good humour, and where his good sense instructs us in the language of friendship. His epistle to Pisos has, perhaps, been too much considered as an attempt on his part to give a perceptive theory of the whole art of poetry. It is, in fact, only an epistle upon the subject, in which his design is evidently desultory. Horace knew poetry too well, to think of submitting so ethereal a subject to the trammels of systematic theory; and it is not his fault, if the world has been since annoyed with sickening attempts to teach the art of inspiration. The infallibility of all his tenets of taste it is not our business here either to impeach or support; but, in a general view, it must be confessed, that his maxims, though misapplied by pedants to narrow the range of dramatic genius, have, with reference to all that was then known in that species of poetry, a most respectable weight and felicity. (*n*)

HORATII. See Rome.

HORIZON, Artificial. See Quadrant.

HORN, a musical wind instrument, which, whether of the short kind, called a bugle horn, or the long coiled kind, called a French horn, has a scale of intervals alike defective, and similar to that of the common Trumpet, which see. The supplying of chromatic notes to the scale of the French horn, so as to render it an instrument of general use in an orchestra, is said to have been first attempted in the beginning of the 18th century, in Germany; and since 1740, Messrs. Messings, Spandau, Porto, Leanders, Petrides, &c. have succeeded here in different degrees, in supplying all the requisite notes to the horn, by means of the hand, or a turned block of wood thrust into the mouth of the instrument, so as to alter the length of the sounding part of the tube, in the requisite degrees, during performance.

The late Mr Charles Clagget, as we have explained in our article Chromatic *French Horn*, attempted to accomplish the same thing, by means of two attached tubes, one half a tone higher than the other, either of which the performer could blow at pleasure; but it did not succeed, so as to continue in use. In 1810, Mr William Clare in-

* Speaking of the better traits of his character.

vented and transferred to Mr Perceval, opposite St James's Palace, the patent for a polyphonian French horn, whose scale is rendered complete by means of finger-holes in its sides, and keys like those of a flute. (ϛ)

HORN, Cape. See Fuego.

HORN-Pressing, is the art of moulding or forming toys and various articles in horn or tortoise-shell. These animal substances are capable of being so softened by the application of a moderate heat, that they can be moulded by pressure into any required shape, and the surface may be imprinted with any design in the sharpest and most delicate relief. Another valuable property is, that pieces may be made to adhere firmly together without any cement. In the article Button-*Making*, we have already given a description of the method of pressing horn buttons, by means of iron moulds and a strong vice. The same machine, and similar moulds, are used for knife-handles or other simple articles; but for making hollow articles, such as snuff-boxes, tooth-pick cases, powder-flasks, tubes of opera-glasses, ink-horns, &c. a screw-press is used. The process is extremely simple: The horn or tortoise-shell is boiled in water until it becomes softened, and is then put into moulds of iron or brass, made in two or more pieces, and with cavities between them to correspond with the article which is to be fabricated, and, with all its intended ornaments, engraved in the interior surface of the mould. This mould being made hot, the horn or shell is put between its two halves, and the mould being put in a small screw-press, the halves are forced together to imprint the horn, and press it into the cavity of the mould. If the article has any considerable relief, this cannot be done at one heat, and therefore the press, with the moulds in it, is put into a copper, and boiled still longer: it is then taken out, and, by a lever applied to the screw, it is screwed tighter, so as at length to obtain the impression desired. When a single piece of horn or tortoise-shell is not sufficiently large to fill the mould, two or more pieces are put together: they are cut to fit to each other with a proper degree of overlap, and when sufficiently softened by boiling in water, the surfaces are forcibly pressed together, and they will thus be united as firmly as if they were originally in one piece. The screw-press employed for this business is very simple, being only an iron frame, with a screw through the top of it; and, for the convenience of putting it in and out of the boiler or copper, a small tackle of pulleys is fixed just over the copper, and by the side of it is a block of stone, with a hole or cavity in it large enough to receive the press, and hold it firmly upright, whilst a lever or wrench is applied to the screw to turn it round and produce the pressure, which being done, it is again returned into the boiler. To obviate the inconvenience of thus lifting the press in and out of the boiler, Messrs Poltzappfell and Deyerlin of London have made the machine represented in Figs. 1. and 2. of the Plate. Plate CCXCIX. Fig. 1. being a section, and Fig. 2. an elevation, AA is a box or case of cast iron; B, a boiler or copper to contain the water; and C, the grate for the fire, which is to be placed beneath it to heat the water; E is the flue or chimney, at which the smoke passes off; FFG is a press, made very strong, of cast iron, and capable of being drawn up out of the water, or let down into it at pleasure, by means of racks *a*, *a* at each side, which are actuated by pinions *d*, *d*; the axes *o* of these pinions extend across the machine, and have each a wheel N at the end; and these wheels are moved at the same time by two arms or endless screws, cut upon an axis, which extends from one to the other, and is turned by the handle H: the press is guided in this ascent or descent by grooves in the side of the boiler. When raised up out of the water, the moulds, with the horn or tortoise-shell between them, are put beneath the presser I, and a severe pressure is produced by turning the wheel K. This wheel has an endless screw R upon its axis, which works the teeth of a large wheel L, fixed on the top of the screw P. The screw is received into a female screw formed within the box or presser I, which is guided and prevented from turning round by the cross bar *e e*, through which the presser is fitted; by this means, when the screw P is turned round by the wheel L and endless screw, the horn or tortoise-shell is pressed between the moulds; the press is then lowered again into the water of the boiler, in order to be still farther softened by the boiling; but when the press is down in the boiler, the screw can be screwed tighter by turning the wheel K until the desired impression is obtained. By turning the handle N, the press is then raised up out of the boiler, and by turning back the wheel K, the pressure is released, and the moulds can be removed.

The Figures X, Y and Z represent a pair of moulds proper for forming a cylindrical snuff-box: X is the internal mould for the box, into the bottom of which a piece of shell, softened by boiling, and cut round, is first placed; and round the inside a long slip is curled, the ends being made to lap over with a proper joint. The external mould Y is then put into the cavity of the horn, and is forcibly pressed by the screw so as to give the horn the shape of Y when it is withdrawn from the mould: a similar mould is used for making the lid of the box. Small boxes, and those which are slightly raised, can be made from one single piece without joining; also tooth-pick cases and similar articles.

The Chinese are famous for making lanterns of horn very thin and transparent. We are informed, in the *Annales des Arts*, that they employ the same methods as we do of effecting the joinings by softening the horn in hot water, but that they use a long beam or lever, for making the pressure. This method is for making up the leaves of horn from small pieces; but as the boiling would disfigure these leaves, they are united together to form the lanterns, by warming them at the fire, and pressing the edges of them together by hot pincers, made flat on the inside; by this means the joints are so perfect that they can scarcely be perceived. See a translation of this paper in the *Repertory of Arts*, 2d Series, vol. xxix. An account of the manufacture of Chinese lanterns will be found in the *Memoires des Sçavans Etrangers*, tom. ii. p. 350, in a Memoir by M. D'Incarville. (J. F.)

HORNS. See Anatomy, *Comparative*.

# HOROLOGY.*

Horology is the art of constructing machines for measuring time. The word is derived from the Greek Ὡρολογιον, (through the Latin *horologium*,) compounded of ὡρα, *an hour*, and λεγω, *to read* or *point out*; hence ὡρολογιον, a machine for indicating the hours of the day.

Long before sun-dials were invented, clepsydræ, or

* The Editor is indebted to Mr Thomas Reid for the following article on Horology.

water clocks, had been made in the most remote periods of antiquity, and were used in Asia, China, India, Chaldea, Egypt, and Greece, where Plato introduced them. Julius Cæsar found them even in Britain, when he carried his arms thither; and it was by them he observed, that the nights in this climate were shorter than those in Italy: (See his *Commentaries*, lib. v. xiii.) Toothed wheels, although known a considerable time before, were first applied to clepsydræ by Ctesibius, a native of Alexandria, who lived 140 years before the Christian era. At what time, or by whom, was invented the clock with toothed wheels, crown wheel 'scapement, and the regulator in the form of a cross suspended by a cord, with two weights to shift on it, can now only be guessed at, as no positive information on this subject has been handed down to us. It was this kind of clock, a large turret one, which Charles V. king of France, surnamed the Wise, caused to be made at Paris by Henry Vick, who was sent for from Germany for the express purpose, and which was put up in the tower of his palace about the year 1370. Julien le Roy, who had seen this clock, has given some account of it in his edition of Sully's *Regle Artificielle du Temps*, Paris 1737: (See Plate CCC. Fig. 1. and the Description of the Plates at the end of the volume.) Before a clock could be brought even to the state of the one made by Vick, there must have been many alterations and progressive improvements upon that which had first been projected, so that it must have been invented at least two or three centuries before Vick's time. As the same word for a sun-dial among the Greeks and Romans was also that for a clock, disputes have arisen, whether the *horologia* of Pacificus and of Gerbert were sun-dials or clocks. Father Alexander asserts that the horologium of Gerbert was a clock; while Hamberger supposes it to have been a sun-dial, from the pole-star having been employed in setting it. Pacificus was archdeacon of Verona about the year 850. Gerbert was pope, under the name of Silvester II. and made his clock at Magdeburg, about the year 996.

Richard of Walingford, abbot of St Albans in England, who flourished in 1326, by a miracle of art constructed a clock, which had not its equal in all Europe, according to the testimony of Gesner. Leland too, an old English author, informs us, that it was a clock which shewed the course of the sun, moon, and stars, and the rise and fall of the tides; that it continued to go in his own time, which was about the latter end of Henry the Seventh's reign; and that, according to tradition, this famous piece of mechanism was called *Albion* by the inventor.

"In 1382," says Father Alexander, "the Duke of Burgundy ordered to be taken away from the city of Courtray, a clock which struck the hours, and which was one of the best known at that time, either on this side or beyond seas, and made it be brought to Dijon, his capital, where it still is in the tower of Notre Dame. These are the three most ancient clocks that I find, after that of Gerbert."

"We know no person," continues this author, "more ancient, and to whom we can more justly attribute the invention of clocks with toothed wheels, than to Gerbert. He was born in Auvergne, and was a monk in the abbey of St Gerard d'Orillac, of the order of Saint Bennet. His abbot sent him into Spain, where he learned astrology and the mathematics, in which he became so great a master, that, in an age when these sciences were little known, he passed for a magician,* as well as the Abbot Trithemius. From Spain he came to Rome, where he received the abbacy of Bobio in Italy, founded by Saint Columbus; but the poor state of its funds compelled him to return to France. The reputation of his learning and uncommon genius, induced Adalberon, Archbishop of Rheims, to establish him, in 970, as rector of the schools there, and at the same time to make him his private secretary. It was near the end of the tenth century, about the year 996, when he made at Magdeburg this clock, so wonderful and surprising, *by means of weights and wheels.* He was Archbishop of Rheims in 992, a situation which he held during three years, then archbishop of Ravenna in 997, and at last sovereign pontiff, under the name of Silvester II. in 999; and he died at the beginning of the fifth year of his pontificate, in 1003." The clock constructed by Gerbert seems to have been made after he left Rheims, and before his appointment to Ravenna; and it is highly probable, that this was the period when clock-making was introduced into Germany.

"William Marlot," continues the same author, "to show how wonderful this piece of work was, makes use of an expression which can hardly be suffered in our language: *Admirabile horologium fabricavit, per instrumentum diabolica arte inventum.*"

Since toothed wheels had been known above 1300 years before Gerbert is said to have made his horologium, and above 1100 after they had been applied to the clepsydra, and as they were also sculptured on Trajan's column at Rome, where they are still to be seen, there seems to be nothing unaccountable in Gerbert's having fallen on the way of applying wheels to make a clock different from the clepsydræ, which had been long in use. Besides, Father Alexander seems to have investigated the history of horology more profoundly and indefatigably than Hamberger; and Gerbert may have made use of the pole-star, for other purposes than merely to set a sun-dial by it, and probably for the purpose of drawing a meridian line, in order to regulate his clock. If it were a sun-dial, as some suppose, why does Marlot, who wrote at Rheims in 1679, consider it as such a wonder, since it appears from our *History of* DIALLING, that dials were well known, and in common use, 1600 years before Gerbert's time? Hamberger, however, admits, that the clock was invented in the eleventh century; and he thinks it probable, that we are indebted to the Saracens for it. Now Gerbert's clock was made near the commencement of the same century. The college in Spain, where he had been instructed, had Arabians or Saracens among its professors, and was at that time the only place in Europe where any learning or science was to be found.

The argument against Gerbert's horologium being a clock, in our acceptation of the word, is, that he made use of the pole star, as if to set a sun-dial by it; and yet we have no positive information that it was a sun-dial. Berthoud admits, that such a clock as Vick's could not have been a new invention; and he thinks, "that the different parts which compose the balance clock, have only been made after a long train of research and of time, which supposes the highest antiquity for the successive discoveries, and that clocks were not known in France till the middle of the 14th century."

The art of horology might be going slowly on in Germany, though the balance clock was unknown in France till 1370, previous to which Vick had been sent for. Had this not taken place, it might perhaps have remained still longer unknown. It must be allowed, that there is something inconsistent in Father Alexander's argument, for giving the clock to Gerbert, and refusing it to Pacificus,

* It may have been for a crime of this kind that he was afterwards banished from France.

"because it was not known in France till 250 years after. The discovery was of too great utility not to be spread abroad, particularly in monasteries, where it was so much required to regulate the office of the night. In the famous monastery of Cluny, however, the sacristan, in 1108, went out to see the stars, in order to know the time when to awaken the monks to prayer." In the early stage of the art very few clocks could have been made, and those which were constructed could not be of much use.

"As all arts are at first imperfect," says Hamberger, "it is observed of these clocks, that they sometimes deceived; and hence in the *Ordo Cluniacensis Bernardi Mon.* the person who regulated the clock is ordered, in case it should go wrong, 'ut notet in cereo, et in cursu stellarum vel etiam lunæ, ut fratres surgere faciat ad horam competentem.' The same admonition is given in the *Constitutiones Hirsaugiensis*." From what is said here, it may be inferred, that even those who had clocks in the earliest periods, could not place much dependance on their time-keeping; and with great probability we may suppose, that many a palace and monastery might continue a long time unprovided with such a machine. It was near the end of the 15th century before they came to be in use among private persons.

The art of clockmaking seems to have been introduced into Europe by some of the Romish clergy. They were, in general, especially the higher orders, possessed of wealth, time, and leisure, to cultivate such of the arts and sciences as were then to be attained; and if the art of horology did not originate with them, they certainly were among the first who did every thing in their power to promote and encourage it. Time measuring being so desirable for the regulation of the stated services required of the church, which took place at all hours of the day and night, their attention was naturally called to a subject in which they were so much interested.

Those who wish for more information on the origin of clocks, are referred to the following works. *The Artificial Clockmaker*, by William Derham, D. D. London, 1698. *Traité general des Horloges*, par le R. P. Dom. Jacque Alexandre, Religieux Benedictin de la congregation de Saint Maur. A Paris, 1794. A Dissertation by Hamberger in Beckmann's *History of Inventions*, vol. iii. Lond. 1797. *Histoire de la Mesure du Temps par les Horloges*, par Ferdinand Berthoud, mechanicien de la marine, &c. &c. A Paris, 1802. This last is a very interesting work for an amateur in horology, and was the result of seven years labour, when the author was at a very advanced period of life. To these may be added *Histoire de l'Astronomie Moderne*, tom. i. p. 60, edition de 1785, and *Histoire de l'Astronomie Ancienne. Eclaircissemens*, liv. iv. § 34. liv. ix. § 5. Vitruvius's *Architecture*. Pollius Vitruvius lived 40 years before Christ, and was architect to Augustus. In a triumph of Pompey, among the spoils brought from the East, was a water clock, the case of which was strung round with pearls. *Pliny*, lib. xxxvii. cap. i. *Memoires de l'Academie des Inscriptions*, tom. xx. p. 448.

It would be a waste of time to describe the nature of wheels and pinions, as this kind of machinery is now so generally known. It may be sufficient to remark, that a clock or a watch movement is an assemblage of wheels and pinions, contained in a frame of two brass plates, connected by means of pillars, the first or great wheel of which, in an eight day clock movement, has concentric with it a cylindrical barrel, having a spiral groove cut on it. To this cylinder is attached one end of a cord, which is wrapped round in the groove, for any determined number of turns, and to the other end of the cord is hung a weight, which constitutes a power or force to set the wheels in motion. Their time of continuing in motion will depend on the height through which the weight has to descend, on the number of teeth in the first or great wheel, and on the number of teeth or leaves of the pinion upon which this wheel acts, &c. The wheels in spring clocks and in watches are urged on by the force of a spiral spring, contained in a hollow cylindrical barrel or box, to which one end of a cord or chain is fixed, and lapping it round the barrel for several turns outside; the other end is fixed to the bottom of a solid, shaped like the frustum of a cone, known by the name of the *fusee*, having a spiral groove cut on it; on the bottom of this cone, or fusee, the first or great wheel is put. The arbor on which the spring barrel turns, is so fixed in the frame, that it cannot turn when the fusee is winding up; the inner end of the spring hooks on to the barrel arbor, and the outer end hooks to the inside of the barrel. Now if the fusee is turned round in the proper direction, it will take on the cord or chain, and consequently take it off from the barrel. This bends up the spring; and if the fusee and great wheel are left to themselves, the force exerted by the spring in the barrel to unbend itself, will make the barrel turn in a contrary direction to that by which it was bent up. This force of the spring unbending itself, being communicated to the wheels, will set them in motion, and they will move with considerable velocity. Their time of continuing in motion will depend on the number of turns of the spiral groove on the fusee, the number of teeth in the first or great wheel, and on the number of leaves in the pinion upon which the great wheel acts, &c. The wheels in any sort of movement, when at liberty or free to turn, and when impelled by a force, whether it is that of a weight, or of a spring, would soon allow this force to terminate; for, as the action of the force is constant from its first commencement, the wheels would be greatly accelerated in their course, and it would be an improper machine to register time or its parts. The necessity of checking this acceleration, and making the wheels move with an uniform motion, gave rise to the invention of the *escapement*, or *'scapement*, as it is commonly called. To effect this, an alternate motion was necessary, which required no small effort of human ingenuity to produce.

## CHAP. I.

### *On the Escapement, or 'Scapement.*

The escapement is that part of a clock or watch connected with the beats which we hear them give; and these beats are the effects of the moving power, carried forward by means of the wheels in the movement to the last one, which is called the *swing wheel* in a pendulum clock, and the *balance wheel* in a watch. The teeth of this wheel act on the pallets or verge, which are of various shapes, and which form the most essential part in a 'scapement; the drop from each tooth of the swing or balance wheels, on their respective pallets, giving one beat or impulse to the pendulum or balance, in order to keep up or maintain their motion; and were it not for the pallets which alternately stop the teeth of the swing or balance wheels, the motive force would have no check. Hence it is, that, by this mechanism of the 'scapement, the wheels in the movement are prevented from having their revolutions accelerated, which would take place to such a degree, as to make the machine run down in a minute or two; whereas, from the resistance opposed by the pallets, it is kept going for twenty-four or thirty hours, for a week or a month, or even for twelve months. In the clocks or watches, however, which as a matter of curiosity have been made to go so long, it was not possible to have an accurate measure of time.

No part of a clock or watch requires so much skill and judgment in the contrivance of it, and so much care and nicety in its execution, as that of the 'scapement; none of the 'scapements of the present day require this more than the ancient crown wheel and verge 'scapement, which, when nicely executed, upon the proper principle, does extremely well for a common pocket watch. But this is a thing hardly now to be met with. From the time of Dr Hooke, and during the last century, many ingenious contrivances for 'scapements were suggested; but the number of them adopted in practice is very limited. The crown wheel and verge 'scapement is represented in Plate CCC. Fig. 2, where V is the verge, and C the crown wheel, *p*, *p* the pallets, and B B the balance. It is the oldest that is known, and must have been the only one used in clocks, for several centuries, previous to the middle of the seventeenth, or towards the end of it. Although it has been so long in use, and so well known to every clock and watch-maker, that its merits are now overlooked, and held in little estimation, yet, if it is duly considered, it will be found to have been a very masterly and ingenious device. The crown wheel and verge are of such an odd shape, that they resemble nothing that is familiar to us. Yet some ancient artist had contrived it for the purpose (and it certainly was an ingenious thought) to give an alternate motion to a plain wheel, or cross, which he had suspended from the upper end of its axis by a string, or which at first might rest on the lower end of the axis or *foot pivot*. This plain wheel was like the fly of our common kitchen jack. In place of this circular rim, or plain wheel on the axis, there were some of them that had two arms upon it, forming something like a cross; on these were made a sort of notches, concentric to the axis, in which were hung a small weight on each arm, which, by shifting more or less from the centre, the clock was made to go slow or fast. From the weightiness of this kind of balance, and the rude execution of the work, the friction on the end of the foot pivot would be so great, that it is probable there was some difficulty to make the clock keep going for any length of time. Recourse was then had to suspend the balance by a small cord, so that the end of the lower pivot should not rest on the foot of the potence. This ingenious idea has in modern times been adopted both by Berthoud and Le Roy, who have had the balances in some of their marine time-keepers suspended by a very small wire, or a very delicate piece of watch pendulum spring wire. The mechanism of the movement of these old clocks is exactly the same as has been frequently made for an alarm. To construct this, and apply it to a clock, there was hardly a step to go; and therefore in all probability the invention of the alarm part took place before that of the striking part, though some have thought otherwise. The contrivance of the striking part was a more complex process, and less likely to take place.* The alarm-clock is represented in Plate CCC. Fig. 3.

This opinion is strongly corroborated by the observations of Hamberger in Beckmann's *History of Inventions*. "These horologia," he remarks, "not only pointed out the hours by an index, but emitted also a sound. This we learn from *Primaria Instituta Canonicorum Præmonstratentium*, where it is ordered that the sacristan should regulate the horologium, and make it sound before matins to awaken him. I dare not, however, venture thence to infer, that these machines announced the number of the hour by their sound, as they seem only to have given an alarm at the time of getting up from bed. I have indeed never yet found a passage where it is mentioned that the number of the hour was expressed by them; and when we read of their emitting a sound, we are to understand, that it was for the purpose of awakening the sacristan to prayers. The expression *horologium cecidit*, which occurs frequently in the before-quoted writers, I consider as allusive to this sounding of the machine. Du Fresne, in my opinion, under the word *Horologium*, conceives wrong the expression *de ponderibus in imum delapsis*, because the machine was then at rest, and could raise neither the sacristan or any one else, whose business it was to beat the *scilla*."

When an alarm is set off, the weight, which is the moving force of it, very soon falls to the bottom, and then the alarm ceases.

In attempting to make the first 'scapement, there can be little doubt that something of the circular or cylindrical kind was contrived, and the only thing which could give it an alternate motion, was either a spiral spring or a pendulum; but these things being then unknown, the clockmaker was obliged to seek after other methods, and at last produced the crown wheel and verge 'scapement. How came it that means so complicated were fallen on, when those which were more simple and better were over-looked?

It is a very singular circumstance, that a small ball or weight, when suspended by a slender thread, and drawn a little aside from the perpendicular, on being let go, continues to vibrate for a considerable time, and with the utmost regularity. Many things in domestic life were hung up or suspended by strings, and were every day seen or observed; yet what a long time elapsed before any thing of this kind was ever thought of, or applied to regulate the motion of a clock! It is said that Galileo took his idea of a pendulum from the motion of a lamp, suspended from the roof or ceiling of a church, which had been accidentally set a vibrating. He used the simple pendulum in his astronomical observations, long before it was applied to a clock. Some of the earlier astronomers, as well as Galileo, used a common string and ball, which they made to vibrate a little while, during the time of an observation of any of the heavenly bodies. Yet even these astronomers did not think of its application to clocks. Some watch-finishers, when their watch is finished, for want of a pendulum clock, regulate it by means of a ball and string, which will answer very well, by taking 50 vibrations of a pendulum's length for seconds, in the same time that the wheel ought to make one revolution.

As gravitation is the principle on which the pendulum is founded, it cannot properly be considered as an invention, as some have called it, whatever name may be given to it when applied to regulate the motion of a clock. The pendulum having before this been long known in its simple state, and used as a sort of time measurer, it was no wonder that the idea of applying it to a clock was entertained by several persons nearly about the same period. The movement of the old balance clocks was not adapted for the application of the pendulum, so as to give motion to it; the wheels in it were all flat ones except the crown wheel, and no other 'scapement at this time was known but that of the crown wheel and verge; so that, without considerable difficulty and invention, the pendulum could not well be ap-

* In many parts of India, where public clocks are unknown at this day, they strike the hours upon a plate of silver, or silver alloyed with another metal, of a lenticular form, about 18 inches in diameter. It is hung on a frame by a doubled string; and when the hour is pointed out, either by their sand-glasses, clepsydræ, or water-dropping instruments, which they sometimes use, they strike with a wooden hammer on the middle of the circular plate, and thus indicate, by the number of blows, the hour of the day. The sound which is produced is strong, clear, and pleasant. This contrivance is used in many of the towns and camps throughout India.

plied to this construction of a clock movement. The pocket watch had been made a considerable time before this, and the construction of its movement, which had a contrate wheel in it, would naturally lead them to that of one which would adapt itself to the motion of a pendulum, as by means of the contrate wheel the crown wheel could be made to stand in a vertical position; whereas, in the old balance clocks, the position was horizontal. Galileo seems early to have discovered the properties of the pendulum, and the investigation was prosecuted with great success by Huygens. The son of Galileo applied the pendulum to a clock at Venice in the year 1649; but to what sort of a movement we cannot pretend to say, though we suspect, from that want of success which seems to have attended his trials, that he had not adopted the contrate wheel movement, already mentioned, as the most proper for it. We know that Huygens made use of this sort of movement, as the only one fit to be regulated by the motion of the pendulum, which he had also applied. Of late, another candidate for the application of the pendulum to a clock has been brought forward by such respectable authority, that leaves little or no room to doubt of its authenticity. Mr Grignion informs us, "that a clock was made in 1642, by Richard Harris of London, for the Church of St Paul's, Covent Garden, and that this clock had a pendulum to it."

It appears, from unquestionable evidence, that Galileo, mathematician to the Grand Duke of Tuscany, first discovered the properties of the pendulum, used it in his astronomical observations, and wrote a tract explaining the principles of it. This tract was translated from the Italian into French at Paris, printed in 1639 in a duodecimo volume, and sold by Pierre Ricolet. He intended to apply it to a clock, but this he never put into execution. Father Alexander says, "that they had nothing better than the balance clocks in France until the year 1660."

The application of the pendulum to a clock, and of the spiral form of a pendulum spring to the balance of a watch, were the greatest improvements that could possibly have been made in the machinery of time measuring, and they both happened to take place nearly about the same period.

Notwithstanding the application of the pendulum, and the ingenious contrivance of cycloidal cheeks by Huygens, in order to make the long and short vibrations be performed in nearly as equal time as possible, yet the clock did not keep time with that correctness which was expected: This arose from the great extent of the arc of vibration, the lightness of the pendulum ball, the great *dominion* which the clock had over the pendulum, and the bad effects produced by the cycloidal cheeks, which, however excellent in theory, were never found useful in practice. See Plate CCC. Fig. 4. where a front view of the cycloidal cheeks is represented in Fig. A. This led artists and amateurs of the profession to think of farther means of improvement; accordingly, about the year 1680, a clock was made by W. Clement, a clock-maker in London, having, in place of the crown-wheel and verge 'scapement, a 'scapement which was nearly the same as the common recoiling 'scapement of the present day. The swing-wheel, S W, was flat, having a sort of rachet or saw-like teeth: and the pallets, P P, had remote resemblance to the head of an anchor, by which it acquired at that time the name of the *anchor 'scapement*. See Fig. 5. The ball of the pendulum was made much heavier than what had formerly been adopted, the arc of vibration much shorter, and the motive force much less. From the excellent time-keeping of the clock, this was found to be a great improvement, and hence this 'scapement was afterwards generally practised. It passed into Holland and Germany, and was hardly known in France until the year 1695. See *Histoire de la Mesure du Temps*, tom. i. p. 100.

At the time when this clock of Clement's appeared, Dr Hooke claimed the invention of it as his, and affirmed, that after the great fire of London, in 1666, he had shewn to the Royal Society a clock with this very 'scapement. "Considering," says Sully, in his *Histoire des Echappemens*, "the genius, and the great number of fine discoveries of this excellent man, I see no room to doubt that he was the first inventor of it." The pendulum with this 'scapement had received the name of the *royal pendulum*.

The *dead-beat* 'scapement of Graham's next succeeded, which was invented some time after the beginning of the eighteenth century, and has continued to be that which is generally used in regulators, or astronomical clocks, with a very few exceptions. See Fig. 6. About ten or fifteen years afterwards, it came to be known in France, and was adopted there also, as the best for clocks intended to measure time very accurately. Lepaute, a very ingenious watchmaker in Paris, produced, about the year 1753, or some time before it, a 'scapement founded on that of Graham's dead-beat one. See Fig. 7. In Lepaute's, the rest of the teeth on the pallets was always with the same effect, because it was on the same circle, whichever of the pallets it rested upon; the impulse given was also always the same on whichever pallet it was given, the flanches of the pallets being planes equally inclined. This was no doubt some improvement on Graham's; but the teeth of the swing wheel in Lepaute's consisted of sixty small pins, thirty being arranged on each side of the rim of the wheel; and where pin-teeth are used, oil, which is in some degree necessary, cannot easily be kept to them, the attraction of the rim of the wheel constantly draining the oil from these pin sort of teeth; an evil which is perhaps not easily to be got the better of, unless by using stone pallets and hard tempered steel pins.

Notwithstanding the seeming superiority and great character which the dead beat 'scapement had long acquired over that of the *recoiling* one represented in Plate CCC. Fig. 8. this last had, however, its partizans; and among them were artists and amateurs possessed of first rate talents. Such were Harrison, Professor Ludlam of Cambridge, Berthoud, Smeaton, and others. Harrison, indeed, always rejected the dead beat 'scapement with a sort of indignation. The author of the Elements of Clock and Watch Making, has said a great deal in favour of the dead beat, and as much against that of the recoiling one, without having shown in what the difference consisted, or what was the cause of the good properties in the one, or what the defects in the other. It appears doubtful if these causes were known to him; yet he was very deservedly allowed to be a man of considerable genius. When pallets are intended to give a small recoil, their form, if properly made, differs very little from those made for the dead beat, as may be seen by the dotted lines upon the dead beat pallets in Fig. 6.

We shall endeavour to point out the properties and defects naturally inherent in each: When the teeth of the swing wheel, in the recoiling 'scapement, drop or fall on either of the pallets, the pallets, from their form, make all the wheels have a retrograde motion, opposing at the same time the pendulum in its ascent, and the descent, from the same cause, being equally promoted. This recoil, or retrograde motion of the wheels, which is imposed on them by the reaction of the pendulum, is sometimes nearly a third, sometimes nearly a half or more of the step previously advanced by the movement. This is perhaps the greatest, or the only defect that can properly be imputed to the recoiling 'scapement, and is the cause of the greater wearing in the holes pivots, and pinions, than that which takes place in a clock or watch having the dead beat, or cylindrical 'scapement; but this defect may be partly removed by making the recoil small, or a little more than merely a dead beat. After a recoiling clock has been brought to time, any additional motive force that is put to it will not greatly increase the arc of vibration, yet the clock will be found to go considerably faster; and it is known that where the arc of vibration is increased, the clock ought to go slower, as would be the case, in some small degree, with the simple pendulum. The form of the recoiling pallets tends to accelerate and multiply the number of vibrations, according to the increase of motive force impressed upon them, and hence the clock will gain on the time to which it was before regulated. Professor Ludlam, who had four clocks in his house, three of them with the dead beat, and the other with a recoil, said, "that none of them kept time, fair or foul, like the last: This kind of 'scapement gauges the pendulum; the dead beat leaves it at liberty." Were it necessary, many good proofs could be adduced of the excellent performance of clocks which had the recoiling 'scapement.

Let us now make a similar comparative trial with the dead beat 'scapement. An additional motive force being put to it, we find that the arc of vibration is considerably increased, and the clock, in consequence of this, goes very slow. There are two causes which produce this; the one is, the greater pressure by the swing wheel teeth on the circular part of the pallets during the time of rest; the other is, the increase of the arc of vibration. It was observed in the case of recoil, that an additional motive force made the clock go fast; and the same cause is found to make the clock having the dead beat go slow. As the causes are the same, and yet produce effects diametrically opposite, does not this evidently point out what is necessary to be done? The pallets should be so formed, as to have very little of a recoil, and as little of the dead beat; and here any variation in the motive force, or in the arc of vibration, will produce no sensible deviation from its settled rate of time-keeping. We have been informed, that a clock was given by Mr Thomas Grignion to the Society for the encouragement of Arts, Manufactures, &c. "which had a dead beat 'scapement, so constructed, or drawn off, that any diminution or addition of motive force would not alter the time-keeping of the clock." All the 'scapements of this kind which have been hitherto made, were commonly drawn off nearly in the same way as Mr Grignion's, that is, the distance between the centre of the pallets, and the centre of the swing wheel, is equal to one diameter of the wheel; and the line joining the centre of the pallets, and the acting part of them, is a tangent to the wheel, taking in ten teeth, and 'scaping on the eleventh. This is nearly the same as represented in Plate II. of Mr Cuming's book. The only difference is, that Mr Grignion's circle of rest is the same on each pallet. But whether it possesses the properties which have been ascribed to it, shall be left to the determination of those who may chuse to try this experiment with it.

Clockmakers in general have an idea, that, in a 'scapement, the pallets ought to take in seven, nine, or eleven teeth, thinking that an even number would not answer. This opinion seems to have arisen from the old crown wheel having always an odd number of teeth, because an even number could not have been so fit for it.

There seem to be no rules (as some have imagined) necessarily prescribed by either the recoiling or the dead beat 'scapement, for any particular distance, which the centre of the pallets ought to have from that of the swing wheel. The nearer that the centres of the swing wheel and pallets are, the less will be the number of teeth taken in by the pallets, when a tangent for them is drawn to the wheel. It is very obvious, that when the arms of the pallets are long, the greater will be the influence of the motive force on the vibrations of the pendulum, and *vice versa*, when the pallets are short, the angle of the 'scapement will naturally be greater than may be required, but this can be easily lessened by making the flanches so as to give any angle required. When this angle is not quite half a degree on each side, a very small motive force will keep a pretty heavy pendulum in motion. We have known a very good clockmaker, who thought that the flanch of the pallets was an arbitrary or fixed point, which could be made only in one way, and it was some little while before he could be convinced of the contrary. The flanches may be made so long as to act something like detents, so as to stop the wheel altogether by the teeth, (see Fig. 5.) or they may be made so short as to allow the wheel teeth to pass them altogether, without giving any impulse at all to them. It is true, that there would be no 'scapement here; only it shows that the flanch of the pallets may be made to give any angle of 'scapement, from a few minutes to two or three degrees. Whatever the angle of the flanches may be taken at, all that is requsite is, to make the wheel 'scape so, that the tooth, when it drops on the pallet, shall fall just beyond the corner of the flanch, on the circular or recoiling part of the pallet.

Harrison's clock pallets (which are sometimes made to act by means of very delicate springs, and sometimes by their own gravity), have a very considerable recoil, which was a most ingenious contrivance, to do away the necessity of having oil put to them. The construction of them seems to be but little known; and they have very rarely been adopted in practice. Indeed, it is a 'scapement of such a nature, that very few would be competent to execute it properly. The circumstances which led to the invention of them, were mentioned by Mr Harrison himself to the late Professor Robison. Having been sent for to look at a turret clock which had stopt, he went to it, though it was at a considerable distance from his home, and found that the pallets were very much in want of oil, which he then applied to them. On his returning, and ruminating by the way on the indifferent sort of treatment which he thought he had met with, after having come so far, he set himself to work, to contrive such a 'scapement, as should not give to others that trouble to which he had been put in consequence of this turret clock. Hence the origin of his pallets. A drawing and description of them will be given in a future part of this article.

The justly celebrated Mr Mudge, in a small tract, published in June 1763, relative to the best means of improving marine time-keepers, suggested, as a great advantage, that of making the moving power bend up, at every vibration of the balance, a small spring, whose returning force should be exerted in maintaining the motion of the balance, (see Plate CCC. Fig. 9.) The first essay of this most ingenious contrivance was a small pocket watch, executed by himself, nearly about this period; and this is the same principle which, some years afterwards, he adopted and practised in those time-keepers which he made.

About two or three years or so after the publication of this tract, Mr Cuming contrived a clock 'scapement, nearly on the same principle as that of Mudge's, where the motion of the pendulum was maintained by the force of gravity of two small balls, which acted upon it during the time of the descent. In this 'scapement, the centre of motion of the pallets is independent of that of the pendulum and verge, although the same, and concentric with them; two detents were applied for locking the swing wheel teeth, one for each pallet; from each of the pallet arbors a wire projected in an horizontal position, and on the end of these wires the balls were fixed, which were alternately raised up, at every vibration of the pendulum, by means of the action of the swing wheel teeth on the pallets. In a periodical philosophical journal, it is insinuated that Mudge had borrowed the idea of the 'scapement, which he used in his time-keepers, from this of Cuming's. That Mudge's 'scapement was his own invention, is clearly evident from the hisorical facts which have been stated. And although there is an apparent similarity between Cuming's and it, yet we are not inclined to be of opinion, that Mr Cuming borrowed his from Mudge's. The 'scapement of the clock made by Cuming for his Majesty the king in the year 1763, is of the free or detached kind, a name which was not then known. The improvement which he himself made upon it two or three years after, was to keep up the motion of the pendulum by the gravity of two small balls, independent of the motive force through the wheels of the movement. In this 'scapement, he insists on the adjustment between the pendulum screws and crutch being made so as just to unlock the swing wheel and no more. This can then be only unlocked at the time, when the force of the pendulum in its ascent is nearly gone, and that the pendulum should not then meet with the arm of the ball, but to receive it, as it were, just before the descent of the pendulum has commenced. In that part of Mr Mudge's, each pallet and detent were formed in one, and the unlocking takes place a considerable while before the end of the vibration. Thus, the springs which maintain the motion of the balance are bent up, not only by means of the action of the swing or balance wheel teeth on the pallets at every vibration till the wheel teeth are locked, but are still a little more bent up when unlocking by the exertion or momentum of the balance, or pendulum itself, previous to the vibrations being nearly finished; and this is one of the greatest properties of this 'scapement, whether it is applied to the balance and spring, or to the pendulum. No 'scapement appears to be better calculated than this is, to keep the pendulum or balance constantly up to the same arc of vibration, notwithstanding its having what some have been pleased to call a *defect* in the recoiling one, that of opposing the balance or pendulum in its ascent, and promoting its descent. In the spring pallet 'scapement, as in the recoiling one, the pendulum is opposed in its ascent, and has its descent equally promoted; but there is still a difference between them, notwithstanding this similarity. In the spring pallet 'scapement, no retrograde motion is given to the wheels, pinions, and pivots, which produces that early wearing on them, and where the seconds' hand partakes also of this retrograde motion, as in the common recoiling 'scapement. These are circumstances which have no place in that of the other. In such 'scapements as those now mentioned of Mudge's or Cuming's, it has been said by some, that it matters not what sort of work the clock movement is, or however ill it may be executed; since the motion of the pendulum is kept up by a force, which, in some degree, is independent of the motive force produced through the wheels in the movement. This may be so far true, yet there is no 'scapement, where any irregularity in the pitchings, pinions, &c. of the movement will be more readily discovered than in this, during the going of the clock, which will be very perceptible to the ear at the time of raising up the balls, or that of bending up the springs. We would therefore by no means advise, that this sort of 'scapement should be put to a movement of indifferent execution: on the contrary, it seems to require one finished in the best possible manner. The motive force put to it requires to be greater than that which is usually put to clocks having the dead beat 'scapement. It may be asked, whether weights or springs are the best for these sorts of 'scapements, which is perhaps a question not easy to be resolved. We confess that springs appear to be preferable; they seem to have, as it were, an alertness or quickness of action, when compared to the apparent heavy dull motion of gravity in the balls. The pivots which are at the centre of motion of the pallets and balls would be regarded by many as objectionable, from the belief that oil is necessary to them. Oil does not seem to us in the least degree requisite, considering the very small angle of motion which they would have; and we have always thought, for the same reason, that oil was not necessary to the pivots of such detents as were sometimes used in the detached 'scapement.

We shall now proceed to give a description of a clock 'scapement, on the same principle as that of Mudge's in his marine time-keepers, which was put to a very capital regulator or astronomical clock, made some years ago by Mr Thomas Reid, for Lord Gray's observatory at Kinfauns Castle. It had a mercurial compensation pendulum, and its time of going without winding up was forty-five days. The great wheel, the second wheel, and the swing wheel pivots, were run on rollers, three being put to each pivot. Rollers were first applied by Sully to the balance pivot of his marine time-keeper, and have since been adopted by Berthoud, Mudge, and others. They have sometimes been used for clock pivots, but in such an injudicious manner, that, in place of relieving the friction of the pivots, they have at last jambed them to such a degree, that the pivot could not at all turn or revolve upon them.

In Plate CCCI. Fig. 1. SW is the 'scapement or swing wheel, whose teeth are cut not unlike those of the wheel for a dead beat, but not near so deep. P, P are the pallets, the upper ends of whose arms at *s*, *s* are made very thin, so as to form a sort of springs, which must be made very delicate; for, if they are any way stiff, the force of the swing wheel will not be able to bend them when raising up the pallets. In order that these springs may have a sufficiency of strength, and at the same time be as delicate as possible, they are cut open at the bending parts, as may be seen at Fig. 2. These springs come from a kneed sort of sole, formed from the same piece of steel, by which sole they are screwed on to cocks, which are attached to the back or pillar plate of the clock-frame. The pallet arms must be made very light and stiff, in order that their weight may have the least possible load or burden on the springs; *a*, *a* are the arms of the pallets, as represented in the front view, Fig. 1. and are fully as broad as is necessary. Their thickness may be made much less than this. An edge view of the pallet arms is seen in Fig. 2. The acting parts of the pallets at P, P, Fig. 1. should be made of such thickness as to allow room for inserting a piece of ruby, agate, or any fine or hard sort of stone, the thickness of the stone being a very little more than that of the 'scapement or swing wheel. Each of these stone pallets has a sort of nib or detent for the wheel teeth, which is left at the end of the pallet flanches, as may easily be seen at the left hand pallet, Fig. 1. These nibs are made for the locking of the swing wheel teeth, and their use will be more particularly explained afterwards. On the back of the pallets are screwed to each a kneed light brass piece, *c*, *c*, as seen at Fig. 1. On the lower ends of these kneed pieces, the screws *d*, *d* are put through, serving the double purpose of adjusting the 'scapement, and setting the pendulum on beat. The upper part of the pendulum-rod is composed of a sort of frame, whose steel plates A, A, A, A, Fig. 1. are represented as being contained within the dotted circular lines; the thickness of these ring-sort of plates is seen at A, A, A, A, Fig. 2. This frame has three pillars to keep the plates properly together; and though they are not represented in the drawing, yet any one may readily conceive where their places ought to be, and what should be their length and height. At *e*, *e*, Fig 1. is seen on each side the ends of a thin steel plate, or traverse bar, which goes from plate to plate, and is fixed in the frame. An oblique view of one of them is seen at *e*, *e*, Fig. 2. In the steel frame plates, there is a circular opening, as represented by the dotted inner circle, Fig. 1. This opening must be of such a diameter as to allow the swing wheel and the cock which supports it to come freely through; a part of the cock is seen at *f*, *f*, Fig. 2. the sole of which F is screwed to the back of the pillar plate of the clock; the other knee K turns up to receive the pivot of the arbor of the swing wheel, the pivot at the other end of this arbor being supposed to run in the fore plate, or in a cock attached to it, and it is the pivot which carries the seconds' hand. This description of the manner by which the swing-wheel is supported within the pendulum, it is to be hoped will be sufficiently understood, notwithstanding the want of a proper drawing of that part. The swing-wheel S W, and part of its pinion arbor *g*, are seen edgewise at Fig. 2.; also the arm *a* of one of the pallets P, and its screw *d* bearing on the steel bar *e*, *e*. At the point of contact between the end of the screw *d* and the bar *e*, a small piece of fine stone may be inserted into each bar. This will prevent any wearing or magnetic attraction which might otherwise take place, if the screw was left solely to act on the steel bar; for the smallest wearing here would in some degree alter the effects of the 'scapement. In Fig. 1. B represents a part of the bar of the pendulum rod, which is fixed into the lower part of the steel frame; an edge view of this bar is seen at B, Fig. 2. At the upper part of the steel frame is inserted a piece *c*, *c*, Fig. 1. and 2.; in this piece the pendulum spring is fixed, whose top-piece goes into a strong brass cock, which is firmly attached to the back of the clock-case, or to a large stone pier; the end of the projecting part of this cock is seen at DD, Fig. 1. and a side view of this part of it at DD, Fig. 2. The top piece of the pendulum spring has a long and strong steel pin through it, which lies in a notch made across on the upper side and projecting part of the pendulum cock. By this strong pin, the pendulum is suspended. In the side of the pendulum-spring top-piece, is made a large hole, so as to admit freely a strong screw, the head of which is seen at E, Fig. 2. This screw serves to pinch the top-piece and cock firmly together, after the pendulum has been made to take a true vertical position. This strong pin and screw are not represented in the drawing, but the description which has been given will, it is presumed, easily supply this want. In the pendulum spring *h*, *h*, Figs. 1. and 2. may be seen an opening in it, so as to have the appearance of a double spring, as seen at *h*, *h*, Fig. 2. This opening is made to allow the spring parts of the pallets *s*, *s* to be brought very near together, and this at the bending part of the pendulum spring, so that it and the bending part of the pallet springs should be as it were in one common centre. A part only of the cocks on which the spring pallets are screwed, is represented by *k*, *k*, Fig. 1.: *m*, *m* are the heads of the screws by which they are fixed to these cocks. It must be observed here, that the spring pallets are so placed, that they should act on the line of suspension and gravitation of the pendulum, which necessarily brings the swing wheel to the place where it is; no verge, crutch, or fork, are required; the influence of the oil on the verge pivots, and the friction by the crutch or fork on the pendulum rod, are done away by this arrangement. The motion of the pendulum is kept up *entirely* by the force of the spring part of the pallets, independent of any impediment in the wheel work, so long as it has force sufficient to raise up the pallets readily and easily: this force may be considered as permanent and invariable, and so should be the arc described by the pendulum. If the length of the pendulum and of the arc it describes are invariable, so should be the time which is kept by the clock. Having described the parts which compose this 'scapement, it will now be requisite to show their mode of action, which is extremely simple.

When the pendulum is set in motion, it will, by means of either one or other of the screws *d*, unlock the swing wheel; which, in the drawing, is represented as being locked by one of its teeth on the nib or detent part of the right hand pallet; and the moment when the wheel is unlocked, the tooth at the left hand pallet is ready to press forward and raise up the pallet; and, of course, it bends up the spring. Let the pendulum be now brought to the right hand side, the steel bar *e* will meet with the screw *d*, and carrying it or pushing it on, it will by this means unlock the swing wheel, and allow it to escape. At this instant, the wheel tooth meeting with the pallet on the left hand side, it will force its way on the flanch, and raise it up till it is stopped by the detent or pallet nib. Here the wheel is locked until the return of the pendulum to that side, when it will be again unlocked. From the time of the unlocking at the right hand pallet, till the same takes place at the left hand, the pendulum, during its excursion to the right, is opposed by the spring part of the pallets, and on its return it is assisted by the same part, until the pendulum comes in contact with the point of the screw *d* on the left hand part: Here it is again opposed in its excursion, as far as the arc it describes; and on its descent or return, it is assisted or impelled by that of the spring part of the pallet, in conjunction with the force of gravity. In this clock, all that the motive force through the wheels has to do, is to raise up the pallets, by bending up the springs; and these, along with gravity, maintain the motion of the pendulum.

When clocks of the common construction get foul in the oil, or dirty, the arc of vibration falls off, or is less than what it was when the clock was clean and free. In this 'scapement, however, when the clock gets foul, the force of the swing wheel teeth, on the detent part of the pallets, will be lessened, consequently the wheel will more easily be unlocked by the pendulum: hence we may expect a small increase in the arc of vibration; but whether this will affect the time-keeping, by making it slow, must be left to the experience of those who may think of making such trials. It appears to us, that if any lengthening of the arc of vibration takes place, it will be equally accelerated by the greater tension of the spring part of the pallets.

Another clock, having the same kind of 'scapement, has since been made by Mr Thomas Reid, where the adjustments for 'scapement and beat are transferred from the pallets to the pendulum itself. By this means, these adjustments are not only easier made, but are effected without that danger to which the pallets are exposed, when this is done by the screws which are in them. This 'scapement has also been very advantageously applied, even where a a verge and crutch were adopted.

The following is a scheme and description of another clock 'scapement, which the writer of this article contrived about twelve or fifteen years ago.

In Plate CCCI. Fig. 3. SW is the swing wheel, whose diameter may be so large, as to be sufficiently free of the arbor of the wheel that runs into its pinion, which in eight-day clocks is the third. The teeth of this swing wheel are cut thus deep, in order that the wheel may be as light as possible, and the strength of the teeth little more than what is necessary to resist the action or force of a common clock weight through the wheels. They are what may be called the locking teeth, as will be more readily seen from the use of them, afterwards to be explained. Those called the impulse teeth, consist of very small tempered steel pins, inserted on the surface of the rim of the wheel on one side only. They are nearly two-tenths of an inch in height; and the smaller they are, so much more room will be given to the thickness of the pallets. If they have strength to support about eighty or a hundred grains, they will be strong enough. There is no rule required for placing them relatively to the locking teeth, only they may as well be opposite these teeth as anywhere else. P, P are the pallets, whose centre of motion is the same with that of the verge at *a*. These pallets are formed so as to have the arms sufficiently strong, and at the same time as light as may be. That part where the arms meet at the angle at *a*, has a steel socket made out of the same piece as the arms, being forged together in this manner. This socket is made to fit well on the verge, on which it is only twisted fast; and is turned pretty small on the outside, in order to allow the arbors of the detents to be laid as close to the verge as may be, so that their centres of motion may coincide as nearly as possible. A perfect coincidence of the centres might be obtained by using a hollow cylinder for the verge, with the detent arbors running in the inside of it, but this would have occasioned more trouble. That part of the pallet frame, as it may be called, in which is set the stone for receiving the action or impulse of the small pin teeth, is formed into a rectangular shape, so as to allow room for a dovetail groove, into which the stone pallets are fixed, as may be seen at PP, Fig. 3. and at P, Fig. 4, which also gives a side view of the verge at *a*, and where the socket of the pallets is seen, as fixed on the verge. At *b*, Fig. 4, is seen the outer end of one of the stone pallets made flush with the steel. That part of the stone pallets upon which the pin teeth act may be seen in Fig. 3, where they are represented in their respective positions relative to the pin teeth. Their shape or form is exactly that which gives the dead beat. In Fig 3. are seen the detents *d*, *d*, whose centre of motion is at *c*, *c*. They are fixed on their arbors by a thin steel socket, made as forged with the detents, much in the same way as the pallets were, as may be seen at *c*, Fig. 5, which gives a side view of one of the detents and its arbor. The screws *e e*, *f f*, in the arms of the detents, have a place made to receive them, which is more readily seen in Fig. 5. than in Fig. 3. The screws *e e*, serve for the purpose of adjusting that part of the 'scapement connected with the pallets, pushing the detents out from locking the wheel, by means of the locking teeth. The ends of the screws *e*, *e* on the unlocking, are met by the ends of the stone pallets, one of which is represented at *b*, Fig. 4. The screws *f*, *f*, serve to adjust the locking of the wheel teeth on the detents. *g*, *g* are brass rectangular pieces or studs, which are fixed to the inside of the pillar frame plate, and may be near an inch in height. The ends of the screws *f*, *f*, rest on the side of these studs, and according as they are more or less screwed through at the ends of the detents, so much less or more hold will the detent pieces have of the teeth. These holding pieces of the detents are not represented in the drawing, as they would have made other parts of it rather obscure. They are made of stone, and are fitted in by means of a dovetail, cut in a piece left for that purpose, on the inside of the detent arms, as may easily be conceived from the drawing, where it is represented in part at *e*, Fig. 5; and is in the line across the arm with the screw *e*, which is close by the edge of the detent stone-piece, which projects a little beyond the end of the screw. Having described the parts of the 'scapement, we shall now explain their mode of action. On the left hand side, the pin-tooth is represented as having just escaped its pallet, as seen in Fig. 3; but, previous to its having got on to the flanch of this pallet, let us conceive that the back of the pallet, or end piece *b* of it, had come, in consequence of the motion of the pendulum, to that side, and opposing the screw *e*, which is in the detent arm, pushes or carries it on with it, and consequently unlocks the tooth of the wheel, which then endeavours to get forward; but the pin-tooth, at this instant of unlocking, meeting with the flanch of the pallet at the lower edge inside, and pushing forwards on the flanch, by this means impels the pendulum, and after having escaped the pallet, the next locking tooth is received by the detent on the right hand side, where the wheel is now again locked. In the mean time, while the pendulum is describing that part of its vibration towards the left hand free and detached, as the pallets are now at liberty to move freely and independently of the small pin-teeth, on the return of the pendulum to the right hand side, the detent, by means of the back of the pallet on that side, is pushed out from locking the wheel, and, at the instant of the unlocking, the wheel gets forward, and the pin-tooth is at the same instant ready to get on the flanch of its pallet, and give new impulse to the pendulum, as is obvious by what is represented in the drawing, Fig. 3 After the pin-tooth has escaped the pallet, the wheel is again locked on the opposite or left hand side; the pendulum moves on to the right freely and independently till the next locking on the left takes place, and so on. It may be observed, that the unlocking takes place when the pendulum is near the lowest point, or point of rest, and of course where its force is nearly a maximum. Without attaching any thing to the merits of this 'scapement, we may remark, that the clock was observed from time to time by a very good transit instrument, and, during a period of eighty-three days, it kept within the second, without any interim apparent deviation. This degree of time-keeping seemed to be as much a matter of accident as otherwise; and cannot reasonably be expected from this, or any clock whatever, as a fixed or settled rate.

This 'scapement being a detached or free 'scapement, can at pleasure be converted either into a recoiling or a dead beat one, without so much as once disturbing or stopping the pendulum a single vibration. To make a dead beat of it, put in a peg of wood, or a small wire to each, so as to raise the detents free of the pallets; and these being left so as to keep them in this position, the pin-teeth will now fall on the circular parts of the pallets, and so on to the flanch, and the 'scapement is then, to all intents and purposes, a dead beat one. To make a recoiling one of it, let there be fixed to each arbor of the detents a wire, to project horizontally from them about 3½ or 4 inches long; the outer ends of the wires must be tapped about half an inch in length; provide two small brass balls, half an ounce weight each, having a hole through them, and tapped so as to screw on the wires; the balls can be put more or less home, and be adjusted proportionably to the force of the clock on the pendulum. No recoil will be seen by the seconds' hand; yet these balls will alternately oppose and assist the motion of the pendulum, as much as any recoiling pallets can possibly do; and as their effects on the pendulum will be exactly the same, it may be considered as a good recoiling 'scapement. This sort of detached 'scapement, by becoming a dead beat, or a recoiling one, at any time when required, makes it convenient for making various experiments with the different 'scapements.

We shall now proceed to describe a clock 'scapement, whose pallets require no oil, invented by the late Mr John Harrison, who received the parliamentary reward of 20,000*l*. for a marine time-keeper.

In Plate CCCI. Fig. 6. S W is the swing wheel, whose teeth are shorter than usual. On the verge is a brass arm, of a sort of cross and flat pronged form, as may be seen at *e, e, e*, Fig. 6. and at *e, e*, Figs. 7. and 8. Upon this arm are screwed two brass-cocks, marked *d, d*, in Fig. 6. and *d* in Figs. 7 and 8; the upper pivots of the pallet arbors, as seen at *a*, Figs. 7. and 8. run in these cocks, and the lower pivots in the end of the prongs. On the lower end of the pallet arbors is a brass socket to each, having freedom to move easily on them, and also a proper end-shake between the prongs and the pallet arms. On the end of the sockets, next the pallet arms, is rivetted a thin piece of brass to each, the piece on the socket of the driving pallet being shaped as seen at *h, h*, Figs. 6. and 7. and having two holes in it: one of these holes has a range, limited by a pin fixed to the brass arm from the verge; the other hole, which is at the outer end, allows range to a pin, which is fixed to an arm on the pallet arbor, as may be seen at Figs. 6. and 7. The piece of brass on the socket of the leading pallet arbor is shaped as seen at *k, k*, Figs. 6. and 8. having a tail which comes to rest on the outer edge of the cock *d*, after being carried a little way by the motion of the pallet; at the outer end, at *k*, is a small brass screw, serving as a counterbalance to the opposite arm or pallet hook. In this pallet arm is an opening, through which the swing wheel comes, as may be seen at *l*, Fig. 8. the arm at the other end being filed thin down, leaving a sort of shoulder on it. AB, Fig. 6. is a stout piece of brass, rivetted or screwed to the verge collet; CC is the steel crutch, having another arm, which comes up on the inside of the piece of brass; the ball or paume of the crutch is kept to the verge collet by a sort of spring collet, which has two screws outside, and through to the verge collet, the crutch having liberty to turn on the verge. The piece of brass AB has two short knees turned up, having a hole tapped in each to receive the two screws *s, s*, Fig. 6. whose ends bear on the upper arm of the crutch, and serve to move the arm to one side or the other, so as to put the pendulum or clock on beat; *p, p*, is a piece of hard wood put on the lower end of the crutch, having an opening in it, to clip or take in with the middle rod of a gridiron pendulum.

The parts of this 'scapement being described, it now remains to explain their action. The tooth of the swing wheel, which has hold of the hook of the leading or right hand pallet, carries it on, until another tooth meets with the hook or notch at the end of the driving pallet arm. When this takes place, the wheel is made to recoil a little back; at this instant, the hook of the leading pallet gets free of the tooth, and is made to rise clear of the top of it, by means of the counterbalancing of the brass arm, and the screw *k* at the end of it. The tooth of the swing wheel, which has now got into the notch at the end of the driving pallet arm, carries it forward, until another tooth, meeting with the hook of the leading pallet, causes the wheel again to recoil. This allows the notch of the driving pallet to get free of the tooth; and the brass piece, which is on the pallet arbor, falls down, till it comes to rest on the pin in the brass cross piece, making the pallet notch get quite clear of the top of the tooth, and so on. There is a great deal of ingenuity displayed in the contrivance of this 'scapement, yet the nice and ticklish balancing of the pallets occasion some degree of uncertainty in their operations; and whether the great recoil which it has may not be against the time-keeping of the clock, remains, perhaps, yet to be proved. Was it this 'scapement which was in a clock of Mr Harrison's, at his house in Orange Street, of whose going Mr Short said, "That he could depend on it to *one second in a month*," and "that it had been going for fourteen years at this rate?"

The properties of a good 'scapement are, that the impelling force should be applied in the most uniform and direct way, and with the least friction and loss of motive force: that it require little oil, or none; and that the oscillations of the regulator, whether it is a pendulum or a balance, be made in as free and undisturbed a manner as possible. The nice execution required in a 'scapement, whether for a clock or a watch, formerly engrossed so much of the attention of workmen, that they, in some measure, lost sight of the properties of the pendulum, as well as that of the spiral or balance pendulum spring, and thought that the time-keeping of their machines depended more on the 'scapement than on any other thing, without considering, that this, from principle, lies wholly, or almost wholly, in the pendulum and in the spiral spring. Berthoud imputes a notion like this to Harrison, for attempting to make the 'scapement in his time-keeper so that the long and short vibrations should be made in equal times. Whereas he says, "he ought to have looked for this in the isochronous property of the spiral or balance spring. But this property (he adds) was unknown at that time to the English artists; and was a discovery of those in France, from whom the English artists afterwards obtained it." If this be the case, how did it happen that Mr Mudge, long before the period when Le Roy and Berthoud disputed about the property of this spiral spring, each claiming the merit of having first made the discovery, mentioned in his tract, published in 1763, "That the pendulum or balance spring, from physical principles, made the balance perform the long and the short vibrations to equal times?" He learned this from Dr Hooke's works, with which he was well acquainted; and this property of springs was known to Dr Hooke, and pointed out by him nearly a hundred years before Mudge published his pamphlet. It is but too true, that few or none of the English artists seem to have been acquainted with these properties till very lately, though Mr Mudge had pointed them out so long before, and though they were contained in the works of Dr Hooke. Lepaute's book was published at Paris in 1767, and does not contain the most distant hint of these properties of the balance spring; hence they were not known there at the time when Lepaute wrote, otherwise he would have mentioned them. It was soon after this, that the disputes commenced between Le Roy and Berthoud regarding this subject.

Watch finishers always made the pendulum spring for the watches of their own finishing, while at the same time, knowing nothing of its properties, the general practice was to taper them, so that the coils, when bending or unbending, should preserve an equal distance with one another; and this method has been used ever since the application of the spiral spring. Those who finished watches for Mudge and Dutton, were never employed to make the pendulum spring. This was always done at home by either Mudge or Dutton themselves, who, no doubt, endeavoured to make them as nearly isochronous as possible. This, among other causes, perhaps gave their watches the celebrity which they at that time had deservedly acquired.

The pallets of the 'scapement at the turret clock in Greenwich Hospital, are said to have been contrived by Mr Smeaton. The following narrative will show how he came to be concerned in it. It may be observed, that at that time he was one of the commissioners.

The turret clock, which is in the cupola of Greenwich Hospital, was undertaken by the late Mr John Holmes, and executed under his directions by Mr Thwaites. But before any thing was done, Mr Holmes consulted two gentlemen, who happened to be his most intimate friends; the one was the Rev Mr Ludlam of Cambridge, the other Mr John Smeaton, both of whom were very eminently qualified to give such advice as was wanted in this business, not only about the 'scapement, but how every part of the clock should be fitted up, so as to insure safety and utility in its performance. Several very long and masterly letters (of which Mr Reid has copies, though none of the originals were ever published) passed between them on that occasion, and evince much ingenuity. They agreed that the 'scapement should have a recoil. Mr Smeaton recommended, that the pallets, in place of having planes, as was common for their acting parts, should have curved surfaces, the leading pallet being concave, and the driving one convex; and when the pendulum was at or near to the extremity of the vibration, the 'scapement should then be nearly dead. This was, as he said, what "old father Hindley at York had ultimately come into!" Mr Ludlam advised, that the swing wheel teeth should be thick and deep, and of such a shape as to roll as it were on the pallets, and not to slide on them, which would prevent biting or wearing. The pallet arms were of brass, made so as to put it in the power of the clockmaker to take the pallets very easily out, when repairing was necessary. These methods had long before this been used by Harrison, and were adopted in a clock of his in Trinity College, Cambridge, as mentioned by Mr Ludlam. Broad rubbing surfaces were strongly advised by them. Mr Smeaton at this period took away gudgeons from a mill wheel, whose diameters were only 2½ inches, and put others in their place of 8 inches, with great success, as it afterwards proved. On the same principles which have just now been mentioned, was the 'scapement made for the clock, which Mr Thomas Reid put up in St Andrew's Church, Edinburgh; and although it has been going for about thirty years, there is not yet the smallest appearance of biting or wearing on the pallets.

'Scapements have been divided into classes, one of which has been called those of the remontoir kind. Now, the mechanism of a remontoir may be applied to any 'scapement, and even then it can hardly be said to form a part of it, more than the wheels of the movement, or the weight which moves them.

The motive force passing through the wheels, may at times be unequally impressed upon the 'scapement either of a clock or watch. This idea gave rise to the invention of what has been called *remontoirs;* that is, that the movement should at intervals be made to wind up either a small weight, or bend up a delicate spring, which alone should give its force to the 'scapement, by which means the pendulum or balance was supposed to be always impelled by an equal and uniform force. The earliest thing of this sort was used about the year 1600. Huygens applied it to some of his clocks, and gives a description of it in his *Horologium Oscillatorium;* and Harrison had one in the marine time-keeper, which gained him the great reward. We are of opinion, that they are of no great use either to a clock or a spring time-piece; for if the pendulum of the one is well fixed, and the momentum of the ball is not too little, any small inequalities of the motive force through the wheels will hardly be perceptible; and in the spring time-keeper, the isochronism of the pendulum or balance spring is sufficient to correct any inequalities whatever in its motive force. As their mechanism, however, is curious, and has been rarely described, it may not be uninteresting to our readers to have such an account of it as would enable them to make and adopt it should they think it proper.

The one which we propose to describe, is that which was contrived by Mr Reid for the clock of St Andrew's church. Suppose a small frame, separate and independent of the clock frame, to contain two wheels, one of which is the swing wheel, having within it the 'scapement work. The other wheel is crossed out, so as to be as light as may be, the rim being left just so broad as to admit fixing on it seven kneed pieces or teeth, each about a quarter of an inch thick and half an inch long, three of which are on one side of the rim, and four on the other side. Three on each side have the knees of different heights, corresponding each to each. The fourth is a little higher than either of the third highest. The wheel on which these are fixed, has a tooth prolonged beyond the rim, of the same thickness and length as the others, making eight teeth in all, having a small space left between each. These teeth become as it were so many wheels in different planes, and are at equal distances from one another, with the same extent of radius coming to the centre of the swing wheel arbor, being just so much larger than that of the swing wheel, as to allow the swing wheel teeth to clear the arbor of it. The edge or side of the teeth which rest on the swing wheel arbor is a plane, and rounded off on the opposite side, to the point or angle formed by this plane. The arbor of the swing wheel has eight notches cut into it a little beyond the centre. These correspond to the eight teeth of the other wheel, and are sufficiently wide and deep to allow the teeth to pass freely through them. Each notch stands at an angle of 45 degrees to the one which is next it, which difference is continued along the arbor through the whole, making 360 degrees for one revolution of the swing wheel. On each of the arbors of these wheels was fixed a pulley having a square bottom, in which were set about ten hard tempered steel pins a little tapered, something like the pullies at the old thirty hour clocks, whose bottom was round in place of square. The pendulum was fixed to the wall of the steeple, as well as the frame containing the 'scapement work, and the apparatus which has been described. The arbor of the eight toothed wheel had one of its pivots prolonged with a square on the end outside. The clock frame containing the movement was in the centre of the steeple, and the pinion in it, which suppose to be that of the swing wheel, had one of its pivots also prolonged and squared outside. These squared pivots were connected by a steel rod and Hooke's joints. The main weight of the clock being put on, must urge not only the wheels to turn, but that of the wheel having the kneed teeth; but some one or other of these teeth pressing on the arbor of the swing wheel cannot turn, consequently none of those in the large frame can turn, nor can the swing wheel turn here unless some other means are used. An endless chain was provided, and passed over the two pullies fixed on the wheel arbors, and through two common pullies, to one of which is hung the small weight which is to turn round the swing wheel, and to the other a counter weight. The weight which turns the swing wheel, has its force placed on that side so as to make the wheel act properly with the pallets; now, while the swing wheel is turning, (the pendulum being supposed in its motion,) one of the other wheel teeth is gently pressing on its arbor. Whenever this tooth meets with its own notch, it will, by means of the main weight, be made to pass quickly through it; *while passing*, the small weight is wound up a little by the main one; the succeeding tooth then meeting with the swing wheel arbor, rests on it for a quarter of a minute, till its notch comes about; it then passes in its turn, and so on. The swing wheel makes a revolution every two minutes, in which time the wheel with the eight teeth makes also one. The minute hand, by this mechanism, when passing one of the notches, makes a start every quarter of a minute; at every such passing, the small weight is wound up a little by the great or main one. After the clock had gone a considerable time with this, it was found that the kneed teeth got a little swelled on their parts of rest, by the force of the main weight which made them fall on the swing wheel arbor. To remedy this, an endless screw wheel was put on the arbor of the remontoir wheel, (or wheel with the kneed teeth,) working into an upright endless screw, on the upper end of whose arbor was fixed a pretty large fly, in order to lessen the velocity of the remontoir wheel, and make the kneed teeth fall gently on the swing wheel arbor. This helped the swelling greatly, but did not entirely prevent it, though it existed now in a less degree. The endless chain had also a tendency to wear fast; in consequence of this, and of no provision having been made for the swelling of the kneed teeth, by making the notches on the swing wheel arbor much wider than was required for them when newly finished and first applied, this part of the remontoir was taken away, and the rod, with Hooke's joint, was put on the square of a pivot of the swing wheel, prolonged on the outside of its frame. These matters being guarded against, it might be well for some artist in future to try such a remontoir. During the four years it was in use, the clock went uncommonly well, and was the admiration of a gentleman who lived opposite the church, and who was an amateur in horology. One of Mr Reid's men who took an interest in this clock, said it did not do so well after the remontoir was taken away. This, however, may have been more owing to a change in the position of the weights, than to any thing else, occasioned by a chime of eight large bells being put up in the steeple. For the weights, in place of having their natural fall, were carried a great way up in the steeple above the bells and clock, in order to fall down again; and here a complication of rollers and pullies became requisite.

Harrison's remontoir is a very delicate spring, which is bent or wound up eight times in a minute. Were it necessary, a more obvious description could be given of it than that which is given with his time-keeper. In Haley's, the remontoir spring is bent up 150 times in a minute. In the 'scapement of Mudge's marine time-keepers, what may be called the remontoir, was bent up 300 times in a minute; the 'scapement here became in some degree wholly the remontoir. A variety of 'scapements may be seen in *Thiout*, and in some of the modern periodical works; yet, for the purpose of common or ordinary sort of clocks, they are confined chiefly to those of the dead beat, and the recoil. Where accurate performance is expected, some may have recourse to 'scapements of a different description.

About the year 1752, Le Roy, Lepaute, and other clockmakers in Paris, were much engaged in making clocks having only one wheel; and some had not even a single wheel in the movement. They were, however, more expensive in making, and performed much worse, than those which were constructed in the ordinary way. Simplicity in the machinery seems to have been their chief object. It requires, however, experience to know what simplicity in machinery is; although apparently more simple, a clock having two wheels in it, will not be equal to that having three or four; yet it does not follow, that, by having more wheels, the clock will be proportionally better: it has already been mentioned, that there are bounds which cannot be overstepped with impunity. This subject cannot be better exemplified than by making a comparison of one of Hindley's clocks, having two wheels, and giving thirty vibrations in a minute, with a clock giving the same number of vibrations in the same time, and with three wheels. The first or great wheel, in one of Hindley's, had 180 teeth, the second or swing wheel 120, and the pinion 8. The number of these teeth, and of the pinion leaves, amounts to 308. In the other, the wheels were 48, 40, and 30, and two pinions of 8; the sum of these is 134; the difference is 174, being the number of teeth more in the one than in the other, and more than the sum of the teeth in the three wheeled clock.

We shall now proceed to give a short account of such watch 'scapements as have been thought worthy of notice, from the old crown wheel and verge to the modern free or detached 'scapement; but, in order that the reader may be able to follow our descriptions, we have given from Berthoud a view of an assemblage of wheels and pinions, to represent something like the movement of a watch or a small clock. They are contained in a frame made for the purpose of allowing them to be more readily seen. Plate CCCII. Fig. 1. DE is the pillar plate, or pillar frame plate; G F the fore frame plate. A is the balance; the arbor or axis on which it is fixed is the verge, whose two pallets, *p*, *p*, scape with the teeth of the crown wheel C. The pivots of the balance turn or run in the frame; those of the crown wheel C, and of its pinion *d*, run in the potence I, and in the counter potence H, both of which are screwed on the inside of the pillar plate, the arbor of the pinion *d* being at right angles to the axis of the balance. The contrate wheel K and its pinion C turn also in the frame; the teeth of the contrate wheel pitch into the balance (or crown) wheel pinion, and can turn or drive it; the third wheel L, and its pinion *b*, run in the frame; the teeth of the third wheel pitch into the contrate wheel pinion, and turn it. The centre or second wheel M and its pinion *a*, have a long arbor going beyond the outside of the dial RS. The second wheel M, pitches with the third wheel pinion *b*, which it likewise can turn. N is the first or great wheel, pitching with the second wheel pinion *a*. X is the ratchet, *m* the click, and *n* its spring. On the arbor of the great wheel the ratchet is fixed; and, on winding up the main spring, the ratchet and arbor turn freely in the hole at the centre of the great wheel, which keeps its place during the time of winding. OP is the main spring deprived of its barrel; the inner end of it hooks on to the lower part of the great wheel arbor, and the outer end is hooked to the rim of the barrel, but is here fixed to a temporary stud. The force of the main spring, after being wound up, sets all the wheels and pinions in motion, and would oblige the ratchet and arbor to turn round independent of the great wheel; by this the main spring would be instantly unbent, but is prevented from this, by the click *m* being forced by its spring *n* to fall into the teeth of the ratchet, applying its end to the face of the ratchet teeth; by this means the main spring must unbend itself very slowly, the motion of the wheels being checked by the 'scaping of the verge with the crown wheel teeth. Q is the cannon pinion, put spring tight on the arbor of the second wheel, whose socket or cannon goes outside or beyond the dial, where it is squared for the purpose of the minute hand being put on it. T is the minute wheel, *g* its pinion; the cannon pinion pitches into or leads the minute wheel; the hour wheel V having a hollow arbor or socket *t*, is put on the cannon pinion, and is led by the minute pinion which pitches into its teeth. It is on the socket of the hour wheel which comes a little above the dial, that the hour hand is put. When a wheel pitches with a pinion and turns it, the pinion is said to be driven by the wheel; if the pinion turns the wheel, the wheel is then said to be led by the pinion. The pendulum or balance spring *s s* has its inner end fixed to a collet, which goes spring tight on the arbor of the balance; the outer end is fixed or pinned to a stud fixed on the inside of the fore plate. In the action of the crown wheel teeth on the pallets, the balance spring is either bent up or unbending; it is by the small force of it, that the balance is made to give twice the number of vibrations that it would give without it. It should have been observed, that, by putting a key on the square of the cannon pinion, and turning it about, this will not only move the minute hand about, but will oblige the hour hand to follow slowly, in the ratio of one turn to twelve of the minute hand.

The first watches may readily be supposed to have been of rude execution. Having no pendulum spring, and only an hour hand, and being wound up twice a day, they could not be expected to keep time nearer than 15 or 20 minutes in the twelve hours. After the application of the pendulum spring, they would no doubt go considerably better, and may now be made to keep time sufficiently correct for the ordinary purposes of life. Indeed, when the crown wheel and verge 'scapement is executed with care, it will do uncommonly well. Let the angle of the verge be 93 or 95 degrees, the teeth of the crown wheel undercut to an angle of 28 or 30 degrees, and scaped as near to the body of the verge as just to be clear of it, (it is to be understood here that the verge holes are jewelled.) To carry the matter still farther, the body may so far be taken away as to admit the teeth near to the centre, which will tend to allow the vibrations of the balance to move more freely and independently; but this requires such nice execution *here*, and in other parts of the 'scapement, that from not having encouragement, few are fit to execute it, and therefore it may in general be safer not to bring the wheel teeth so near to the verge. Care must also be taken to have the balance of a proper diameter and weight, which has of late been much neglected since the old fashion of half timing has been left off, that is, making the watch go without the pendulum spring, if it goes slow 30, 32, or 33 minutes in the hour, the balance may be considered of such a weight as to be in no danger of knocking on the banking from any external motion the watch may meet with in fair wearing. When the pallets of the verge are banked on pins in the potence, they should, to prevent straining, both bank at the same time, alternately the face of one pallet on a pin, when the back of the other is on its pin; or the banking may be done by a pin in the rim of the balance, but not near the edge of it. Which of the two is preferable, we shall not stop to determine.

The verge watch, as has been already said, when properly executed, will perform extremely well. About thirty years ago or more, the writer of this article had some of them made up in such a way, that they went fully as well as any horizontal 'scapement, and for a longer time; this last requiring oil to the cylinder, after going ten or twelve months. Oil, however, should never be allowed to come near the wheel teeth or pallets of a verge. Verge or contrate wheel watches have, of late years, been very much overlooked and neglected in many respects, and in none more so than in the relative position of the balance wheel, and contrate wheel arbors. They are rarely seen but at a considerable distance from one another, which gives a very oblique direction in the pitching of the contrate wheel with the balance wheel pinion. It is well known, that where force is indirectly or obliquely applied, it will work under great disadvantage. These arbors ought to be placed as near to each other as can be. In order to obtain this, reduce the balance wheel pinion arbor *towards the end to the smallest size it will bear*, and turning a hollow out of that of the contrate wheel, will allow them to come very near the line of their centres. To get this pitching to the greatest advantage, some place the counter potence within the arbor of the contrate wheel, so as to have the line of the balance wheel pinion direct to the centre of the *contrate wheel*, as may be seen in Plate CCCII. Fig. 1.

It has been recommended by a very celebrated artist, that the movement wheels should be placed in such a manner as to act at equal distances from the pivots of those pinions which they drive, in order to divide the pressure or action of the wheel between the pivots, and that one should not bear more than the other. This is apparently sound reasoning; but having put it in execution, the pivots unexpectedly seemed to wear very fast, even more so than in the common barred movement; the pivots, it is true, were small, and the motive force rather great. It is to be wished that it were again tried by others to bring it to the test. No pivots have been found to stand so well as those in movements of the double barred sort.

A pendulum spring collet, made as it ought to be, is as seldom to be met with, as that which we have noticed regarding the *position* of the contrate and balance wheel arbors. Yet simple as the thing is, it seems to require a rule to shew *how it should be done*, there appearing to be none, if we may judge by the greatest part of those which have hitherto been made. The ring of the collet should be no broader than to allow a hole to receive the pendulum spring, and the pin which fixes it. The *slit* in the collet, for the purpose of its being always spring tight on the inside taper of a cylinder or verge collet, should be put close to where the small end of the pin comes, when the spring is pinned in. The pendulum spring, in this case, will have the first or inner coil at such a distance, as to allow the point of a small screw-driver to get into the slit without any danger to the spring, when it is wanted to set the collet and spring to any required place. If the slit is put at the other end of the pin, where it is oftener than anywhere else, it is evident that the workman cannot get into it without danger. The outer end of the pendulum spring ought to be pinned or fixed into a brass stud or cock, in performing which operation it goes easily on; whereas with steel cocks or studs, there is a kind of crossness and trouble, which shews that they should never be used.

Studs are, in general, very improperly placed, being at a greater distance from the curb pins than is requisite. We have seen this distance so great, that the motion of the pendulum spring between the stud and the pins was such, as to take away a part from every vibration of the balance; which is something like a pendulum when suspended to a vibratory cock, where it would not be allowed to have half the motion it would otherwise have acquired.

A few years ago, our modern improvers would have the joint transferred from the pillar plate to the brass edge, than which nothing worse could have been proposed. In the old way, the whole of the movement was kept in its place by the united assistance of the joint, and of the bolt and its spring; whereas, in the other way, the movement had its sole dependence on the pins of the brass edge feet, from which it would be disengaged by violent exercise on horseback, &c.

From what has been said of the imperfections in watches, it may be seen, that they are inevitable, arising from a want of energy of mind in workmen, of which not one in a hundred is possessed. Can it be supposed, that every new watch, which is purchased, is complete, and requires no assistance? Whoever thinks so, must be disappointed. Persons of this description, on finding it not to go as they expected, bring it to a watchmaker, many of whom cannot put it in a better state than that in which the workman left it. But it is not brought to him with the view of any thing being done to it, but to see what is the matter with it; never considering, that any irregular going or stopping must imply some fault or other, and is the very cause that brings them to the watchmaker. It does not follow, however, from this, that every watch which stops is badly executed; this will happen sometimes with those of the very best execution, and frequently from an over-nicety of execution. On its being left with him, he takes it down, to examine what is wanting to make it keep time. The owner, on being told afterwards that it will cost so much to make it do what is required, strongly suspects, though he is polite enough not to say it, that there must be some imposition on the part of the watchmaker. Much is the trouble which many have of rectifying the faults of work given in to them, and thought to be complete, and much money is paid to others to have them rectified. We have known four guineas paid to a workman for doing a particular branch; and not being executed to the satisfaction of the watchmaker, he has given half as much more to another to have it corrected. There are as few excel in this art as in those of sculpture, painting, and engraving, which are called the fine arts, a name to which the other is equally entitled, but which labours under the great misfortune that few or none are able to appreciate its merits.

The old 'scapement, even after the application of the pendulumspring, not giving that satisfaction which was required, induced Huygens and Hooke to think of other means of improving it, or to substitute a superior mechanism in its place. In this pursuit, the mechanical talents of Hooke stood conspicuously eminent over those of the justly celebrated Huygens.

Some of the movements of Huygens' watches, or timekeepers, were much larger than those of our box chronometers. The contrate wheel was cut into teeth of the same form as those of the common crown wheel, and made to 'scape with a verge of the usual kind. On the axis of this verge was a sort of contrate or crown wheel, having teeth like the ordinary contrate wheel, which drove a pinion fixed on the axis of the balance. The verge, when 'scaping with its wheel, caused the balance to make several revolutions from every impulse on the pallets. Plate CCCII. Fig. 2. Some of them had no pendulum spring, having been made perhaps before its application. When the balance made several revolutions in every vibration, each being two seconds, this 'scapement would be but ill suited for the coils of a pendulum-spring. Those having the pendulumspring appeared about 1675. This was the origin of half-timing, upon seeing, when the pendulumspring was applied, that it made the balance give two vibrations in the same time that it gave one without it. About the same period, Dr Hooke brought into notice his watch with a new 'scapement; which, for seventeen years before, he had been privately endeavouring to improve. This was very different from the old crown wheel one, and as much so from that of Huygens. It had two balances, on the axis of each of which was a toothed wheel, pitching into one another. The verge or axis of these balances had each a pallet on it. The balancewheel was flat, having a few ratchet or saw-like teeth; its arbor run in the frame, parallel to those of the balances, at a point equally distant from them; the three points forming, as it were, the angles of an equilateral triangle. When a tooth of the balancewheel gave impulse on one pallet, the other, by the pitching of the two wheels, was brought about to meet another tooth, (after the wheel had escaped from the pallet on the opposite side,) in order to receive impulse in its turn. There was a pendulumspring on one of the balances, and the object of their being pitched together was to prevent the effects of external motion on them, while it served the double purpose of bringing alternately about the pallets, which still gave some recoil to the wheels by the reaction of the balances. Although this was a very ingenious contrivance for a 'scapement, yet it appears not to have given that satisfaction which was expected from it, (probably from indifferent execution, which, from Sully's account, was the case,) and the old one was again adopted. However, some years afterwards, other artists, among whom was Dutertre, were attracted by this 'scapement of Dr Hooke's, and were led, from time to time, to make improvements on it. From it originated the duplex 'scapement, which has of late years been so much in repute. A large old German clock had a 'scapement on the same principle as the above, of which the maker's name is unknown. Dr Hooke's claim to his own 'scapement, remains however undisputed.

The famous Tompion, who contributed greatly to bring the art of Horology in England to that reputation which it had acquired for a long period of sixty years or more, during which he practised it, made a 'scapement about 1695, and flattered himself with being very successful. The verge or axis of the balance was a small solid steel cylinder, cut across at the middle, and nearly half way down; along the length way of this part cut across, a deep angular notch was made, forming a sort of pallet on the right hand side; the balance wheel was flat, and much like Dr Hooke's; and the spaces between the teeth sufficiently wide to allow the cylinder to turn freely between them. When a tooth of the wheel impelled the pallet, and when on escaping from it, the tooth following dropped on the outside of the cylinder, near the left edge, resting on the cylinder during this vibration of the balance, after passing the left edge, and meeting a little recoil, it got on the pallet, and gave a new impulse, which was given only at every second vibration. An excellent property was observed in this 'scapement, that any inequalities in the motive force made no deviation in its timekeeping; but the friction of the balance wheel teeth on the cylinder and its edges was so great and destructive, that it was given up in consequence of it.

Knowing what Tompion had been doing, being bred under him, Graham, a good many years after, set to work with the cylinder 'scapement, and ultimately succeeded. Although this 'scapement is now pretty generally known, yet we may be allowed to give an account of what he did. Plate CCCII. Fig. 3. In place of Tompion's solid cylinder he made a hollow one; on the points of the wheel teeth of Tompion were raised something like small pins or stems, on the tops of which a sort of inclined or curved wedge-like teeth were formed, of such a length as to have very little freedom when in the inside of the cylinder, and the outside of the cylinder to have the same freedom between the point of one tooth and the heel of the other. A notch or opening was made across the cylinder, not quite half way down the diameter; the edges of the cylinder made by this opening were dressed so that the curved edge of the tooth might operate easily on them; the right hand edge was flanched outward, the left one rounded; when the balance was at rest, and the wheel in its place to 'scape, the point of the tooth got then just in on the cylinder edges, and no more; a second notch was made below the other, to allow the bottom of the wheel to pass, leaving hardly a fourth of the circumference of the cylinder, the other leaving more than a semicircle. The highest part of the wedge or curved tooth being on a circle, greater or beyond that on which the point was, it is evident that, if the wheel is urged forward, it will make the cylinder to turn, and the angle of 'scapement will be according to the height of the wedge. When a tooth of the cylinder wheel escapes from the left edge of the cylinder, the point of it falls into the inside of the cylinder, after reposing there, and then passing and impelling the right hand edge; on escaping it, the point of the succeeding tooth drops on the outside of the cylinder, where it reposes; on the return of the balance, it gets on the left hand edge, giving a new impulse, and so on. The teeth impel at both edges of the cylinder, giving by each a vibration to the balance.

This 'scapement being the best of any that had preceded it, (Debaufre's perhaps excepted) procured for Graham's watches a very considerable reputation, as their performance was much superior to that of those of the old construction. However, on comparing the going of some of Graham's with those of a later date, we confess that none of his, though excellent, were ever equal to them in this. The cylinders were rather large in diameter, the balance too light, the motive force too weak, and he had great difficulty in obtaining good pendulum spring wire, meeting sometimes with iron, where he expected steel wire. Watches having the cylinder 'scapement were not known in France till 1728, when Julien Le Roy commissioned one of them from Graham. They were losing their character here, some time before the introduction of the duplex, which contributed afterwards still more to bring them down. The duplex will in its turn be supplanted, for reasons which will be afterwards noticed. Flat movements, shallow balance wheels, steel and brass of bad materials, from the difficulty of getting them good, injudicious execution, and low prices, must have tended to make the cylinder 'scapements so bad as they were of late; many of the cylinders were destroyed and cut to pieces in a very few years, and some of them could not last so long. Let these be compared with the cylinder 'scapements of old Hull, many of which that we have seen, have little or no impression even on their edges, after having been in use thirty years and upwards. Of what did Hull's art consist? There must have been some causes for it; but what these are, we shall not attempt to conjecture. As Graham, with whom he was instructed, did, Hull soldered in the plugs of his cylinders, with silver solder, which caused a very tedious process afterwards in making the cylinder; but this is not offered as any reason for his excelling in the art of cylinder 'scapement making. The acting edges of the teeth have hitherto been made too thin, particularly for steel cylinders, with the view of lessening the friction; but, from cutting soon, this friction increased, and was worse than a greater friction which was constant.

When the vibrations of the balance are at the lowest point, the resistance of the pendulum spring is at the least; but the more it is bent or unbent, the greater is the resistance; consequently, when at the height of the wedge or tooth, it is greater than when the tooth first begins to act. Two or three different curves for this purpose have been imagined; one approaching nearly to a right line, which is supposed to give the wheel time to acquire a velocity during the passing of two-thirds of the curve, and the least resistance of the spring, by which the other third more readily overcomes, when the resistance to it is at the greatest. This has been thought to give a greater extent to the arc of vibration, and has been adopted by the French artists. Another curve, where equal spaces make the balance describe equal portions of a circle, is thought to give the least wearing to the edges of the cylinder, and is that which is practised by our 'scapement makers. Arguments equally good for either, it appears, might be given.

The weight and diameter of the balance, are circumstances very materially connected with the wearing on the cylinder edges. Whatever will prevent this wearing, should be carefully attended to. When the diameter is large, the balance must of consequence be less heavy; a sort of sluggishness in its motion takes place, the pendulum spring making great resistance to the teeth passing the cylinder edges, and causing wearing to go rapidly on. On the contrary, when the diameter is small, and the weight at a proper medium, there is an alertness in the vibration; the momentum of the balance has such force over the pendulum spring, that it allows the teeth to pass the edges quickly; and hence there is a less tendency to wear them. The diameter of the balance should be less than that in a verge watch of equal size, nor should it be heavier than just not to allow setting, unless where a going in time of winding is used. The cylinder 'scapement, on the whole, must be allowed to be a very excellent one; and where care is taken to have it made as it ought to be, such watches will give very good performance. Provision for oil on the cylinder should be made as ample as can be admitted; that is, the part where the tooth acts, should be as distant from the notch where the wheel bottom passes as possible, and at the same time more distant from the upper copper plug; the lower notch should not be longer than to give freedom to the wheel bottom to pass easily. When they are made long, which they frequently are, the cylinder will break there, if the watch receive a slight shock from falling. The acting part of the tooth, as has already been noticed, should not be too thin, nor the stems too short. If the diameter of the balance is too great, any addition of motive force will make the watch go slow; if too little, the watch will go fast; and if of a proper weight and diameter, any addition of motive force will make no change on the time-keeping. We have made the motive force more than double, and no change took place; the pendulum spring no doubt had its share in keeping up this uniformity. Balances whose diameters are rather small, will have a natural tendency to cross farther, that is, the arcs of vibration will be greater than where the diameters are great. Their weight will be in the ratio of the squares of their diameters; from which it follows, that if the balance is taken away from a watch which has been regulated, and another put in its place, having the diameter only one half of the former, before the watch could be regulated with the same pendulum spring, the balance would require to be four times heavier than the first. One way of estimating the force of a body in motion, is to multiply the mass by the velocity. Let us then calculate the respective forces of two balances, whose diameters are to one another as two to four. The radii in this case express the velocity. According to this principle, we shall have for the small balance two for the radius, multiplied by eight of the mass, equal to sixteen; and for the great one, four of the radius by two of the mass, equal to eight; sixteen and eight are then the products of the mass by the velocities; consequently they express the force from the centre of percussion of each balance; and as it is double in the small one, it is evident that the arcs of vibration will be greater, having the faculty of overcoming easily any resistance opposed to it by the pendulum spring, without requiring any additional motive force.

Let us take an example done in another way, which is the square of the product of the diameter multiplied by the velocity or number of degrees in the vibration, and this again multiplied by the mass or weight, so as to compare the relative momentum of two balances of different diameters, &c. Suppose one balance to be .8 of an inch in diameter, the degrees of vibration 240, and the weight eight grains; the other .7 of an inch in diameter, the arc of vibration 280°, and the weight 10 grains

$$240 \times .8 = 192 \times 192 = 36764 \times 8 = 294112.$$
$$280 \times .7 = 196 \times 196 = 38416 \times 10 = 384160.$$

The balance having the smaller diameter, has its momentum to that of the greater, as 384 is to 294. When the arcs of vibration are great, the nearer to isochronism will the long and short ones be.

When a little expence in the cylinder or horizontal 'scapement is not grudged, a ruby cylinder is certainly a great acquisition to prevent wearing on the edges; if it is not steel cased, and wholly of stone, it is so much the better, giving a little more scope to extend the limits of the banking, the steel crank of the other confining the extent of banking. There is no doubt a greater risk of breaking than in the cased one; yet this might be considerably lessened, were some attention paid to make the notch which frees the bottom of the wheel, as has been proposed in the case of the steel cylinder, no longer than is necessary. It would be desirable to have the cylinder, formed by the strata of the sapphire or ruby, being placed in a vertical position instead of a horizontal one. This is surely attainable, when we know that diamond splitters can distinguish the strata or layers of the diamond, a stone which may be supposed more compact than either the ruby or sapphire. We have seen a cylinder, wholly of stone, in a watch belonging to a gentleman, who was wearing it when between 70 and 80 years of age; he used frequently to let it fall without any accident happening to the cylinder. Three small griffs or cocks placed on the potence plate, so as to allow the balance edge to come into notches fitted for it, and having sufficient freedom, would prevent either the cylinder or the cock pivot from breaking. A little practice should make the stone cylinder easier, and perhaps cheaper made, than the cased one; at all events, even on equal terms, it ought to be the preferable of the two. From what has already been said, it appears that the weight and diameter of the balance are matters not merely arbitrary; for if the motive force is too great for that of the force of the balance, the watch will go fast when in the laying or horizontal position, and slow when in the vertical or hanging position: by diminishing either the motive force, or making the balance heavier, the watch may be made to go the same in both positions. The properties of the pendulum spring may conduce a little to this. It is in some degree a desideratum for a pocket watch to have the balance pivots and holes made so that the balance with its spring, when in a state by itself, and free of any communication with the wheels, should vibrate the same length of time, whether it is in a vertical or a horizontal position. We know when it is in the last, that it will continue to vibrate twice the length of time that it will do in the other. We are humbly of opinion that this could be come at. But who will be at the trouble and expence to make such experiments as may lead to it? Mr Earnshaw's pivots, with flat ends and shallow holes, should come very near to this object. About forty years ago we used to hollow out the ends of balance pivots.

In the interim, between Tompion's having left off his trials in attempting the horizontal 'scapement, and Graham's having brought it to a state of perfection, M. Facio, a native of Geneva, having discovered the art of piercing holes in rubies, or any hard precious stone, came to Paris with this art as a secret; and not being well received either by the Duke of Orleans, at that time regent of France, or by the watchmakers, he repaired to London with it about the year 1700, which was at that time a school where the art of horology was more cultivated than at Paris. He was admitted a member of the Royal Society, and having entered into a kind of partnership with a native of France, who had been settled in London, whose name was Debaufre, they carried on the business of watch-jewelling.* Facio's partner had, at this time, contrived a new 'scapement; it was a dead beat one, which was the thing now sought for. Plate CCCII. Fig. 4. The balance and balance wheel holes of it were jewelled; the pallet was made of diamond, formed from a very short cylinder of two-tenths of an inch in diameter; the upper end of the cylinder was cut down nearly one-half of the diameter, and flanched to the lower end and opposite side, rounded off from the circular part of the base left at top, to the lower end of the flanch, resembling something like a cone bent over, and wanting a part of the top. Two flat balance wheels, having ratchet or crown wheel sort of teeth, were on the same arbor, the teeth of the one being opposite to the middle of the spaces of the other; the distance between these wheels was a little less than the diameter of the cylinder; the drop of the teeth in 'scaping, falls on what was left of the upper base of the cylinder, (the lower base being taken away in forming the pallet) and near to the edge formed from the flanch; here they rested during the time of the vibration of the balance. On the return, the tooth gets on the flanch, and passes over it, during which, giving impulse to the balance, and escaping at the lower end, a tooth of the other wheel drops opposite on the same base of the cylinder, and so on. A watch having this 'scapement, and bearing Debaufre's name, was put for trial into the hands of Sir Isaac Newton, who, in shewing it to Sully in 1704, gave a very flattering account of its performance. It attracted Sully's notice very much, but thinking it by no means well executed, and not being quite satisfied with two wheels, it was thought that an improvement would be made by having one wheel only and two pallets, which was part of the scheme of the 'scapement he adopted for his marine time-keeper made in 1721. Considering the genius which Sully was allowed to possess, this was by no means an improvement on Debaufre's 'scapement.

Although an Englishman, Sully's name was unknown to his countrymen; and would have remained so, had it not been for the accounts given of him by the French artists, in whom he excited an emulation, and whom he inspired with a taste to acquire such a pre-eminence in their profession as had been before unknown to them. Julien le Roy, who was intimately acquainted with Sully, and Berthoud, are uncommonly lavish of their encomiums on him. Soon after he had completed his apprenticeship with Mr Gretton, watchmaker in London, he went over into Holland, Germany, and Austria, and attracting the notice of several of the princes and nobility, he was much employed by them. Having seen, in the library of Prince Eugene, the *Memoirs of the Royal Academy of Sciences of Paris*, he eagerly acquired the French language in order to read them. This excited in him a strong desire to see Paris, to which he repaired about the year 1713 or 1714, under the patronage, and in the suite of the Duke of Aremburg, at whose hotel he lodged, with a pension of 600 livres. He had not been long there, when our countryman, Law of Lauriston, under the authority of the court of Versailles, got him engaged to establish a manufactory of clocks and watches. In consequence of this he came twice to London, and having carried away a great number of workmen at a vast expence, and spent much money on tools and other articles, Law began to murmur, and the establishment in two years or little more fell to the ground. This made him complain bitterly of his bad fortune to a friend; but fortunately a nobleman to whom this was mentioned, feeling much for the disagreeable situation in which Sully was placed, sent him in a present some shares in the public funds, value 12,000 livres, which enabled him, for several years afterwards, to pursue very zealously his favourite scheme of making a marine time-keeper to ascertain the longitude at sea. In this attempt he was not so successful

* Some of Debaufre's family, or name, were at this profession in London so late as 1773.

in his first trials, as he had led himself to expect. It was in general believed, however, that had he lived he would have been the first to have deservedly acquired one or other of the premiums which were before that time offered, by four of the greatest maritime powers in Europe, to those who should produce a time-keeper which could ascertain, to a certain extent, the longitude at sea. Philip the Third, who ascended the throne of Spain in 1598, was the first who proposed a reward of 1000 crowns for this invention. The States of Holland soon after followed his example, and offered 100,000 florins. The British Parliament, in the reign of Queen Anne, voted 20,000*l.* sterling for the same purpose; and the Duke of Orleans, Regent of France, in 1716, promised, in the name of the King, 100,000 livres. Sully may literally be said to have died a martyr to the cause in which he was engaged. Having got a false address to a person who it was said was occupied in the same pursuit with himself, he got so overheated in his anxious and vain endeavours to find him out, that he died in a few days after at Paris, in the month of October 1728, and was buried with great pomp in the church of St Sulpicius. Sully acted so conspicuous a part in the profession, that no apology is necessary for giving this short account of him.

It may be observed here, that Debaufre's 'scapement has this advantage, which is not in Graham's, that the impulse is given the same in every vibration; and the time of rest on both sides is the same, bearing mostly on the foot pivot end, and a little on the sides of the pivots, and not wholly on the sides of the pivots, as in Graham's. Having made one or two watches, to which this 'scapement was put, they were found to perform very well; and we would recommend it to the attention of 'scapement makers: A little practice will make the execution of it very easy. The two thin steel wheels may at pleasure be placed at any distance from one another; their diameters should be as large as can be admitted between the potence foot and the verge collet. An agate, or any hard stone, for the pallet, whose height is half the spaces between the teeth, or a little less, is fixed on the verge or axis of the balance; the level of the base of the pallet on which the teeth rest being a very little above that of the line of the centre of the balance wheel pinion. The teeth must be a very little undercut, so that the points only may rest on the pallet. The verge should be placed more inward in the frame than in the common contrate wheel movement, in order to give room for the balance wheels. The necessity of a contrate wheel movement for this 'scapement is a trifling objection, which will wear away in spite of prejudice.

In 1722, the Abbé Hautefeuille, who long before this had at Paris disputed, in a process of law with Huygens, the right of the invention and application of the pendulum spring to the balance of a watch, published a quarto pamphlet, containing a description of three new constructions of 'scapements for watches. One of these was the anchor, or recoiling 'scapement, on the verge of which was attached a small toothed segment of a circle, or rack, working into a pinion, which was the axis of the balance. Plate CCCII. Fig. 5. The idea of the axis of the balance being a pinion, seems to have been taken from the 'scapement of Huygens, with this difference only, that the balance should not make so many revolutions as that of Huygens, and is contrived so as to make scarcely one revolution at every vibration. This 'scapement is the same as it came from the hands of Hautefeuille, without any improvement having been made upon it even to this day, although a patent was taken out for the same invention above twenty years ago, by some person in Liverpool. The name of lever watches, which they received from the patentees, is that which is generally given to those having this 'scapement, which is the same that Berthoud has described in his *Essai sur l'Horlogerie*, published in 1763; see tom. ii. No. 1933, and plate xxiii. fig. 5, of which our Figure is a copy. Berthoud, under certain modifications, introduced the principle of this 'scapement into some of his marine time-keepers.

A very able and ingenious artist at Paris, M. Dutertre, who was zealous in his profession, and had considerable success in his pursuits, invented, in 1724, a new 'scapement, or rather improved that of Dr Hooke's with two balances, which has already been described. Plate CCCII. Fig. 6. The additions and improvements, however, which he made, were so great, as to give him a sort of title to claim it as his own, and to render it, in the opinion of good judges, the best 'scapement by far that was known at that time. The additions which he made, consisted in putting another wheel upon the same arbor with the first, but it was considerably larger in diameter, having the same number of teeth with the other, and forming the principal merit of the 'scapement. The balance arbors at one place were made rather thicker than usual, for the purpose of having notches cut across them, and as deep as to the centre. This part of the arbors becomes then a semicylinder. The larger wheel, which may be called that of *arrête*, or repose, is placed on its arbor, so as to correspond with the semicylinders and their notches, the points of whose teeth are made just to clear the bottom of the notches, alternately passing one of them, and resting on the semicylindrical part of the other. The action of the two wheels shall now be explained. Let us suppose, that one of the larger wheel teeth, after reposing on one of the semicylinders, is, on the return of the vibration of the balance, admitted to pass through the notch; after having passed, a tooth of the impulse-wheel falls on the corresponding pallet, gives impulse, carrying it on till it escapes; when another tooth of the wheel of repose falls on the other semicylinder, and rests there until the return of the vibration of the other balance; when it passes the notch in its turn, and the corresponding pallet presenting itself, is impelled by a tooth of the impulse wheel, and so on. Hooke's 'scapement had a small recoil; the aim of Dutertre was to make a dead beat one of it, in which he succeeded. There is a drawing of this 'scapement in Plate xiv. fig. 4. of Berthoud's *Histoire de la Mesure du Temps*. He says, "that the properties of this 'scapement are such, that sudden shocks do not sensibly derange the vibrations; that the pressure of the wheel-teeth of *arrête* on the cylinders, corrects the impulse that the balance receives from the wheel work, which, on the motive force being doubled, prevents the vibrations from being affected."

In Plate xli. fig. 16. of the first volume of Thiout's work, is a drawing of this 'scapement, modelled for that of a clock, described at page 101. He says, "Fig. 16. is an escapement of the Sieur Jean Baptiste Dutertre, which has only one pallet, on the axis of which is the fork. The two ratchets or wheels are on the same arbor, when the pallet escapes from the small ratchet; the larger one, which is called the ratchet, or wheel of *arrête*, rests on the arbor of the pallet, and leaves the vibration to be pretty free. Plate CCCII. Fig. 7. On the pallet's returning to meet with the teeth of the small ratchet, the pallet-arbor, or cylinder, being notched or cut across into the centre, allows the wheel of *arrête* to pass; and the wheel of impulsion, after getting a small recoil, gives new force to the vibration; so that in two vibrations only one of them is accelerated: Hence it was thought, that the half of the vibrations being *free*, and independent of the wheel work and its inequalities, they would be more correct than others; but experience did not confirm this." This is, then, the duplex 'scapement, or the nearest possible approach to it.

It is more than fifty years since we saw a small spring clock having this 'scapement, made by a very ingenious clockmaker of this place, whose name was Robert Brackenrigg. It may be supposed to have been made a very few years after Thiout's work was published.

In 1727, Peter le Roy gave an account of a 'scapement which he had made, having one pallet on the axis of the balance, and a notch below it, a wheel of *arrête*, and one of impulse, as described in the preceding 'scapement; so that one half of the vibrations were independent of the wheel work. Dutertre claimed the pretended invention of Le Roy, who, finding it not to answer his expectations, gave it up. That Dutertre made the one which is represented in Plate xli. of Thiout, we have no doubt; and there is unquestionable authority, that he brought Dr Hooke's to the improved state which has just been mentioned. It is said, that he had made a free or detached 'scapement; but no account whatever has been given of it.

The duplex 'scapement, as it is now called, was introduced into its native country about thirty years ago or more, under the name of Tyrer's 'scapement, the name, it is supposed, of him who put the last hand to improve that which came in a lineal descent from Dr Hooke. In place of the notch being made right across the arbor, as has been mentioned before, Tyrer's had a very small cylinder or roller, whose diameter was .03 of an inch, into which was made, in a longitudinal direction, a deep angular notch of 30 or 40 degrees. Plate CCCII. Fig. 8. The cylinder was sometimes of steel, but most frequently of ruby. When the points of the teeth of the wheel of repose fall into the notch, they meet with a very small *recoil* by the balance, in what may be called the returning vibration. This goes so far as to make the point of the teeth for a little to leave the notch, at the side opposite to that by which it came in. The balance on returning, is now in the course of that vibration, when it is to receive impulse from the wheel, which takes place immediately on the tooth of the wheel of repose leaving the notch and the small cylinder, and as soon as the tooth of impulse escapes from the pallet,—the next tooth of repose falls to rest on the small cylinder, and so on.

This 'scapement of Tyrer's is much superior to that of the cylinder, or horizontal one; it is almost independent of oil, requiring only a very little to the points of the wheel teeth of repose. It can carry a balance of much greater momentum, and, when well executed, performs most admirably. But there are so many circumstances or minutiæ to be attended to in it, that some of them may at times escape the eye of the most judicious and careful; the watch may stop, and yet the 'scapement be in every other respect as complete as possible. This has often given the wearer cause to complain, and to suspect the qualities of his watch, and hence watchmakers have been induced to abandon this 'scapement, and adopt inferior ones. The pallets of Tyrer's were at first very thin. We frequently urged the necessity of having them made much thicker, and were pleased to see that this was gradually adopted. Why should they not be made as thick as the pallet of a detached 'scapement? There is no 'scapement which requires to have the balance wheel teeth more correctly cut, or the steady pins of the cock and potence more nicely fitted to their places in the potence plate. The minutiæ alluded to were, too much or too little drop of the impulse teeth on the pallet, the 'scapement not set quite so near to beat as might be, the balance rather heavy, or the points of the teeth of repose too much or too little in on the small cylinder. In a good sizeable pocket watch, the wheels having fifteen teeth, the ratio of the diameter of the wheel of repose to that of impulse may be as .520 of an inch to .400, the cylinder .030. The angle of 'scapement will be 60 degrees, taking from the escape of the impulse tooth, to that of the tooth of repose falling on the cylinder; the balance passes 20 degrees of these, before the impulse tooth gets again on the pallet, consequently it has only 40 degrees for the acting angle of the 'scapement. There is a variety of 'scapements in Berthoud's *Histoire*, which appeared in 1802, many of which are of very inferior note to that of Tyrer's, and yet he takes no notice of the latter. This is remarkable, as he surely must have seen it, considering the great number of them which were made.

While Dutertre was engaged with Hooke's 'scapement, an artist in England, whose name is unknown, produced a 'scapement with the dead beat, which seems at that time to have been the great object of pursuit. Julien Le Roy having got one of these watches, showed it to Sully in November 1727, and told him that it was a 'scapement very deserving of notice. Thiout mentions it as a 'scapement of M. Flamenville, having two pallets of repose; and says that it had much attracted the attention of the English watchmakers, who had made it for three or four years. Plate CCCII. Fig. 9. (See page 108, plate xliii. fig. 26. of his first volume.) With our workmen it went by the name of the 'scapement with the tumbling pallets. The axis of the balance had two semicylindrical pallets, whose faces stood in the same plane or centre of the axis; the balance wheel was the common crown wheel one, the teeth of which got a very small hold of the pallets. When escaping from the face of one pallet, a tooth on the opposite side dropped on the semicylindrical part of the other pallet, where it rested during the going and coming of the vibration; getting then on the face, it gave new impulse, escaping in its turn; the pallet on the opposite end of the verge received a tooth on the semicylindrical part, and so on. After having been laid aside for some time, it was of late years taken up by several, who no doubt must have thought well of it. Among these was Kendal, a man possessed of no common talents. He transformed it into one having two crown wheels on the same pinion arbor, the tops of the teeth in the one pointing to the middle of the spaces in the other, and with only one pallet, the diameter of the semicylinder being of any size. (See Plate CCCIII. Fig. 1.) About thirty years ago we had some watches made with this 'scapement, and after a few years trial gave them up. The principle of the 'scapement is good, as long as the parts of it remain unimpaired, and the oil continues fresh; but the acting parts having such a small hold of one another, get soon altered, which causes a great deviation from the rate of time with which it first sets out. They cannot be expected to last long, unless with a diamond pallet, and a steel wheel of the hardest temper.

The *free or detached 'scapement*, is that in which the greater part of the vibrations of the balance is free and independent of the wheels, the balance wheel being then locked; when unlocked, it gives impulse, which only takes place at every second vibration. In Mudge's detached 'scapement, the impulse is given at every vibration. The progress which has of late years been made in improving the detached 'scapement has been very wonderful, when we consider that half a century ago the name of this 'scapement was unknown. The first rude draught of any thing like it, appears to be that of Thiout's, described at p. 110 of the first volume of his work, and shown in Plate xliii. fig. 30, which he calls "A 'scapement of a watch, the half of whose vibrations appear independent of the wheel work, during the time they are made. A hook retains the ratchet or balance wheel; the return of the vibration brings the pallet to its place of being impelled by the wheel; in the returning, the hook is carried outwards, and leaves the wheel at liberty to strike the pallet, and so on. This sort of 'scapement cannot act without the aid of a spiral or pendulum spring"

Peter Le Roy's 'scapement is the next step that was made towards this invention. He contrived it in 1748, and, like Thiout's, it has hardly ever been made use of. Both of them have a great recoil to give the wheel before it could be disengaged, and their arcs of free vibration are not much extended. Berthaud informs us, that in 1754 he made a model of one, which he gave to the Royal Academy of Sciences. Camus, on its being shown to him at that time, told him that the late Dutertre had made and used such a 'scapement, having a long *detent* and free vibrations. Nothing appears now to be known of the construction of Dutertre's, and Le Roy seems to have acknowledged the priority of it to the one he contrived in 1748. "My thought, or invention," he says, "was not so new as I had imagined. Dutertre's sons, artists of considerable repute, showed me very soon after, a model of a watch in this way by their late father, which the oldest Dutertre must still have. This model, very different from my construction, is, however, the same with respect to the end proposed."

The detached 'scapement in Le Roy's time-keeper, which was tried at sea in 1768, is very different from that of 1748.

Berthoud, in his *Traite des Horologes Marines*, published in 1773, has given, in No. 281, an account of the principle on which the model was made in 1754; and, in No. 971, a particular description of the parts composing it, which are represented in plate xix. fig. 4. of that work. It may be somewhat interesting to lay before our readers what is contained in No. 281. "I composed," says he, "in 1754, an 'scapement upon a principle, of which I made a model, in which the balance makes two vibrations in the time that one tooth only of the wheel escapes, that is to say, the time in which the balance goes and comes back on itself; and, at the return, the wheel escapes and restores, in one vibration, the motion that the regulator or balance had lost in two. The 'scapement wheel is of the ratchet sort, whose action remains suspended (while the balance vibrates freely) by an anchor, or click, fixed to an axis carrying a lever with a deer's-foot joint, the lever corresponding to a pin placed near the centre of the axis of the balance. When the balance retrogrades, the first vibration being made, the pin which it carries turns a little back the deer's-foot joint, and the balance continuing freely its course, its liberty not being disturbed during the whole of this vibration, but by a very small and short resistance of the deer's foot joint spring. When the balance comes back on itself and makes the second vibration, the same pin which it carries raises the deer's foot lever in such a way, that the anchor which it carries unlocks the wheel, in order that it may restore to the balance the force which it had lost in the first vibration. This effect is produced in the following manner: In the instant that the deer's-foot jointed lever is raised, the wheel turns and acts upon the lever of impulsion, formed with a pallet of steel which acts upon the wheel, and with another arm which acts on a steel-roller placed near the axis of the balance; and, in the same instant that the wheel acts upon the lever of impulsion, the second arm, which its axis carries, and which is the greatest, stays on the roller, and the motion of the wheel is communicated to the balance almost without loss and without friction, and by the least decomposition of force. As soon as the wheel ceases to act on the lever of impulsion, it falls again, and presents itself to another tooth." "To render the vibrations of the balance more free and independent of the wheel work," continues Berthoud in No. 282, "and diminish as much as possible the resistance it meets with at every vibration, the pin must be placed very near the centre of the balance, so that the lever may not be made to describe a greater course than that required to render the effect of the click perfectly sure, and while the balance turns, and makes its two vibrations, prevent only one tooth of the wheel from escaping; an effect which would be dangerous, by the seconds' hand, which is carried by the wheel, announcing more seconds, or time, than the balance by its motion would have measured. It was the dread of such a defect that made me then give this 'scapement up, which, I confess, seemed to be rather flattering; but it did not give to the mind that security in its effects which is so necessary, particularly in marine time-keepers, the use of which is of too great consequence, to allow any thing suspicious in them to be hazarded."

The principle given here by Berthoud is the same as that of the detached 'scapement now made, although the parts of the model are more complex. This 'scapement had received a variety of modifications under his hand. In 1768, he had five marine clocks planned to have spring detents to their 'scapements, the lifting spring being placed on the roller, or pallet, which received the impulse. These were not finished till 1782. Subsequent improvements, made by the late Mr Arnold and others, can hardly be considered as differing very materially from those of Berthoud. This 'scapement in pocket watches may sometimes come under such circumstances as have been noticed with Tyrer's; but no other can well be admitted into box-chronometers, whether it is made in the manner of Arnold, or in that of Earnshaw. In the 'scapement of Arnold, (see Plate CCCIII. Fig. 2.) that part of the face of the pallet at the point, or nearly so, on meeting the cycloidal curved tooth to give impulse, rolls, as it were, down on this curve, for one half of the angle, and in the other goes up; or it may be thus expressed—the curve goes in on the pallet for the first part of the impulse, and comes out during the last. In making this curve too circular near the point of the tooth, as has been done by some, when the drop is on the nice side, the pallet has to turn a little way before the wheel can move forward, which has sometimes caused stopping; but, where attention is given to the proper form, this is not likely to happen. In that of Earnshaw, (see Fig. 3) the face of the pallet is considerably undercut. Here, the point of the tooth will slide up for the first part of the impulse, and down in the last; in the first it seems to have little to do, and may acquire some velocity in order to overcome the part it has to perform in the last. The face of the pallet being undercut, had been found requisite from experience, as is said, in order to prevent cutting or wearing. In Berthoud's box-chronometers, or time-keepers, the face of the pallet is made straight, or in a line to the centre. One of these, after twenty-eight years going, the greater part of which was from Europe to India, and in the Chinese seas, was put into our hands, and neither the face of the steel pallet, or that of the detent, had the least appearance of being any way marked. This was the more remarkable, as the wheel was uncommonly thin. It must have been made of very fine brass. The wheel had ten teeth; the ratio of the diameter to that of the roller, or pallet, was .530 to .340; the balance weighed 174 grains, and made two vibrations in a second. The balance was suspended by a short and weak spring, which had been broken by some accident before we got it. The length of this suspension spring required to be .9 of an inch, and of so delicate a nature, that many were made for it before the chronometer could be brought any way near to time. It seemed, indeed, to have more influence on the timing than any spiral spring could possibly have. Each of the balance pivots turned between the rollers, which were more than one inch in diameter; and from them and the suspension spring, perhaps, arose that ease and freedom in the motion of the balance, in consequence of which the balance wheel teeth had little to do when impelling the roller or pallet; and this may have been one cause why the pallet face was not cut or marked. It may be observed, that it had the common spiral balance spring, and a compensation consisting of two laminæ, or blades of brass and steel, pinned together and rivetted; and in the moveable end was a screw, which, by its connection with an arm in which the curb pins were placed, served to regulate for mean time. Three screws in the balance were also used for this purpose.

When the diameter of the pallet roller has a considerable proportion to that of the wheel, the angle of 'scapement will be less, and the hold on the face of the pallet will also be less; but the impulse given will be more direct, and the chance of stopping, from any counter-action by external motion, will also be greatly lessened. In this angle more must be included than that which is made from the drop of the tooth to its escaping the pallet. The angle of 'scapement is included between the point where the tooth escapes from the main pallet or roller, and the point to which the lifting-pallet comes in returning, after having passed the lifting-spring. There can be no 'scaping unless the lifting pallet has passed the lifting spring: It is then again ready to unlock the wheel. It is desirable, that the unlocking of the wheel should be made with the least possible resistance to the vibrations of the balance; which is attained, by having the end of the lifting-pallet as near to the centre of the balance as is consitent with its getting such a hold of the lifting-spring, that in its course, it can readily and easily bring out the detent from locking the wheel. The hold of the tooth on the detent should not be more than the hundredth part of an inch. But, in doing this, the supplementary angle becomes greater and increases the angle of 'scapement; and therefore it may be proper to have the lifting-pallet a little longer. A little additional length will greatly reduce the angle of 'scapement, and not much increase the evil of a greater resistance to the vibrations of the balance.

In a box chronometer, where the balance wheel has twelve teeth, and the whole angle of 'scapement is to be 60°, it is required to find the ratio of the diameter of the wheel to that of the roller. The supplementary angle being taken at 15°, the angle of impulse must then be 45°, which is rather wide as otherwise; but it will be less than this, when the thickness of the points of the teeth, and the spaces for drop and escape, are not taken into the computation. Now 360° being divided by twelve, the number of the wheel teeth, gives 30° for the quotient; and again divided by 45, the number of degrees for the angle of impulse, the quotient will be 8°. The diameter of the wheel is supposed to be .6 of an inch. To find that of the roller, say, as 12 : 6 : : 8 : 4. Four tenths of an inch is the diameter required for the roller, which will give somewhat less than 45° for the angle of impulse. The diameter of the roller may be found in another way, sufficiently near for practice. The diameter of the wheel is .6 of an inch, or .600; then say, as 113 : 355 : : .600 : 1.885; this last being divided by 12, the number of the wheel teeth, gives for the quotient .157, the distance between the teeth. This distance taken as a radius for the roller, would give 60° for the angle of impulse. About one-fourth more of this added, will give .200 for the radius, so that the angle may be about 45°.

Nothing should be overlooked, which can contribute to make the balance unlock the wheel with the least possible resistance. When the wheel is locked by the extremity of the teeth, it must be easier unlocked than when the locking is at a less distance from the centre. The unlocking cannot be done easier than with a wheel for such a detached 'scapement as was contrived about fifteen years ago by Owen Robinson, (see Plate CCCIII. Fig. 4) a very judicious 'scapement maker, who wrought long with the late Mr Arnold. This wheel is like that for Tyrer's 'scapement. The long teeth of *arrête* rest on the detent, and the upright teeth give impulse. It is evident that the unlocking with such teeth must be very easy, when compared with the teeth of those wheels which are made after the ordinary way.

Lest what has been said concerning the principle of a detached 'scapement may not be sufficient, we shall endeavour to describe the 'scapement itself, such as it is at present commonly made, so as to give an idea of it, and of the manner by which it acts. The balance-wheel of a pocket chronometer has fifteen teeth not very deep cut, and a little under cut on the face. A notch cut into a round piece of steel or roller, which is thicker than the wheel, forms the face of the pallet. Sometimes a small piece of ruby or sapphire is inserted into the notch at the face of the pallet, for the wheel teeth, to act upon, so that no wearing may ensue. The ratio of the diameter of the wheel to that of the roller, is that of .425 to .175. When the wheel and roller are in their places, the wheel supposed to be locked, the roller must turn freely between two teeth, having only freedom, and not much more. From the centre of the roller to the point of one of the teeth, that next the last escaped, let a line be drawn at a tangent to this tooth. On this line is placed the detent and lifting springs. The detent piece on which the wheel is locked, is a small bit of fine stone, either ruby or sapphire, set into steel, formed into a delicate spring, of such a length as to be equal to that of the distance of two or three spaces between the teeth, with a sole and steady pin at one end, which must be fixed to the potence plate by a screw. This is what is called the *detent spring*, the end of which goes within a little distance of the circle described by the extremity of the lifting pallet. On the left hand side of the detent spring is attached another called the *lifting spring*, which cannot be too delicate, but is made a little thicker towards the outer or lifting end than anywhere else. This end of the lifting spring projects a very little beyond that of the detent spring. On the arbor of the roller and balance, and placed near the roller, is twisted a short and thick steel socket, in which is set a bit of precious stone, the face of which is made flat, and nearly in a line with the centre, behind it is chamfered on towards the point, and made rather thin than otherwise. This is called the *lifting pallet*. The length or height is made so as to unlock the wheel to the best advantage; that is, by only carrying the detent a short way beyond the unlocking. This excursion is to be confined to as small an angle as may be. Near to the detent piece is fixed a stud, in which is a screw to regulate the depth of the detent into the wheel teeth. The point of the screw should be hardened, and have a part of the ruby detent to rest upon it, when the detent spring presses that way. When the balance is at rest, the face of the lifting pallet is very near to the outer side and end of the lifting spring. If the balance is brought a very little about to the left, the lifting pallet will pass the end of the lifting spring. On the balance being now turned towards the right, at the moment of the wheel being unlocked, the main pallet or roller presents itself, to receive the point of one of the teeth, and is impelled with considerable force; meanwhile the detent falls again to its place, and locks the wheel. The balance, having completed this vibriation, returns. In the returning, the lifting pallet pushes the lifting spring easily aside, being no longer supported by the detent spring when turning in this direction, that is, from the right to the left, the detent is again ready to be disengaged on the next return of the balance to the right, and so on.

The detached 'scapement of Mudge was contrived about sixty years ago or thereabouts, if we may reckon from the year 1766, when he showed it to Berthoud, who was then in London, and who informs us that it had been made a considerable time before.

This 'scapement consists of a wheel and pallets, like those made for the dead beat 'scapement of a clock, only the wheel teeth are not cut half the depth. On the verge or arbor of the pallets is placed an arm of any length, generally a little more than that of the pallets. (See Plate CCCIII. Fig. 5 ) The end of the arm is formed into a fork-like shape. On the axis of the balance is a short pallet, whose acting end may be of a small circular form, having the sharp part of the angles blunted, coming a little way within the prongs of the fork, which alternately acts, and is acted upon. There is also on the balance axis a small roller, having a notch in it. On the end of the arm is attached a small steel piece or index, in a plane which may be either above or below the prongs of the fork; this index is on the outside of the roller, when the free part of the vibrations is performing, and prevents the wheel teeth from getting away from the place of rest. On the return of the balance, the index passes with the notch in the roller to the opposite side. Meanwhile the short pallet gets into the fork, meeting with one of the prongs, pushes it on a very little way, and thus disengages the teeth of the wheel from the circular part of the pallet, where they rest during the free excursions of the balance. During the disengaging, the teeth get upon the flanch of the pallet, and give impulse, which causes the opposite prong of the fork to come forward on the short pallet, and communicate impulse to it. In Mudge's 'scapement, as drawn in the plate for the work published by his son, there are two short pallets, and the prongs of the fork lie in different planes. The impulse in this 'scapement is given at every vibration; and it seems to have done uncommonly well, particularly in the watch which he made for her Majesty Queen Charlotte. It is by no means suited for the execution of ordinary workmen, as it requires more address than usually falls to their share. The late Emery was much taken up with it; and although he had a little success, and had the aid of a very excellent hand, yet he experienced considerable difficulties. It might be somewhat easier managed, by adopting Lepaute's mode of Graham's dead beat, which we have tried.

In 1792, a very neat and ingenious detached 'scapement was contrived by the late Howells, founded on that of Kendal's, (in whose hands he had occasion frequently to see it,) in which the wheel teeth rested on the cylindrical part of the pallet, during a part of the going and returning vibrations of the balance. See Plate CCCIII. Fig. 6. In the other, after impulse is given on the face of the same semicylinder, and just before the tooth is quitting it, a detent is presented to receive one of the wheel teeth, by which the action of the wheels is suspended during the greater part of the going and returning vibrations, the pallet being then free and independent of the wheels. This 'scapement is composed of two crown wheels on the same arbor, the points of the one being opposite to the middle of the spaces of the other. On the axis or verge of the balance, which stands quite close to that of the balance wheels, is a semi-cylindrical pallet, whose diameter should be according to the angle of 'scapement required, which will also regulate the distance of the wheels from each other. The pallet is put near to the collet on which the balance is rivetted; a small arbor, having very fine pivots, is run in so as to stand parallel with that of the balance, and placed at some distance outside of the wheels, but where a line drawn from it, and passing at equal distances from the points of the wheel teeth, when continued, shall fall in with the centre of the balance; on this arbor is fixed an arm, at the end of which is a small fork and index; on the verge or balance axis, and near the lower end, is a short pallet, and a roller connecting with the fork and index, in imitation of Mudge's, acting in the same way as has been described, but only in the locking and unlocking part. Where the arm passes between the wheel teeth, which may be at ninety degrees or so from where they act on the pallet, are fixed two detent pieces, one for each wheel, opposite to the arm, and in the same line. A part of it is prolonged beyond the arbor outside, by way of a counterpoise, where two screws in fixed studs serve here as a banking to it. It may easily be conceived, that one of the wheels being locked, suppose that on the left, the balance, when returning from the left to the right, will, by means of the short pallet and forked arm, &c. carry the detent away; and just as the point of the tooth is free, the face of the semicylinder is presented, to meet with a tooth of the same wheel, and get impulse; but before this tooth has nearly escaped, the detent is ready to receive a tooth of the opposite wheel, and so on. This 'scapement gives an impulse at every vibration, as is done in Mudge's. In the tenth volume of the *Transactions of the Society for the Encouragement of Arts, &c.* there is a description and drawing of it. It may be observed, that were the semicylindrical pallet faced with a piece of precious stone, the 'scapement would go on for a considerable time without falling off.

In the marine keepers which Mr Mudge himself had made, the 'scapement is on a very flattering principle, which he suggested as the means of improvement many years before he put it in practice. Its good performance seems to have been unequalled; and it is singular, that, notwithstanding the efforts of three or four of the best hands that could be got to the establishment set up by Mr Mudge, junior, in order to put these 'scapements to timekeepers which they were employed to make, not one was ever produced that was at all equal to the original ones. The 'scapement is *apparently* very complex, elaborate, and of course expensive in making; yet, when once executed, it will be permanent in its effects, and require no after adjustment like the common detached one. After what has happened, it is not likely that it will be again adopted. The basis of it is that of the curious old crown wheel and verge. In place of the verge being in one, having two pivots and the balance rivetted on it, let us conceive that each of the pallets of the verge has an arbor and two pivots, and that the balance is on a double kneed crank, having a pivot at the end of each knee, one being near to the foot, the other near to the collet on which the balance is rivetted; these pivots, and those of the pallet arbors, are in one upright line, coinciding and concentric with one another, having their motion, as it were, free and independent of each other, unless when in a part of the action of the 'scapement; the face of the pallets, in place of being flat, are hollow, or a little curved, having a nib at the edge to lock the wheel by. On the lower end of the lower pallet arbor is an arm projecting nearly as far as the bending of the crank knee, in which is fixed a pin that acts on the inner side, and near to the end of the arm, and is alternately acted upon; close by the arm, and on the pallet arbor, the inner end of a spiral spring is fixed; the outer end is in a stud, having a certain tension or bending up before fixing in the stud. The upper pallet arbor has the same as has been described to the lower one, and a pin in the upper knee of the crank. It may easily be conceived, that the length of the crank knees ought to be such as to allow it to sweep round and behind the crown wheel, its boundary or banking being that of the crown wheel arbor, or its pinion arbor. When the pallets are not raised up, and the wheel unlocked, the tendency of the spiral springs is to bring them down within the spaces of the crown wheel teeth. Suppose the upper pallet raised up, and the wheel locked, the under one being in the reverse position, and the balance vibrating towards the right, the pin in the upper crank will, of course, meet with the small arm, and carrying it on a little way, the wheel-tooth gets disengaged, by which the wheel getting forward, the lower pallet is raised up, and the wheel is again locked. In the interim, the upper arm being carried on a few degrees, by means of the momentum of the balance in vibrating, bends up the spiral still more than what was done by the wheel raising up the pallet, the re-action of which, in the returning vibration, gives impulse by means of the arm on the pin of the crank. The pin in the lower crank now getting forward, meets with the arm of the lower pallet arbor, carries it on, the wheel gets disengaged, and so on. This 'scapement cannot set itself off; for before this can be effected, the balance must get some degree of external circular motion in its plane. The balance may be said to be free in that part of the vibration, after the pin of one crank has left its corresponding arm, till the pin of the other meets with its arm; this is, however, very momentary. The balance had on its arbor two spirals or pendulum springs, for the purpose of obtaining the most isochronous vibrations. Something in this way had been proposed by one of the Bernoullis. Drawings and a description of this 'scapement will be found in the work published in 1799, by Mr Thomas Mudge, junior. The compensation, like every thing of Mudge's, is ingenious, though nothing of this kind can ever be equal to that of being in the balance itself. The train of wheels went contrary to the ordinary direction, and we have no satisfactory reason assigned for it.

Although the balance in pocket watches may be put very well in equilibrium, yet many things contribute to make them go unequally in different positions, such as in hanging, laying, &c. which require time, and give a great deal of trouble, before they can be completely corrected. In order to get the better of this, Breguet, an eminent watchmaker in Paris, contrived a 'scapement, which, with the pendulum spring stud, revolved round the centre of the balance once every minute. By this means, whether the balance was in equilibrium or not, the going of the watch was little affected by it, as every part of it was up and down in the course of a minute, which compensated any want of equilibrium. This contrivance is merely mentioned by Berthoud in his *Histoire*, as he did not think himself at liberty to give any description of it, since Breguet had a patent or *brevet d'invention* to make them. We have heard it said that the same invention had been made before by the late Mr John Arnold.

Those who wish for farther information respecting 'scapements, may consult *Traité d' Horlogerie* par M. Thiout, *Histoire de la Mesure du Temps*, par M. F. Berthoud, and the *Transactions of the Society for the Encouragement of Arts, Commerce, &c.*

## CHAP. II.

### *On Compensation Balances.*

Compensation against the effects of heat and cold in time-keepers, has been one of the greatest improvements that could have been applied to them. Without this they would have been far from keeping time, and would have varied continually with the temperature of the atmosphere, so that no fixed or settled rate could have been obtained. The detached 'scapement will show this more than any other; for if there is no compensation to it, the watch will vary nearly thirty seconds in twenty-four hours. The influence of oil on the cylinder 'scapement becomes in itself a sort of compensation, and the effect of changes of temperature is much less obvious in it than in the detached 'scapement. There is very great reason to believe that Harrison was the first who applied a compensation; but there are no written documents to warrant us in ascribing to him the honour of the invention, to which, however, we think he has a just title. Some very imperfect hints had been given by Martin Folkes, Esq. President of the Royal Society in the year 1749, of Harrison's having some mechanism of this sort in the three time-pieces which had been made prior to the fourth, which gained the reward voted by parliament. But as no description of it was ever made public, the French artists have had it in their power to claim a priority in the invention. In Harrison's fourth machine, it is known that the compensation piece in it was composed of laminæ of brass and steel, pinned and rivetted together in several places. Perhaps those in the three former differed little or nothing from this.

The first pocket watch made in Europe with a compensation was by F. Berthoud. It was begun in 1763, and finished in the beginning of 1764; and was sold in London in 1766, to Mr Pinchbeck, for his Britannic Majesty King George the Third. The compensation was effected by laminæ of brass and steel pinned together; one end of which being fixed to the potence plate, the other acted on a short arm from a moveable arbor, a longer arm having the curb pins in it, being made to move nearly in the circle of the outer coil of the spiral spring. It had a common crown wheel and verge 'scapement, and a going in time of winding. The balance was so heavy as to set, being sixteen grains in weight, and the vibrations were four in a second. Mr Kendal adopted this mode of compensation in some of his pocket watches.

Mudge, some time before the year 1770, made a watch for Mr Smeaton, in which the compensation was effected by two long slips of brass and steel soldered together: being dressed up, it was turned up into a spiral, as close together in the coils as to be free, and no more. The inner end was fixed to a circular curb-wheel, a short portion of the outer end had a pivot, bent in the circle of the outer coil, and supported by a small stud, through a hole of which it moved freely; at this end was the curb pins, between which the spiral or pendulum-spring passed; the effect of heat or cold on it was counteracted by the spiral compensation piece. The 'scapement of this was the cylindrical one; and so long as the oil kept clean and fresh, the compensation might be useful to it. In 1774, we made one or two of the same sort for horizontal watches. At that time no better 'scapement and compensation were known, at least so far as came under what was then the common practice.

In the voyage undertaken for the trial of Le Roy's Time-keeper in 1768, and published by Cassini in 1770, along with the description and drawings of it, Le Roy has given that of a compensation balance, which is exactly like those of the present day, only the laminæ are pinned together, in place of the brass being melted on the steel. Plate CCCIV. Fig. 1. The compensation of the time-keeper, however, was not of this kind; it consisted of two glass tube thermometers, bent nearly into the form of a parallelogram, with a small ball at one end to each, the other open, and filled partly with mercury, partly with spirit of wine, fixed to the axis of the balance opposite one another: the balls lay very near to the axis. It would appear that Le Roy had not thought of a metallic compensation, until the return of the time-keeper from the voyage of trial. He had taken the idea of this from getting an account of Harrison's, which was sent to the Royal Academy, signed by Ludlam, who was one of the scientific gentlemen appointed by the Commissioners of the Board of Longitude to take Harrison's account of his time-keeper, previous to any part of the reward being paid him.

In a life of Peter le Roy, the son of Julien, the method of compensation is erroneously ascribed to that artist's father, to whom "we are indebted," says the writer of the article, "for the method of compensating the effects of heat and cold on the balances of chronometers, by the unequal expansion of different metals; a discovery which has been brought by our English artists to a state of great perfection, although it had been laid aside by the inventor's son Peter."

It is difficult to understand how this mistake should have been committed; for the following account of the discovery, given by Peter le Roy himself, is in direct contradiction to the preceding statement.

"Observation V.—*Sur la compensation des effets de la chaleur et du froid*

"Selon la gazette du commerce, et la rapport *signé* Ludelam, envoyé à l'academie: pour remedier aux irregularités produites dans les montres marines par la chaleur et par le froid, *M. Harrison se sert d'une barre composée de deux pieces minces de cuivre et d'acier de longeur de deux pouces, rivées ensemble dans plusieurs endroits, fixées par un bout, et ayant de l'autre deux goupilles au travers desquelles passe le ressort du balancier. Si cette barre reste droite dans le tems temperé (comme le cuivre recoit plus d'impression de la chaleur que l'acier,) le coté de cuivre deviendra convexe au tems chaud, et le coté d'acier le sera au tems froid. Ainsi les goupilles fixent tour-à tour les parties du ressort, selon les differens degrés de chaleur, et l'alongent ou le racourcissent: d'où nait la compensation des effets du chaud et du froid.*

"Si j'avois connu cette ingenieuse methode avant d'avoir pensé à mes thermometres, je n'aurois vraisemblablement point hesité à en faire usage dans ma machine.

"J'ai balancé quelque tems, si je ne devois pas lui donner la preference. J'ai même fait quelques essais dans cette vue. J'en parleroi bientôt: mais apres y avoir pensé murement, et avoir mis à part, autant qu'il m'a été possible, ce penchant qui nous parle en faveur de nos productions, mes thermometres m'ont paru préférable," &c. &c.

See *Memoire sur la meilleur maniere, de mesurer le tems en mer*, p. 55, 56, inserted at the end of *Voyage fait par ordre du Roi, in* 1768, *pour éprouver les montres marines inventées par M. le Roy*, &c. par M. Cassini, fils, Paris, 1770.

As must always be the case in the infancy of any branch of science, various methods are fallen on before it arrives at its most improved state. Berthoud, Arnold, and others, had recourse to different modes of compensation before they arrived at the one which gave them complete satisfaction. The former, in his first machines, used small wires of brass and steel, combined nearly like the gridiron pendulum, to effect the purpose of compensation; to those of a later date, was applied a straight piece, Plate CCCIV. Fig. 2; composed of laminæ of brass and steel pinned together, acting on the short arm of a lever. In the end of the other arm, which was long, the curb pins were fixed. Even with those balances which were afterwards made, and composed of brass and steel pinned together, he adopted as a supplementary aid, the straight compensation piece with the moveable arm and curb pins. Fig. 3. Considering the talents he possessed, and the great experience which he must have had, this seems a little curious; as we think, where there is a complete compensation in the balance, it *alone* should be sufficient, and that the curb pins would tend to disturb the pendulum spring rather than give any aid to the compensation. The more free the pendulum spring is, the chance is more in favour of good performance, when the compensation balance is supposed to be fit and complete for what is required. In some of Arnold's balances, two pair of laminæ were placed parallel to the diametrical arms; on the middle of them was fixed a small wire which came through the rim, outside of which, and on the end of the wires, a small ball was fixed to each. Fig. 4. These balls were pushed out or drawn in by changes of temperature. The arguments given in favour of such as Earnshaw's, which are turned first on the steel, and again on the brass, after being melted on the steel, are certainly very strong and convincing, and nothing can well be said against them, and yet there appears to be a softness in such a balance, that cannot exist in those where the laminæ are set or turned up by hand. Fig. 5. There is undoubtedly a great deal more trouble in making the last, and though it has been said that they cannot be true or round when made in this way, yet we have seen some of those done by Owen Robinson, as round and true as any turning could make them, and possessing a degree of stiffness that cannot exist in the other; they have been even unscrewed, or taken to pieces, and again put together, without altering the rate of the chronometer. After all, we are not aware that cronometers with the one balance actually perform better than those with the other.

It may be observed, that on the rim of the turned balances, which is separated into two, there are small pieces of brass, made to slide backwards and forwards, according as it may be found requisite, when under the process of adjusting for heat and cold. In the other, this is done by screwing backwards and forwards the pieces of brass which turn spring tight on small screws left at the outer end of the laminæ, and are bent in the same circle with them. Both balances have what are called meantime screws, placed in the vertical line of the hanging position, which serve to adjust them to their rate of time, &c. We have seen and made compensation balances with three arms, and three pieces, and three meantime screws, which were stiff, and answered very well.

## CHAP. III.

### *On Balance or Pendulum Springs.*

The invention and application of the spiral spring to the balance of a watch is, by the foreign artists in general, ascribed to Huygens, while they admit the idea of a straight spring having been long before this applied by Dr Hooke. It was in 1658 that Dr Hooke observed the restorative action of springs, when he put one to the balance of a watch, and applied for a patent to secure his right of invention. The profits were to be divided between himself, Sir Robert Moray, Mr Boyle, and Lord Brouncker. It was not carried into effect, in consequence of a quarrel between the parties, on account of a very unreasonable demand on the part of these gentlemen. Nor was it till 1674 that Huygens claimed the same discovery. Hooke charged Huygens with plagiarism, through the intervention of Mr Oldenburgh, Secretary of the Royal Society, who communicated to him, when he was twice in England, the registers of the society, and also corresponded with him upon the subject. In 1665, Sir Robert Moray requests Oldenburgh to tell Huygens that such watches had already been made in England, and to ask him if he does not apply a *spiral* spring to the balance arbor? It may be asked, where had Sir Robert seen a spiral spring? The natural answer is, that he must have seen it in the hands of Dr Hooke.

On nothing does a chronometer depend so much as in the good quality of the pendulum spring: great as the power of the rudder is, in controuling and regulating the motion of a ship, it is not more extraordinary than that of this spring, in regulating the motions of a chronometer, and we may be allowed to say, that it possesses something like *invisible* properties. It may be set so as to make the machine go fast or slow, in any position required, while neither its length, nor the weight of the balance, are in any way altered. Le Roy thought that he had made a great discovery, and it must be granted to be one, when he found, "that there is in every spring of a sufficient extent, a certain length, where all the vibrations, long or short, great or small, are isochronous; that this length being found, if you shorten the spring, the great vibrations will be quicker than the small ones; if, on the contrary, it is lengthened, the small arcs will be performed in less time than the great ones." Notwithstanding this condition of *sufficient extent*, the isochronous property will remain no longer than while the form of the spring is preserved, as it originally was. Should the coils be more compressed or taken in, the long vibrations will now be slower than the short ones; and, on the contrary, if they are more let out or extended, the long vibrations will be faster than the short ones. A more general principle for obtaining the quality of isochronism may be applied, by making the spring act proportionally, in an arithmetical progression, according to its tension. Every five degrees of tension should make an equilibrium with a given force or weight of ten grains, that is 5, 10, 15, 20, &c. degrees of tension, should be balanced by 10, 20, 30, 40, &c. grains. To try small springs by this process would require a very nice and delicate tool. In order to obtain these properties in pendulum springs for his timekeepers, Berthoud made them thicker gradually from the outer to the inner end; our old English way is the reverse of this. Whatever may be the form of the spring, whether flat or cylindrical, the best and most direct way is to try them in the timekeeper itself, by taking four hours going, with the greatest force the main spring can give, and then four hours with the least. It is of consequence to have these springs hard, or well tempered.

## CHAP. IV.

### *On the Jewelling of Pivot Holes.*

Our chronometers, from the art of jewelling the pivot holes, may be said to have acquired a durability and character, which they would not have otherwise received. It must not be imagined that there is any time-keeping principle or improvement in a jewelled hole more than in a brass one; and, notwithstanding what has been said in favour of the last, few will be hardy enough to run the hazard of having the balance, and balance wheels, to move in brass holes. It is very well known, that in a common verge watch, where the balance holes are jewelled, its motion will be kept up for a longer time than when it runs in brass holes. The friction at the balance holes cannot be supposed to be less than at those of the fusee; for, in the time of one-fourth of a turn of the fusee, the balance must make more than what is equivalent to 9000 revolutions Berthoud regretted much that he had not an opportunity of getting the pivot holes of his timekeepers jewelled; yet, from that versatility of genius which he possessed, he supplied admirably the want of this, in a manner that very few could have equalled. Some of the balances in his time-keepers were made to give six vibrations in a second, while others gave only one. His number *eight* made one vibration in a second, and was the one which gave the best performance of all those that he had constructed. It seems to have been considered as a wonderful discovery, that jewelled holes wore down the pivots, and thickened the oil, after they had been used for upwards of a hundred years. How came this not to be sooner observed, when so many were engaged in making chronometers, and that too in considerable numbers? That pivots, from a length of time, even with good oil, and with greater probability from bad oil, may have got, as it were, glued in their holes, there is little reason to doubt; but this never arose from particles wearing away from either the steel or the stone, by the friction of the pivot. Let any one try to whet a graver, which requires some degree of force, on a polished Scotch pebble, for instance, and they will find that no exertion whatever will make the graver bite the stone, or the stone the graver: for where any effect of this kind takes place, it must be nearly mutual. The hardness of the Scots pebble is well known to be much inferior to that of the ruby or sapphire. After being exposed to the air for a considerable time, oil gets viscid and thick, which arises, as has been observed by chemists, from its absorbing or attracting oxygen. We suspect that oil, from this cause *alone*, may become more glutinous at a jewelled hole than at a brass one. By its application to brass it soon acquires a bluish green tinge, as if something acted upon it. This is owing to the metal becoming oxidated by the joint action of the oil and air. The oxide thus formed combines with the oil, and forms a metallic soap, which is much less tenacious than that formed at a jewelled hole. By the continuation of this process, the hole in brass in time becomes wider, and the oil disappears, leaving the pivot and hole in a greater or less degree wasted; and, instead of the oil, we have the metallic soap, which has hitherto been considered as rust. To be convinced, however, that this is not the case, we need only attempt to wipe it off from the pivot, from which it easily parts, and which it would not do were it really rust. Oil, however, can have no action on the jewelled hole, and any change that is effected by the oil must be confined to the steel pivot, on which its action is so exceedingly slow, that a great length of time must elapse before the oil is decomposed and disappears; and hence what has been called rust in a brass hole, is seldom or never met with in a jewelled hole. If a little fine Florence oil is put into a small phial for about two-tenths of an inch deep, and remain for a few years, it will become exceedingly viscid and glutinous, and will be intermixed with parts tinged with red of various shades.

The same appearance is sometimes seen at jewelled pivot holes, and has been erroneously supposed to be produced by the operation of the pivot on the hole. It is singular that oil will act more forcibly on fine brass th n on the common sort, or even on copper; a metallic soap somewhat resembling verdigrease will soon show itself on the former, while the latter will have no appearance of being injured. But we are not to infer from this, that copper holes would be preferable to those made in fine brass; for although the oil in this case would be more durable, from its acting more slowly on copper than on brass, yet the increase of friction from the copper would more than counterbalance this advantage. It can hardly have escaped the eye even of the most indifferent observer, that oil acts more readily and forcibly on new than on old work. On the former, it will frequently show itself in the course of 24 hours. Oil varies so much in its quality, that some will become so thick and viscid in the course of a few months, as to stop the machine altogether. This has occurred in the experience of a very celebrated artist, who informs us that "his regulator, which has been found to go to a greater degree of accuracy (though not to a second in two months, as has been said of others) than even that at Verona, as observed by the astronomer Cagnoli, or that at Manheim, as observed by Mayer, was found to perform very indifferently after being cleaned, and at the end of three or four months stopped altogether, which arose from the application of bad oil." We are of opinion, that where the pivots are small, and the revolutions of the wheels quick, jewelled pivot holes are the best. It will not be an easy matter to do without oil, particularly in pocket or box chronometers, although astronomical clocks or regulators may be so constructed as not to require it.

## CHAP. V.

### *On the Machinery for going in time of Winding.*

The earliest machinery for going in time of winding is the simplest and best that has yet been produced; although, upon the whole, it may not be so convenient in its application. In the old thirty hour clocks, the first wheel of the going part had on its arbor a fixed jagged pulley A: (See Plate CCCIV. Fig. 6.) On the arbor of the first wheel of the striking part was a moveable jagged pulley H, with click and ratchet to it. Over these, and through or under the pullies of the counter weight *p* and main weight P, went an endless cord, woven either of silk or cotton. Both parts of the clock were carried on by a single or main weight; and, when winding it up, this was done by the striking pulley; by which means, the weight acted constantly on the going part. This is a method which we adopted in some common regulators, and afterwards found it was the same that Berthoud had used in some of his. The moveable and winding up pulley with its ratchet was on a fixed stud, having a click and spring, which were fixed to one of the plates, as was also the stud. The other pulley was on the arbor of the first wheel, and fixed to it. The only inconvenience and objection to this contrivance, particularly in eight day clocks, arises from the wearing of the cord on the jagged part of the pullies, which produces a great deal of dust, and makes the clock get sooner dirty than it would do, if this was effected in a different way. In clocks which go a month, or six months, as some of Berthoud's did, this will be very much obviated, particularly with a fine and well wove silken cord.

There is a very ancient way of going while winding, which was long applied to the fusees in clocks and watches. On the inside of the great wheel is another wheel, whose teeth are cut to look inward to the centre, upon which acts a pinion of six, which runs in the bottom of the fusee, and is turned round with it. The fusee arbor is free within both the great wheel and the fusee; upon it is fixed the fusee ratchet, and a wheel with about half the number of teeth of those in the inward toothed wheel. It is evident, that if the fusee arbor is turned round, the wheel fixed on it, which acts also into the pinion of six, will by this make the pinion turn; and this again, acting on the inside wheel teeth, will apply as much force to it as the fusee requires in setting up. When wound up, the click in the great wheel, as in the ordinary way, stops the fusee by the ratchet from running back. This method takes six times longer of winding up than by the common way; and the great strain which is laid on the pinion and inside wheel teeth soon destroys them. With a little more apparatus, a fusee of this kind can be made to wind up whichever way the arbor is turned; hence it got the name of the *drunken fusee* (See the particulars of it in *Thiout*, vol. ii. p. 383. and Plate xxxviii. Fig. 14.)

A going in time of winding, of later application to clocks and regulators, consisted of an arbor within the frame, on which was a pin, and an arm inside, with a nib and deer's foot joint; another arm on the outside when pulled down, served to make the jointed nib rise and pass the third wheel teeth; a spring acting on the pin brought the nib in a contrary direction, to act on the third wheel teeth, by which it gave motion to the swing wheel during the time of winding, and continued to do so until getting clear of the teeth.

The general method which is now adopted, both in clocks and chronometers, consists of an auxiliary spring, ratchet, and detent. In clocks, two springs are somewhat used; being doubled round, are screwed by one end to the back of the auxiliary ratchet; the other end is made to act against the arms or crosses of the great wheel. On the opposite side is the click, which acts with the barrel ratchet; and when the force of the weight is taken off by winding up, the force of the springs act on the great wheel, and not being allowed to bring the auxiliary ratchet forward, which they would do; but this is prevented by the detent, consisting of an arbor whose pivots run in the frame, and an arm acting against the face of the small teeth in the auxiliary ratchet.

When this method is applied to a clock or watch fusee, there is a circular and flat steel spring screwed or made fast by one end to the inside of the great wheel; in the other end is a small hole, opposite to which is made a short and circular slit in the great wheel. A pin in the auxiliary ratchet is placed so as to correspond to the hole in the spring and the slit in the great wheel, through both of which it comes; the slit gives range for the bending up of the spring. When the force of the main spring does not act on the fusee, which is taken off when winding up, the auxiliary ratchet and detent, which has a slender spring to keep it to its place, serve the same end as has been described for the clock.

The mechanism of this going in time of winding, was first exhibited by Harrison in his time-keeper, when explaining its principles to the commissioners who were appointed to receive them. It has been said that he took the idea of it from having seen an analogous contrivance in an old kitchen jack, where it had been applied to keep the spit turning while the jack was winding up. There has been a great deal of ingenuity displayed even in jack-making.

It is singular, however, that it was never thought of to apply vanes or wings to the fly, which could have been set so as to regulate the velocity according to the greater or less weight with which the spit might be loaded ; but, simple as the setting of these wings would be, it might not be so easy to prevail upon the cook to take the trouble of either understanding or using them. The water-jack, which has been known in this country for more than seventy years, is very convenient in this respect, as it is so easy to make the discharge of water at the cock to run full, half, or quarter, on the small kind of mill-wheel which drives the whole of the machinery belonging to the jack.

A great many years ago, we contrived an easy way of making a going in time of winding for a clock, to several of which it was applied. The third wheel has a socket (with a small shoulder) truly fitted to it, the hole being soundly and smoothly broached. That part of the third wheel pinion arbor, which works in the socket, must also be truly turned, and made as smooth as any pivot, so as to be free, easy, and without shake. The end of the socket, which is not in the wheel, should be smooth and flat ; its diameter outside about three-tenths of an inch, and to apply to a flat smooth steel shoulder formed on the pinion arbor. On the side of the wheel opposite that on which the socket shoulder is placed, let there be fixed a small steel pin, distant from the centre about three-tenths of an inch, the height of it being about one-tenth. Make a piece of brass so as to have a fine small ratchet wheel on it, of about four-tenths of an inch in diameter, with a sort of hoop or contrate wheel rim on one side of it, three-tenths and a half in diameter inside, the thickness being a little more than that of an ordinary contrate wheel of a watch, and the depth one-twentieth of an inch. The ratchet wheel and hoop have a socket common to both, which is twisted on the third wheel pinion arbor ; this socket on that side of the hoop inside, is the smallest matter lower than the edge of the hoop ; on this part of the socket is fixed the inner end of a small and weak spiral spring, of two or three turns, the outer end having fixed to it a small stud, with a hole in it, that goes over on the steel pin of the third wheel, which works in a short circular opening in the ratchet wheel or bottom of the hoop, of a sufficient range for the spiral spring to keep the clock going during the time of winding up. The detent for the ratchet has one of the pivots of its arbor in the back frame plate, the other runs in a small cock attached to the inside of this frame plate, and sufficiently clear of the third wheel on that side. The edge of the hoop, when the socket is twisted home, should allow the third wheel to have freedom during the action of the spiral spring on it. In applying this going in time of winding apparatus to a clock, it will easily be seen in which way the small ratchet teeth must be cut, and also in which way the spiral spring must exert itself. During the action of winding up, this allows the minute hand to make a retrograde motion, but it resumes its place as soon as the weight is at liberty.

In the early part of the last century, a considerable intercourse was carried on between Holland and Port Seaton, by the ship owners of Prestonpans, in East Lothian. Among the imports, was old iron in hogsheads, and many of the articles were little worse for being used, as, by a law with the Dutch, no iron work was allowed to be repaired. Among the things which came home were some camp jacks, of a very ingenious construction, and evidently of German origin. Two or three of them, one of which we have seen, are still in that neighbourhood. It was composed of the usual wheels and pinions, endless screw, and a small fly, rather weighty. The frame mounted on an upright stand, was about four feet or more in height. A thin and narrow iron bar, of four or five feet long, was attached to the stand, and could be made to slide up and down on it, nearly the whole four or five feet ; one edge of it was toothed like a straight rack, and worked into the pinion of the first wheel, by means of a weight or weights hung on a hook at the lower end of the bar ; when the weight and bar came to the lowest point, it was easily moved up to the greatest height, when the jack was to be wound up. The pinion had a hollow socket, and could turn freely round the arbor of the first wheel ; on the lower end of the socket was a ratchet which rested on the first wheel, where the click and spring was placed to act with the ratchet, which by the hollow socket allowed the pinion to turn freely backward when winding up ; on the weight being allowed to act on the rack, all the wheels were made to turn the proper way, and so on. An idea occurred to us, that, in place of the rack moving, a machine might be made to go by its own weight, by means of a pinion turning down on the toothed edge of a fixed rack. A scheme shall be given for a box chronometer of this construction, which supersedes the necessity of either fusee, barrel, spring, or chain. A contrivance of a similar kind has lately been communicated to the Society of Arts in Paris, by M. Isabelle, and is described in the *Bulletin de la Société d'Encouragement*, No. 52. The same method, which has been known for a considerable time, is used at Liege by Hubert Sarton, who makes eight day spring clocks on this plan.

On the arbor of the first or great wheel is fixed what may be called the fusee ratchet, working with the click and spring, which are on the auxiliary or going ratchet ; in the last is fixed a pin, which comes through the end of the auxiliary spring, and the circular notch in the great wheel, which is keyed on in the same way as in the case with a fusee ; and having also a detent and spring for the going ratchet, the whole forming the great wheel, and the mechanism for going in time of winding. On the great wheel arbor, close to the main ratchet, let a small bevelled wheel be fixed, of any small number of teeth, fully stronger than those in the great wheel, the back of the bevelled wheel lying against the main ratchet : indeed both might be made from one and the same piece of brass. Supposing the diameter of the pillar plate to be 2.25 inches, that of the great wheel would be 1.5 inch, and the number of teeth 72 ; the bevelled teeth being half an inch in diameter, would admit 24 teeth ; and if made a little thicker than the great wheel, the teeth would be sufficiently strong. Another bevelled wheel, of the same diameter and number of teeth as the other, is fixed on a pinion arbor, (a hole being made in the potence plate, to allow the bevelled wheels to pitch together,) which is placed within the frame in a horizontal direction, in that line which passes through the centres of the great and second wheels ; one of the pivots runs in a cock, inside of the potence plate, and placed near to the great wheel arbor ; the other, which is a little beyond the pinion head, runs in a cock fixed on the outside of the potence plate. This pinion has sixteen leaves, of the same strength as the teeth of the bevelled wheels, and runs in with the edge of a toothed rack ; every revolution will be over the length of one inch on the rack, and equal to four hours, or one turn of the great wheel ; the second wheel pinion being 18. The length of rack, supposed to be 8 inches, would allow the time of going to be equal to 32 hours, 8 inches multiplied by 4 being equal to 32. Were the rack 12 inches long, it would admit the time of going to be 48 hours ; or the diameter of the pinion might be increased from .333 to .500 parts of an inch, and the time of going would then be somewhat more than 30 hours. Let a slip of wood be made 15 inches long, $\frac{5}{8}$ths of an inch broad, and rather more than $\frac{1}{4}$th thick; on one side of this, and close to the edge, let another slip of the same dimensions, but not quite so broad, be set on edge at a right angle to the side of the other; this will form a pattern to have two such cast in brass from it; after being dressed up, one is left plain, the other so as to have twelve inches of teeth made on one of the edges; the plain one is screwed to the inside of the case, and the other is screwed on to the plain one, having the toothed edge on the right hand side of the pinion, so as to make the second wheel and pinion turn the proper way. To the ring or cap which incloses the movement of the chronometer, are attached three pieces of brass, kneed up at each end; the distance from the ends is about two inches and a half, in which are holes made quite parallel to one another, and go on three steel rods, 15 inches long and $\frac{2}{10}$ths of an inch in diameter, fixed in the lower and upper ends of the case, and parallel to one another, and near to the dial of the chronometer. The case may be either of wood or brass, having a door on one side, which serves the purpose of getting at the chronometer, either to observe the time, or to push it up after it is nearly run down. In the lower part of the cap, a recess may be made to receive any additional weight requisite to load the chronometer with, in order to give greater extent of vibration to the balance; the upper part of the case should, if necessary, be hung in gimbols, and the lower end loaded with lead to keep it steady. A chronometer might be easily fitted up in this way to go eight days, by giving more length of rack, a greater weight to the bottom of the cap, more teeth to the bevelled wheel which is on the horizontal pinion arbor, fewer to that which is on the arbor of the great wheel, and the second wheel pinion to make more revolutions for one turn of the great wheel. Suppose the great wheel 80, and the second wheel pinion 16, one turn will be equal to five hours; the bevelled wheel which is on it (being 16) will have a revolution also in five hours; the bevelled wheel which turns it, having 24 teeth, will make a revolution in seven hours and a half. The rack being 25.6 inches long, the pinion of 16 making a revolution on it in seven hours and a half, and $25.6 \times 7.5 = 192$, the number of hours in eight days. The length of the case, being thirty inches, could be no inconvenience where eight days going without winding is obtained. A similar, and we think a preferable, construction might be adopted, by having the chronometer fixed, and a weight hung to the lower end of the rack, which, as in the case of a jack, would keep up the motion required for the chronometer. This plan, however, of a moveable rack would require a space for the rack to move in equal to twice its length.

## CHAP. VI.

### *On the Dividing and Cutting Engine.*

Among the inventions in the art of Horology produced in this country, may be mentioned that of the wheel-dividing and cutting engines, which are said to have been invented by Dr Hooke. In the preface to the fourth edition of Derham's *Artificial Clockmaker*, he remarks, that "the invention of cutting engines, (which was Dr Hooke's,) fusee engines, and others, were never thought of till towards the end of King Charles the Second's reign." It is well enough known, that he contrived and used an endless screw and wheel for the purpose of dividing astronomical instruments, in 1664. The wheel-cutting engine was contrived by him in 1655; and, about the same period, he discovered that the barometer indicated changes in the atmosphere, and was connected with the weather. Ten years afterwards, he proposed a clock to register the rise and fall of the barometer, which was executed by Mr Cuming, in a clock made for his present Majesty. Sully carried over to Paris wheel-cutting engines, which were much admired there, not only for their beauty, and fanciful execution, but also for their utility. The French artists unwillingly admit our claim to this invention; and could they have brought forward documents to the contrary, it would most readily have been done. They maintain, that it could not have been invented and improved at the same time by any one man, an opinion in which we must agree with them. A wheel-cutting engine, and one which could divide almost any number, by means of an endless screw and toothed wheel, was made about 70 years ago by Hindley of York, which came afterwards into the possession of Mr Smeaton, from whom Mr Reid purchased it 30 years ago. As Hindley knew what had been done in this way by Dr Hooke, this seems to have been made in imitation of his, with some additions and improvements, as it is evidently not copied from that which is described in Thiout's work, vol. i. p. 53, Plate xxiii. fig. 1. said to have been invented by M. P. Fardoil, watchmaker at Paris. Ramsden's dividing engine, for which he got a considerable premium from the Board of Longitude, was executed on this principle, the great merit of which consisted in having a more perfect screw than had hitherto been made. See our article Graduation, for a copious history of *Dividing Engines*, and a full account of the engines invented by Ramsden and Troughton.

## CHAP. VII.

### *On Equation Clocks.*

The first equation clock, which is a very ingenious contrivance to shew both mean and apparent time, was made in London about 120 years ago. The following history of the invention is given by Berthoud in his *Histoire*.

"The most ancient equation clock," says he, "which has come to our knowledge, is that which was placed in the cabinet of Charles II. King of Spain, and which is mentioned at the end of *The Artificial Rule of Time*, by Sully, (edition 1717,) who gives the following account of it, from an extract of a letter of the Rev. Father Kresa, of the society of Jesus, written to Mr Williamson, watchmaker of the cabinet of his Imperial Majesty, of the 9th January 1715.

"What Mr Baron Leibnitz says, in his remarks at the end of Sully's book;—that if a watch or clock did of itself make the reduction of *equal time* to *apparent*, it would be a very fine and convenient thing;—on this subject I have to tell you, that from the years 1699 and 1700, there has been in the cabinet of King Charles II. of glorious memory, King of Spain, a clock with a royal pendulum, (a seconds' pendulum,) made to go with weights and not with springs, going four hundred days without requiring to be once wound up. I have, by order of his Majesty, and in his presence, seen and explained the instructions, which were sent from London with watches, which contained many curious things. I had orders to go every day to the palace during several months to observe the said clock, and compare it with the sun-dial. And at that time I remarked, that it shewed the equation of time *equal* and *apparent*, exactly according to the Tables of Flamstead,* which are found likewise in the Rodolphine Tables," &c.

* The earliest equation Tables were calculated by our first astronomer Royal, Mr Flamstead, at Greenwich.

Sully, at the end of the letter of which an extract has just been given, makes the following remarks, page 9:

"What the Rev. Father Kresa relates of the clock of the late King of Spain, is very true. It is more than twenty years since such clocks were made in London, and I believe that I am the first who applied this mechanism (for equation) to a pocket watch, twelve or fourteen years ago."

The following is a description of a very excellent and curious equation clock, which belonged to the late General Clerk. It was left, with several other things, to the late Sir John Clerk, and entailed on the house of Pennycuik.

The clock goes a month, strikes the hour, and has a strike silent piece. The 'scapement of it is made after that of John Harrison's, requiring no oil to the pallets; (see p. 476.) and the pendulum is a gridiron compensation one, composed of five rods, three of which are steel, the other two of zinc, or some compound of zinc. On the dial are seen the hours, minutes, and seconds, and their hands. The minute hand keeps mean or equal time; the equation of time is given by a hand with a figure of the sun on it, which makes a revolution every hour as the minute hand does, only for the most part it goes sometimes a very little slower, and sometimes a little faster than the minute hand, keeping solar or unequal time, and shews at all times when the sun is on the meridian. The age and phases of the moon are also represented, the days of the year and of the month, the degrees of the ecliptic, and the signs of the zodiac, the rising and setting of the sun, the length of the day, &c. The dial is a twelve inch arched one. Concentric with the arch is a sort of ring plate wheel of 365 teeth, making its revolution in a year, or 365 days. Its diameter is about 8 inches, and the breadth of the rim or ring 1½ inch nearly. On this ring plate, at the outermost circles containing divisions, are laid down the days of the year; and on the space next within, are the names of the months, the days being numbered by the figures 10, 20, 30, and so on. The next circles contain the 360 degrees of the ecliptic; the space within has the signs of the zodiac, and the numbers 10, 20, and 30, marked for the degrees in every sign, and corresponding with the days of the year and of the month when the sun is in any of these signs. The innermost circles contain what may be called the divisions of the semi-diurnal arcs. On the space outside of this, are marked the corresponding hour figures in Roman characters. This is what gives the time of the rising and setting of the sun, and the length of the day.

In the annual plate ring, are rivetted six small brass pillars, one inch and one tenth of an inch in height, whose opposite ends are screwed by steel screws, and their heads sunk into a plain ring wheel neatly crossed into six arms, the diameter being five inches and three quarters of an inch, and the breadth of the rim three-eighths of an inch. The back of this plain ring is distant from the back of the annual plate ring one inch and a quarter. The plain ring is at the centre, screwed on a brass socket, having a square hole in it. Within the frame of the clock movement, and at a perpendicular distance of six inches from the centre wheel holes, a steel arbor is run in, and at one end prolonged about an inch and a half beyond the fore frame plate, somewhat like a stud. The pivot in the fore plate is of such a length and thickness, as to allow a square on its outside. It is on this square that the equation elliptic plate is put, and above it is put on the annual plane ring by means of its socket, with a square hole in it. That part of the arbor which is above this socket is round, and serves as a stud for the moon's age ring socket, to revolve on it freely and easily. The moon's age ring turns within the annual plate ring, and is divided into 59 equal parts, numbered 3, 6, 9, and so on to 29½. Its diameter is five inches and one eighth; its breadth fully three-eighths of an inch, and it is connected with a plain wheel neatly crossed into six arms, of the same diameter and breadth of rim as the moon's age ring, having six small pillars, nearly an inch in height, rivetted into it, and the moon's age ring screwed at the opposite ends of three of them, by three sunk steel screws. This plain ring has a socket, which runs or turns on the stud, above the annual plain wheel; the face of the moon's age ring comes flush up with that of the annual plate ring, and both come up to the back of the dial, in which an opening in the arch is made, in order to shew a great part of what is on these rings. From the top of the arch, across the opening, and down in a straight direction, is stretched a very fine wire, serving as an index to the days of the year, the moon's age, &c. The annual plate ring and the moon's age ring move or turn from the right to the left hand, yet separately and independently of each other. On the inside shoulder of the socket of the moon's age ring is screwed a small bevelled wheel, having 37 teeth, and one inch in diameter, the use of which will be afterwards explained. In the dial is a circular opening of one inch and three quarters in diameter, a little below the opening in the arch; in this opening is exhibited the lunar globe of an inch and a quarter in diameter, made of brass and silvered; one half of it is perpendicularly painted black, in order to give the phases, the new and the full moon. On the arbor of the lunar globe are two wheels, one of 63 teeth, and about an inch in diameter, the other a bevelled one of the same diameter, and with 37 teeth. Both are placed below the lunar globe; the wheel of 37 and the globe are fast on the arbor, the wheel of 63 being keyed spring-tight above the bevelled one. The arbor of the lunar globe is in the plane of the dial or nearly so, and this bevelled wheel takes or pitches into that of the same number, which is screwed on the moon's age ring socket, as before mentioned; and by means of holes in the ring, the whole, that is, the globe, the bevelled wheels, and moon's age ring, &c. can be made to turn together, when the moon is at any time setting to its proper age. The pivots of the lunar globe arbor run on cocks which are screwed on to the back of the dial. Behind the globe, and at a little distance from it, is screwed on to the back of the dial, a sort of concave or hollow hemisphere of thin plate brass, painted inside of a sky blue colour.

We shall now proceed to shew how the moon's motion is produced. On the top of the month nut socket, where it lies in the plane of the dial, is cut a right handed double endless screw, working into a small brass wheel of 15 teeth, which is on the lower end of a long arbor, standing upright in a slit made in the dial. This slit is covered by a large circular silvered plate, on which are engraved the hours, minutes, and seconds; on the upper end of this long arbor is a pinion of 8, which carries about the wheel of 63, and with it, at the same time, the bevelled wheels, globe, and moon's age ring. The pivots of the long upright arbor run in small cocks attached to the back of the dial. The month nut, or hour wheel socket, makes a revolution in twelve hours, carrying the hour hand. The revolution of the moon's age ring is made in 29 days, 12 hours, and 45 minutes. The wheel of 63 and 15 being multiplied together, the product is 945, and this divided by 8, the number of the pinion, gives 118.125 times six hours, which being reduced gives the lunation, or a revolution of the moon's age ring as above, of 29 days, 12 hours, 45 minutes. The time of the revolution may be made out by another way. It is evident that one tooth of the small wheel of 15 is turned every six hours, of course the wheel will be made to have a revolution in 90 hours, and so will the pinion 8. Then if we say as 8 : 90 :: 63 : 708.75 hours, which is also equal to the given lunation of 29 days, 12 hours, 45 minutes. To produce the annual motion of the ring plate wheel of 365 teeth, the month nut is cut into 42 teeth, and makes its revolution, as was said before, in 12 hours, and turns a wheel of 84, concentric with which is a pinion of 8, leading a wheel of 96, having concentric with it a pinion of 12, leading the wheel of 365, which is the plate ring circle, having on it the days and months of the year, the degrees of the ecliptic, &c. turning once round in 365 days. Now as $365 \times 96 \times 84 = 2943360$, this product, divided by that of $42 \times 8 \times 12 = 4032$, will give 730 times twelve hours, or 365 days. The pinion of 12 is put on a square, which comes in and through a small hole in the large silvered circular plate; the wheel of 96 is put on a round part of the arbor, just below the pinion, and is keyed spring tight on it; by means of a small key which fits the square, to turn the pinion, the annual wheel of 365 teeth can be set to any required day of the month, which can be done without disturbing any of the motion-wheels. The setting of the moon's age ring is equally free as this is from any disturbing cause. The diameter of the month nut wheel of 42 is one inch, and three and a half tenths of an inch; that of the wheel of 84 is 2.5 inches, and near to a tenth and a half more. The wheel of 96 is three inches; its pinion of 12 is .307 of an inch, the pinion of 8 is .316 of an inch in diameter.

The minute pipe-wheel of 56 teeth, and 1.8 inch in diameter, runs on the arbor of the centre wheel, carrying the minute hand. It turns in the common way, the minute wheel *m* of the same number and diameter, whose centre lies nearly under that of the other, about .6 of an inch to the right of the middle line of the fore frame plate, and 1.7 inch from the centre of the minute hand wheel. The arbor of the minute wheel has a pinion of 8, leading in the common way the hour wheel of 96, whose diameter is 3.25 inches, that of the pinion is .426 of an inch. This pinion of 8 is put on the arbor, by means of a square, and with the minute wheel both are fast on the arbor. See Plate CCCIV. Fig. 7. The upper side of the wheel may be distant from the lower face of the pinion about .7 of an inch, the lower side having a proper freedom of the fore plate. Two wheels, one a plain wheel of 38, the other a bevelled one of 38, having the same diameter 1.2 inch, are screwed together, and on a socket common to both; the flat wheel is the uppermost, and is pretty close to the back of the bevelled one, whose teeth look downwards; their socket turns on the minute wheel pinion arbor, between the lower face of the pinion and the upper side of the minute wheel, having a proper end shake between them; the back of the flat wheel of 38 is below the lower face of the pinion .4 of an inch. These wheels of 38 can be made to turn on the minute pinion arbor, independent of it and the minute wheel. The minute wheel and pinion arbor extends a little way beyond and below the minute wheel, perhaps one inch and three or four tenths more to the end of its pivot; it extends also beyond the face of the pinion more than .6 of an inch to the end of its pivot, which runs into a cock C screwed on the fore frame plate. There is a part formed on the arbor of a flat circular shape, and whose thickness is rather more than that of the diameter of the arbor; in the middle of this is a hole tapped, into which is screwed a stud, standing at right angles to the arbor; a bevelled wheel of 38, and diameter 1.2 inch with its socket turns on this stud, which is placed on the arbor at that distance, so that the two bevelled wheels may fairly pitch into one another; the minute wheel is crossed into four, and through one of the cross's openings, the bevelled wheel B, which is on the stud, gets to pitch with the bevelled wheel *b* which is above the minute one. On the inside of the pillar plate is screwed a cock A, near 1.2 inch in height, and so that the middle part of the upper knee shall be opposite to the lower end and pivot of the minute pinion arbor. On one end of another arbor, in length about 2.1 inches, having a shoulder on it, is rivetted a bevelled wheel *c* of the same diameter and number of teeth as the others; another shoulder of just a sufficient thickness is made on this arbor at the back of the bevelled wheel; the rest of the arbor is nearly straight all the way, to the shoulder of a pivot which is at this end; from this shoulder the arbor is squared down for about .6 or .7 of an inch, to receive the socket of a small wheel W of 32 teeth, which turns behind the pillar plate; this wheel is nearly one inch in diameter, and a cock K is screwed on the back of the pillar plate, in which the pivot of the wheel of 32 runs; a pin is put through the socket and square, to keep the wheel fast to its place on the arbor. When the shoulder at the back of the bevelled wheel bears on the outside of the kneed cock, which is on the inside of the pillar plate, the cock having a hole in it which allows the arbor to go through and to turn in it, then the pivot of the arbor will run in the cock which is at the back of the pillar plate. The inside bottom of the bevelled wheel, which is rivetted on the shoulder of this arbor, has the end of the arbor made flush with it, and a hole made in the end and centre of the arbor to receive the lower pivot of the minute pinion, in which it runs or turns, the bevelled wheel which is on the stud being supposed to be set as low down as it shall meet and pitch properly with that which is at the end of the other arbor. It will now be seen that the end shake of these arbors, when combined, will lie between the minute pinion cock on the fore plate, and that which is on the back of the pillar plate. Let us suppose that the bevelled wheel, which is at the end of one of these arbors, remains as it were stationary, and that the minute pinion and wheel are carried about by the minute pipe wheel, which is on the arbor of the centre wheel; during a revolution of the minute wheel and pinion, the bevelled wheel, which turns on the stud, will be carried not only round with its stud, but is made to make another revolution by means of its turning round on the teeth of the bevelled wheel, which is stationary, causing the bevelled wheel, and the flat wheel connected with it, which are below the minute pinion, to make two revolutions in the hour; and as the flat wheel of 38 teeth turns the sun hand wheel of 76 teeth and 2.3 inches in diameter, this last must make its revolution in an hour. Its socket turns freely on that of the minute pipe wheel, which carries the minute hand; between the sun hand wheel and this minute pipe wheel is a slender spiral spring, the inner end of which is fixed to the lower end of the sun's wheel socket, the outer end being fixed in a stud on the upper surface of the minute hand wheel. This spring is for the purpose of keeping forward the sun hand to its place, notwithstanding any shake which may be among the teeth of those wheels concerned in the equation motion work. The sun's hand is of brass gilded, having the figure of the sun on it, at a little distance from the end which points to the minute divisions. The sun's hand lies between the hour and minute hands; the wheel of 76, which carries it, besides the motion of going once round in an hour, has at one time a small motion retrograde, at another a small motion progressive, according to the equation; and there are four times in the year when the minute and sun hands are nearly together. One half nearly of the sun wheel is crossed out, on that side in which the sun's hand lies, in order that the equilibrium of the hand and wheel may be as nice as possible, whatever may be the position of the sun hand.

From the centre wheel hole on the fore frame plate, towards the left hand, and a little upwards, take, with a pair of compasses, a distance of 3.8 inches, and sweep an arch; and then from the centre of the hole, in which the arbor runs, which carries the annual plate wheel, take in the compasses an extent of 4.6 inches, and sweep another arch so as to intersect the first, the place of intersection will be that of an arbor having pivots, one of which runs into a cock, screwed on the back of the pillar plate; the other runs into a cock screwed on the front of the fore frame plate; a notch is made on the edge of each frame plate to admit the arbor to come into its place. On the end of this arbor, which is just behind the pillar plate, is fixed a rack or segment of a circle 5 inches radius, having 32 teeth cut on it, and cut from a number on the engine plate of 318; the rack-teeth pitches into the small wheel of 32, which lies behind the pillar plate, and whose centre coincides with that of the minute pinion arbor, as mentioned before. On the other end of this arbor, and beyond the fore frame plate a very little, is fixed an arm of 4.5 inches long, having at the end of it a smooth hard steel pin, which bears on the edge of the annual elliptic equation plate, being made to do so by means of a coil or two of watch main spring, not very strong, attached to the arbor, near to the inside of the fore frame plate, the outer end being fixed to one of the pillars, or to a stud fixed for that purpose on the inside of the fore plate. The elliptic equation plate is a very irregular sort of a figure, as may be conceived in some degree by the description of its shape; its greatest length over all is 6.5 inches; the centre is 3.8 inches from the broadest end, and 2.7 inches from the narrowest; the nearest edge across the centre is about one inch, and the edge opposite is 1.8 inch; the greatest breadth of the broad end is near to 4 inches, that of the narrowest end is 2.8 inches. During the course of its annual revolution, the edge of the elliptic plate makes the arm which has the steel pin in it rise to various heights, and fall as variously to different depths. By this rising and falling, the rack which is at the opposite end of the arbor, is made to have a motion sometimes backward, and at other times forward, which it communicates to the small wheel of 32, behind the pillar plate, and of course to the bevelled wheel of 38, on the same arbor with it. This continually causes a small change of place to the bevelled wheel of 38, consequently a change of place to that which turns on the stud, and hence to the wheel carrying the sun hand; this change is what gives the equation shewn by the difference of time between the minute and sun hands. When the pin in the arm falls, the equation or sun hand goes forward, and when rising it goes backward. The greatest negative equation for 1815, on the 3d day of November, is 16 minutes, 14.9 seconds, which, added to the greatest positive equation for the same year on the 11th of February, is 14 minutes, 36.5 seconds, making in all 30 minutes, 51.4 seconds; so that one tooth of the wheel of 32 may be nearly equivalent to one minute of equation. To trace properly a true figure to the equation plate must be a very tedious and nice operation; for this purpose the rack, and all the wheels immediately connected with the equation, must be put into their places, as also all those which give motion to the annual plate, and to have a spring tight arm, having a sharp point to it, bearing on the face of the brass plate which is to be the elliptic one: the sharp point must lie so as to coincide with the side of the steel pin, when bearing on the edge of the elliptic plate. The sun and minute hands being on, and the annual plate set to the 1st of January, the equation hand set to the equation for that day, then by setting forward the minute hand until 12 or 24 hours have elapsed, the equation hand may be changed to what it ought to be, in the same time; so by going on step by step in this way, the figure of the equation plate may be truly done. The rack must be artificially made to assist in this; and when the revolution is completely at the end, before taking out the rack and the equation wheels, marks must be made to one of those teeth, which must be marked by its corresponding space in the other wheels, so that when they are again put into their places, they shall give such equation as was done when tracing for the elliptic plate.

Besides the days of the month, which are shewn on the annual plate, there is a common month ring, having 31 figures engraved on it, placed as usual at the back of the dial. One of these figures is shifted every day through the whole ring when the month consists of 31 days; and two figures at the last are shifted at once when the month consists of 30 days, to bring the ring to the first day of the succeeding month; and at the 28th of February four figures are shifted, so as to bring the ring to the 1st of March: by this means the day of the month ring requires no shifting or correcting at these periods, as those in the common way do. To produce this motion, five short steel pins are placed in a circle, on the under side of the elliptic plate, whose radius may be about half an inch, and set at such a distance from one another as to correspond with the number of days between February and April, between April and June, between June and September, between September and November, and between November and February. This may be done by applying the elliptic plate on a cutting or dividing engine, having the number 365 on the dividing plate. When fixed on the engine, and set to the first point of the number, make a point for February on the elliptic plate; then count off 61 from the dividing plate, which will give the place for the pin on the 30th of April; another 61 will bring it to June 30th; 92 will give the 30th of September; 61 the 30th of November; and 90 more will bring it to the 28th of February, the point which was set out from. When the pins are put in the elliptic plate, that for February will require to be longer than the others, for a reason which will be explained when we come to shew the use of these pins. The month-wheel of 84 teeth, and whose diameter is 2.75 inches, has its centre on the left hand side, distant from the central perpendicular line 1.4 inch, and from the centre hole in the fore frame plate 2 inches. The month wheel, as usual, is turned about by the month nut. A long piece of brass forming two arms, each four inches in length, has a small arbor through the middle of the whole length of eight inches. The pivots of this arbor run into small cocks, attached to the front of the fore plate, keeping the long piece of brass very near to the plate; indeed a great part, particularly the end of the upper arm, and towards it, is sunk partly into the fore plate. This long piece of brass is placed so that one of the arms shall come to the socket of the month wheel, and the other, with its end nearly below the circle in which are the five pins, in the annual elliptic plate described as before. A spring is placed below this upper arm to keep it up, unless when any of the pins get on the end of the arm and press it down. The end of the arm is chamfered, or made so that any pin, when approaching it, gets easily on, and presses it down gradually, by means of ascending the chamfered part as it were; and when past this, it meets with a flat and very narrow place, where it cannot remain longer than some time short of 24 hours, say 16 or 18 hours, or perhaps not so long. After having passed the flat part, it meets with a chamfered side opposite to that of the first. Besides that of freeing the pin, this is made for the purpose of more easily setting back or forward the annual plate.

The month wheel has its socket equally long on both sides, and quite straight; the length of each may be .6 or .7 of an inch. Two small brass pillars are rivetted on the upper side, and opposite one another, each at a distance from the centre of the wheel about .7 of an inch, (see Plate CCCIV. Figs. 8, 9.) the height of the pillars from the wheel to the shoulder about half an inch; and from the shoulder of each pillar a sort of straight pivot is prolonged, about one half inch more; the diameter of these pivots about one-tenth of an inch; that of the pillar .2 of an inch. There is another socket which goes easily on the lower or under socket of the month wheel, which is rivetted in a rectangular piece of brass, about an inch long, and half an inch broad, or nearly so, say .4 of an inch. In this piece of brass, on the side opposite that of the socket, are also rivetted two small and straight brass pillars, about an inch in length, and the diameter about one-tenth of an inch. There are holes in the month wheel, to allow these pillars to go easily back and forward in them; their places will be equally between the month wheel socket, and the pillars which are rivetted in the month wheel. The other ends of the small straight pillars are made fast, by two small steel screws, to a piece of brass, which is formed to correspond with two broad crosses of the month wheel. Only one of them is made to have at the end a segment of a circle, whose radius is nearly equal to that of the month wheel. On this segment three teeth are cut, equal in their spaces and form to those of the month ring. In the arms or crosses of the segment are three holes, one of which goes easily over or on the upper socket of the month wheel; the other two holes go easily on the small straight pivots which have been already mentioned. This segment cannot be put on the ends of the small pillars, till the socket of the rectangular piece of brass is put on the lower socket of the month wheel, having previously made the pillars connected with it to pass through their holes in the month wheel. It will be easy to perceive, that when the segment is put on to its pillars, and a sufficient space left behind the month wheel and the rectangular piece of brass, its socket may be made to pump up and down on that of the month wheel, and at the same time carrying the segment back and forward with it; a pin in the month wheel stud keeps the month wheel socket always to its proper end shake, notwithstanding any motion of the segment backwards and forwards. Below the rectangular piece on its socket, a small groove is turned out of it, for the purpose of a forked piece getting in on it; this forked piece is formed on that end of the arm which lies along the fore plate, and on to the socket or centre of the mouth wheel.

From the preceding description it is evident, that when any of the elliptic plate pins come to press down that end of the long arm which lies near and under them, the forked end will raise up the grooved socket, and the segment which is connected with it; hence the teeth of the segment will meet with pins which are at the back of the month ring, and by their means will turn the month ring. On the month wheel is fixed a pin, which, in common, shifts the day of the month ring; but in those months in which there are only 30 days, the pins in the elliptic plate, which press down the end of the arm, make the segment be pumped up only so far as to meet with one of the pins at the back of the month ring, which is a little longer than the other two; and one day being shifted by it, and another by the fixed pin in the month wheel, this makes the shifting from the 30th to the 1st day of the succeeding month. The pin in the elliptic plate for the month of February being longer than the others presses the end of the arm a little more down, consequently the pumping up of the segment must be to a greater height; by this means the three teeth on the segment get hold of the three pins on the back of the month ring; this, with the fixed pin in the month wheel, are ready to shift four teeth of the month ring, viz. from the 28th of February to the 1st of March; and, by this very ingenious sort of mechanism, the month ring shows always the right day of the month, except on the 29th of February in leap-years. It may be necessary to notice, that the fixed pin in the day of the month wheel must be placed at such a distance from the first tooth on the segment, as is equal to the space between the teeth on the segment. The month ring is not attached by rollers to the back of the dial in the usual way, but runs in four rollers, which are fixed on four brass studs on the fore frame plate. This is for the conveniency of seeing more easily the operations of the segment with the month ring, when the segment is pumped up and down.

The construction of the month wheel, and of the apparatus for shifting the month ring, will be better understood from Figs. 8 and 9, where AA is the month wheel; B, B, two arms or crosses nearly similar to those of the month wheel, having a hole in the centre which goes freely on the upper socket of the month wheel; on one of these arms is a segment of a circle, nearly of the same radius as that of the month wheel, having three teeth cut on it, like those of the month ring; *a*, *a*, are two brass pillars rivetted on the upper side of the month wheel, the upper ends being formed into a sort of pivots; on these and the month wheel socket, the segment is made to move freely up and down. C is a rectangular piece of brass, into which a socket is rivetted, which moves up and down on the lower socket of the month wheel, having a groove turned out on it, which receives the forked end of the arm, which pumps it up and down; *b*, *b*, are two small brass pillars, which are rivetted also into the rectangular piece of brass, having two holes in the month wheel, through which they pass easily up and down; the other ends of them go into the segment at *b*, *b*, and are screwed to it by means of two small screws. On one of the arms of the month wheel is screwed a small kneed sort of cock *d*, having a pin fixed in it, for turning the day of the month ring in the usual manner.

## CHAP. VIII.

### *On Repeating Clocks and Watches.*

To those who do not sleep well, nothing can be more convenient and useful than a repeater, whether it is in a watch, or in a small fixed clock. A history of this invention is given by Mr Derham in his *Artificial Clockmaker*. Berthoud, in his *Histoire*, has given the following account of it, which is taken chiefly from Derham.

"The art of measuring time, (says Berthoud,) was again enriched with two fine and useful inventions before the end of the seventeenth century. One was the equation clock; the other, which is the most precious, and of the most general utility, is that kind of striking which has been called repeating. It is of the most ingenious mechanism, and when added to a clock, serves to make known at pleasure, at every instant of the day or night, without seeing the dial, the hour and the parts of the hour, which are pointed out by the hands of the clock. Both these inventions are due to the English artists."

"The clocks in question here, (says Derham,) are those which, by means of a cord, when pulled, strike the hours, the quarters, and even some the minutes, at all times of the day and of the night. This striking or repeating was invented by a Mr Barlow, towards the end of the reign of King Charles II. in 1676."

It is not mentioned by Derham, whether Barlow was a watchmaker or not. We have heard it said by old watchmakers, that he was a clergyman. This seems in some measure confirmed, by his having applied to Tompion to make his repeating watch, when he was about to obtain a patent for the invention.

"This ingenious invention," continues Berthoud, "which had not been before thought of, made at the outset a great noise, and much engaged the attention of the London watchmakers. On the idea alone which each formed of it, they all set to work to try the same thing, but by very different ways; whence has arisen that great variety in the work of repeating motions, which was seen at this time in London.

"This discovery continued to be practised in chamber clocks until the reign of James II. It was then applied to pocket watches. But there arose disputes concerning the author of the invention, of which I shall simply relate the facts to the reader, leaving him to judge of it as he thinks proper."

Towards the end of the reign of James II. Mr Barlow applied his invention to pocket watches, and employed the celebrated Tompion to make a watch of this kind according to his ideas; and at that time, conjointly with the Lord Allebone, chief justice, and some others, he endeavoured to obtain a patent for it.

Mr Quare, an eminent watchmaker in London, had entertained the same notion some years before, but not having brought it to perfection, he thought no more of it until the noise excited by Mr Barlow's patent awakened in him his former ideas. He set to work, and finished his mechanism. The fame of it spread abroad among the watchmakers, who solicited him to oppose Barlow's privilege to obtain a patent. They addressed themselves to the court; and a watch of the invention of each was brought before the king and his council. The king, after having made trial of them, gave the preference to that of Mr Quare.

The difference between these two inventions is this:—The repetition in Mr Barlow's watch was effected by pushing in two small pieces, one on each side of the watch case, one of which repeated the hour, the other the quarters. Quare's watch repeated by means of one pin only fixed in the pendant of the case, which, being pushed in, made the repetition of the hours and quarters, the same as is done at this present time, by pushing in once only the *pendant* which carries this pin.

This invention of repeating the hours in small fixed clocks, and in watches, was soon known and imitated in France; and these machines were very common in 1728, when the celebrated Julien Le Roy was much occupied in their improvement. It was at this period that he made the repeating clock, of which a description is given at the end of *The Artificial Rule of Time*. This was made for the bedchamber of Louis the Fifteenth of France.

The first repeaters, even those of Quare's, as well as others, gave the number of the hour according to the length pushed in of the pendant; which was very inconvenient, by striking any hour, whether the pendant was pushed home to the snail or not. This frequently caused mistakes, in regard to the true hour which ought to have been given. From the report of our predecessor, Mr James Cowan of this place, who went to Paris in 1751 for improvement in his profession, and who executed some pieces under Julien Le Roy, it was *he* who introduced the mechanism into repeaters, which prevented the watch from striking any thing but the true hour. This, we think, was done to the repeating clock for Louis the Fifteenth's bedchamber. In this construction, unless the cord or pendant made the rack go fully home to the snail, it either struck none, or struck the true hour, which was a very considerable improvement. The piece employed for this purpose is called the *all or nothing* piece. Considering the great talents which Julien Le Roy possessed, we have no reason to doubt of this improvement being his.

"Although the *repetition*," says Berthoud, "such as is now in practice, is a particular kind of striking, its mechanism differs totally from that of the striking clock; 1st, Because every time that it is made to repeat, the main repeating spring is wound up; whereas, in the common striking part, the main-spring is wound up only once in eight days, fifteen, or a month: 2d, In the repetition we must substitute for the count-wheel, which determines the number of blows that the hammer must strike, a contrivance wholly different. The first author of this ingenious mechanism substituted for the count-wheel a piece, to which, in regard to its form, he gave the name of the *snail*. The snail is a plain piece, divided into twelve parts, which form steps, and come gradually in from the circumference towards the centre. It makes a revolution in twelve hours. Each of the steps is formed by a portion of a circle. Every time that the clock is made to repeat the hour, the pully which carries the cord is connected with and turns a pinion, which leads a rack, whose arm falls on one or other of the steps of the snail, (on the cord being pulled,) and regulates the number of blows which the hammer ought to give; and as this snail advances only one step in an hour, it follows, that if it is wanted to be made to repeat at every instant in the hour, we should have always the same number of blows of the hammer; whereas, in setting off the wheel-work of an ordinary striking movement more than once in the hour, we should have a different hour. A count-wheel would then not be fit for a repetition. The mechanism of the repetition has a second snail, which bears four steps also in portions of a circle, to regulate the blows which the quarter hammers must give."

The count and hoop wheels, and locking plate of the old striking clocks, for regulating the number of blows of the hammer, and locking the wheel-work, was excellently contrived. It had only one inconvenience, for when set off by accident, it would prematurely strike the hour to come: this made it requisite to strike eleven hours before it could be again brought to the hour wanted. Had it not been for the invention of the repeater, these would have continued, and would have been still made in the modern clocks, the same as in the ancient ones. But the snail of the repeater shewed that it could be adapted for regulating the number of blows for the hammer of a common striking clock, and has prevented the inconvenience of striking over a number of hours, before the clock could be set to the right hour of striking.

"We owe to Julien Le Roy," continues Berthoud, "the suppressing of the bell in repeating watches, a change which has made these machines more simple, by rendering the movement larger, more solid, and less exposed to dust. These watches, which he called *raised brass edges*, are of a more handsome form. From the time of this celebrated artist, all the French repeaters have been made according to this model; but in England, where repeating watches were invented, they make them for the most part with a bell; and in Spain, this construction is still more preferred. In repeating watches without a bell, the hammers strike on brass pieces, either soldered or screwed to the case. Repeating watches with a bell have, also, as those without one, the property of being *dumb*, that is to say, of being able to make it repeat at pleasure, without the hammers being allowed to strike on the bell, or brass pieces."

This effect is produced after the pendant is pushed in, by putting the point of the fore-finger on a small spring button, that comes through the case. Being a little pressed in, it opposes a piece against the hammers, which prevents them from striking either a bell or the brass pieces inside of the case; by which means the blows for hours and quarters are *felt*, though they cannot now be easily heard. This makes this kind of repeaters very convenient for those who are deaf, as during the dark of night they can feel the hour at a time when they cannot *see* it. These *sourdine* or dumb parts have been left off of late years; yet they are not without their advantages, as has been now shewn.

The late Julien Le Roy had tried to render repeating watches more simple, by suppressing the wheel-work which serves to regulate the intervals between the blows of the hammers, and also the main repeating spring. This celebrated artist succeeded in these, to construct new repeating movements, of which several have been made. But it appears that the public have not found them very convenient, so that this mode of composing them has not been imitated.

The only one of this kind which we have seen of Julien Le Roy's, was a very good one in the possession of John Rutherfurd, Esq. of Edgerston. Although they have not been copied, they certainly deserve to be so.

Repeaters have of late been made with springs in place of bells, which are a very ingenious substitute, it must be allowed, of Swiss invention, though they are as superfluous as bells. Considerable trouble is necessary in making and placing them. They ought never to be recommended, if it could be avoided; but we are often obliged to yield to the fashion of the day, even when it does not coincide with our own opinion. When three or more hammers are used to give the quarters, we then would admit springs in place of bells, as when they are well tuned, they give a most beautiful chime for the quarters: were bells introduced for this purpose, they would give a clumsy appearance to the watch. Julien Le Roy saw good reasons for setting aside the bell; and no plan of a repeater will ever be superior or equal to that of his, which Graham frequently adopted in many of his watches, though his repeating motions were different; Julien Le Roy's having what is called the plain, and Graham's the *Stogden* motion, a most ingenious contrivance, requiring great judgment to plan, and nice execution in making it. This motion is well adapted for half quarters: Though we have hardly seen a French repeater with it, yet it is not unknown to the foreign artists, as appears from Thiout's work, tom. ii. p. 367, plate xxxvi. fig. 3. Paris, 1741. This repeating motion must have got its name from the inventor. Upon inquiring after him when in London, in the year 1770, we learned, with much regret, that he had died a few months before in a charity workhouse, at a very great age. The name appears to be German; but whether he was a foreigner or an Englishman, we have not been able to learn.

We shall now lay before our readers a complete description of the repeating movement and motion-work of clocks and watches, which we have taken principally from Berthoud's *Essai sur l'Horlogerie*

Clocks that have a striking part, strike of themselves the hours, and some strike the hours and half hours; but those having a repeating part strike only on a cord being pulled, if it is a clock; and if it is a watch, when the pendant or pusher is forced home; thus two hammers strike the hour and the quarters, which the hands point to on the dial. We shall see, by the description of a repeating clock, how this is produced; but before doing so, we shall give a general idea of this ingenious mechanism, which is nearly the same for a clock as for a watch.

In order to make a clock repeat the hour, (see Plate CCCV. Fig. 2.) the cord X is drawn, which is wound round the pully P, fixed on the arbor of the first wheel of a particular wheel work, the sole object of which is to regulate the intervals between each blow of the hammer. The arbor of this wheel has on it a hook, which takes hold of the inner end of the repeating main-spring contained in the barrel B, Fig. 3. On this arbor is also a plain wheel G, Fig. 1. having fifteen pins in it which serve to raise the hammers, twelve of them for the hours, and three for the quarters. The number of blows that the hour hammer strikes, depends on the greater or less course which the pin wheel G is made to take when pulling the cord, and this course depends itself on the hour pointed at by the hands on the dial. Thus, if the cord is drawn when it is twelve hours and three quarters, the pin wheel is obliged to make an entire revolution; at this instant the repeating spring brings it back, in which course it makes the hammer give twelve blows for the hours, and then three for the quarters. To distinguish the quarters from the hours, a second hammer is added, which, with the first, makes a double blow at each quarter.

It must now be shown by what means the course which the pin wheel takes is regulated on the cord being pulled, and how it is proportioned to the hour which the hands point to on the dial.

A wheel S, or minute wheel, of the dial work, Fig. 3. has its arbor prolonged, and outside of the back of the pillar plate. (In this case, and in common, the repeating work is put between the dial and foreplate of the frame.*) It carries the piece *sh*, Fig. 2. the pin of which *c* turns the star wheel E, which takes twelve hours to go once round, and carries with it a piece L, called the *hour snail*, divided into twelve parts tending to the centre of the star wheel. Each of these parts forms different depths, like as many steps, which gradually come nearer the centre, and which serve to regulate the number of the hours which the hammer must strike. For this purpose the pulley P carries a pinion *a*, which pitches in with a portion of a wheel C, Fig. 2. called the *rack*. When the cord is pulled, and the rack is in consequence made to advance towards the snail, the arm *b* stops on such a step of the snail as it may meet with in its course; and, according to the depth of this step, the hammer strikes a greater or less number of blows. It will strike only one hour if the arm *b* of the rack is stopped on the step 1, the most distant one from the centre, as then the pin wheel getting only one of its pins engaged, the hammer strikes only one blow. If, on the contrary, the step 12, which is the deepest and nearest the centre, is met by the arm *b* in its course, which cannot get there until the pin wheel shall have made one turn, then the spring in the barrel bringing it back, will cause the hammer to give 12 blows.

It remains to be seen how the quarters are repeated. The piece *s*, Plate CCCV. Fig. 2. which turns the star wheel, and takes one hour to make a revolution, is carried by another snail *h* (called the *quarter snail*,) formed by four divisions, making three paths or steps, on one of which, when the cord is pulled, the arm Q of a piece QD, called the *finger*, places itself, and according as the step is nearer or farther from the centre of the snail, the end D of the finger finds itself more or less aside from the centre *a* of the pulley P; so that when the pull of the cord is finished, and the pulley returns by the force of the spring in the barrel, one of its four pins acts on this finger, namely, the one which it finds at a distance from the centre *a*, which answers to the elevation of the arm D, and this is what determines the blows for the quarters: thus when the finger is applied on the pin nearest the centre of the pulley, the

* This part of the repeating work, with the dial wheels, go under the general name of the *motion work*.

hour hammer strikes only the number of hours that the snail L and the arm *b* of the rack have determined. If the finger is placed on the second pin, it does not stop the pulley till after the hour hammer has struck the hour, then a quarter, and so on for the three quarters. Having thus given an idea of the essential parts of a repeater, let us now proceed to a particular description of a complete repeating clock with an anchor 'scapement.

Plate CCCV. Figs. 1, 2, and 3. represent all the parts of a repeating clock, seen in plan. Fig. 1. represents the wheel and pieces contained within the frame, or what are put between the two plates, with the exception of the anchor A, which is placed in this way, to show the 'scapement.

The wheels B, C, D, E, F, are those of the movement. B is the barrel, which contains the clock main-spring. The great wheel is fixed to the bottom of the barrel B, and pitches into the pinion of the wheel C, which is the great intermediate wheel. D is the third, or the centre or minute wheel.* E the fourth wheel, or that where the contrate wheel was usually placed. F the ratchet, or 'scapement wheel. The centre wheel D makes a revolution in an hour. The pinion on which this wheel is fixed has its pivot prolonged, which passes through the fore plate, Fig. 3. This arbor or pivot, Fig. 4. enters spring tight into the cannon of the minute pipe wheel *m*, seen in perspective, Fig. 5. which makes also, by this means, a turn in an hour. This cannon carries the minute hand; and its wheel *m* pitches into the returning or minute wheel S, of the same number of teeth, and of the same diameter as the wheel *m*. The pinion of the wheel S makes twelve revolutions in the time that the hour wheel C makes one. The wheel C, which is one of the dial wheels, takes then 12 hours to make one revolution, and is that which carries the hour hand.

It must be observed, with regard to these three wheels, C, *m*, S, which are called dial wheels, that they are always the same, whether the clock is a striking one or a repeating one; their effect being, to cause the hour or dial wheel C to make a revolution in the space of twelve hours. The wheels G, L, M, N, Fig. 1. and the fly V, form the wheel work of the repeating part. The object of this wheel work, as has already been mentioned, is to regulate the interval between each blow of the hammer. The ratchet R, and the pin wheel G, are fixed on the same arbor in common with the wheel L, within whose centre it freely turns. The spring *r*, and the click *c*, are all placed on the wheel L.

When the cord X, which is wound round the pulley P, Fig. 2. is pulled, the ratchet R, Fig. 2. fixed on the same arbor as the pulley, retrogrades, or goes backwards, and the inclined planes of the teeth raise the end of the click at O. Then the repeating spring brings back the ratchet, whose teeth butt or stop against the end of the click, which carries about the wheel L, and the wheel work M, N, V: but while the ratchet R thus carries the wheel L, and while the pin wheel G, and the pulley P of Fig. 2. which are fixed on the same arbor, turn also, the pins of the wheel G act on the pieces *m*, *n*, Fig. 1. whose arbors prolonged carry the hammers *l*, *m*, Fig. 2. Each piece *m*, *n*, is pressed by a spring, to bring forward the hammers, after the pins had made them rise up or go backward. The spring *r* is only seen, which acts on the piece *m*; that which acts on the piece *n* is placed under the plate which carries the motion work, Fig. 2. The piece *o* serves to communicate the motion of that of *m* to the arbor or piece *n*, which carries the hour hammer.

The piece, (*bascule*,) or see-saw *m x*, Fig. 1. is moveable on the arbor which carries the quarter hammer. On this arbor below *m x*, an arm like that of *m* moves, on which act the three pins placed on the under side of the wheel G. These three pins serve to raise the quarter hammer fixed on the arbor which carries the piece *m*. It is this hammer which the spring *r* presses. When the cord is pulled, the wheel G is made to go backward, the pins of which come to act on the back part of the arm *m*, which yields, and comes from *m* to *x*. The small arm which is below for the quarters makes the same motion; and when the repeating spring brings back the wheel G, a small spring, which acts on these pieces *m*, obliges them to get engaged between the spaces of the pins, and to present the right planes on which these pins act to raise the hammers.

The pulley P, Fig. 2. carries the pinion *a*, which pitches into the rack *b* C, the effect of which is, as has been said, to make the point *b* go upon the steps of the snail L, and determine the number of blows which the hour hammer must give.

The star wheel E, and the snail L, are fixed together by two screws. This star moves on a screw stud V, Fig. 2. attached to the piece TR, moveable itself in T. This piece forms, with the plate, a small frame, in which the star E and snail L turn. One of the radii or teeth of the star bears on the jumper Y, which is pressed by the spring *g*. When the pin *c* of the quarter snail turns the star wheel, the jumper Y moves out, receding from V to the centre of the star, until the tooth of the star arrives at the angle of the jumper, which happens when it has made half of the way which it ought to do. Having escaped this angle, the inclined plane of the jumper pushes it as it were behind, and makes it precipitately finish the other half; so that from the changing of one hour to another, that of the star and of the snail is done in an instant, which is when the minute hand points to the 60th minute on the dial.

The jumper finishing thus in turning the star, each tooth placed in *c* comes on the back of the pin *c*, and makes the *surprise s*, to which it is fixed, advance. The surprise is a thin plate, adjusted on the quarter snail; it turns with it by means of the pin which comes through an opening made in the surprise; the advance which the star wheel teeth causes the surprise to make, serves to prevent the arm Q of the finger from falling into the step 3, which would make the three quarters be repeated when at the 60th minute. As soon as the star changes the hour, it then obliges the *surprise* to advance to receive the arm Q; so that if the cord is pulled at this instant, the hammer will strike the precise hour.

The arm Q and the finger are moveable on the same centre. When we have drawn the cord, and when the pins of the pulley have freed or left the finger at liberty, then the spring *p* makes the arm Q fall on the quarter snail, and the finger D presents itself to one or the other of the pins in the pulley. These two pieces can turn one on the other, and be moved separately: This serves in the case where the arm Q going to fall on the step *h* of the quarter snail, and the finger D being engaged in the pins of the pulley, this arm bends and yields to the pins of the pulley, which at this instant cause it to retrograde or go backward; it is necessary that the pin for the present in

* Our workmen give the name of minute wheel to what Berthoud gives the name of the returning wheel; and what he calls the minute wheel, obliges us to make it the centre or third wheel, in conformity to their language.

hold can make the finger move separately from the piece Q. The spring B brings back the finger D, as soon as the pin has retrograded, so that it may present itself to the pin which stops for the hour alone, or for the quarter, if the arm falls on the step 1, &c.

Having seen the most essential parts of the repetition, there remains only one of which an idea must be given, and which we shall endeavour to make the reader understand. This is the *all or nothing*, which has this property, that if the cord is not fully drawn, so as to make the arm *b* of the rack C press on the snail L, the hammer will not strike; so that, by this ingenious mechanism, the piece will repeat the exact hour; if otherwise, it will not repeat at all.

We have seen, that when the cord X is pulled, the pin wheel G, (Fig. 1.), oversets the piece *m*, and makes it come to *x*; and that before the hammer can strike, a small spring must bring back the piece *m*, to put it in holding with the pins; after that, it is easy to see, that if, in place of allowing the piece *m* to take its situation, it were made to be still more overset, the repeating spring bringing back the pin wheel, the hammer would not strike while this piece remained overset; this is precisely the effect that the piece TR (Fig. 2.) produces, which is on that account called the *all or nothing* piece. This is effected in the following manner: The piece *m* (Fig. 1.) carries a pin, which goes through the plate by the opening *o*, (Fig. 2.); if we pull the cord, the pin wheel causes the piece *m* to move, as we have just now seen. The pin which it carries comes to press against the end *o* of the all or nothing piece, and sets it aside, so that the pin shall arrive at the extremity, which is a little inclined: But the spring *d* tending to bring back the arm *o*, the inclined plane obliges the pin to describe still a small space, which takes the arm *m* (Plate CCCV. Fig. 1.) entirely out of the reach of the pins, so that the hammer cannot strike, unless he pin is disengaged from the end of the arm *o*. To effect this, the arm of the rack must come and press on the snail L, which moves on a stud V, fixed to the all or nothing piece TR. Now, in pressing the snail, the arm *o* of the pin is set aside, which getting free, gives liberty to the arm *m* to present itself to the pins of the wheel G, and to the hammers that of striking the hours and quarters given by the dial work and hands.

The ratchet R (Fig. 3.) is that of the click and ratchet work of the movement; *c* is the click, *r* the spring. The ratchet R is put on a square of the barrel arbor; this square being prolonged, serves to wind up the spring by means of a key; B is the barrel in which the spring or motive force for the repetition must be put; V is a screw, called the eccentric or pivot carrying piece: On the part which enters with force into the plate, a little out from the centre of the arbor of the screw, a hole is made for the pivot of the anchor A. In making this screw turn, the pivot of the arbor of the anchor is made to go farther or nearer the centre, and consequently the anchor itself, so that the points of the pallets take more or less in, according as is required with the teeth of the 'scapement wheel. A, Fig. 2. is the cock of the 'scapement, it carries the silk thread or spring, to which the pendulum is suspended. One of the ends of the silk thread is attached to the arbor *c*, which is called *avance* or *retard*, (fast or slow); the other end of this arbor goes through to the dial, and is squared, to receive a small key. By this means, we can turn the arbor *c* to any side, so as to lengthen or shorten the silk thread which serves to suspend the pendulum, whose length is changed by this method.

The anchor A, Fig. 1, is fixed on an arbor similar to that for a second's pendulum. This arbor carries the fork T, which gives motion to the pendulum. The pivot which this arbor carries at the end where the fork is, enters into a hole made in the cock A, Fig. 2.

Fig. 4. represents in perspective the wheel D, whose revolution is performed in an hour; it is the arbor of it that carries the wheel *m* of Fig. 3. This wheel *m* is seen in perspective in Fig. 5. whose cannon serves to carry the minute hand. Fig. 6. represents in perspective the wheel S of Fig. 3. It is the arbor of this wheel prolonged, which passing to the motion work, carries the quarter snail *h*, Fig. 2. The pinion of this wheel S, pitches into the hour wheel, seen in perspective in Fig. 7; and it is on the socket of this wheel, that the hour hand is adjusted or fixed.

It will be seen from the preceding description, that the pieces of the repeating motion work are here placed on the back of the pillar plate. Placing them on the fore plate will make no difference.

We shall now proceed to describe a repeating watch with a horizontal or cylindrical 'scapement of Graham's.

What has been said concerning the repetitions in pendulum clocks, and the simple or plain watch, being once well understood, the reader will have no difficulty in comprehending the mechanism of a repeating watch, which is only on a small scale what the clock is on a great scale.

Fig. 1. of Plate CCCVI. represents the wheel-work of the movement and of the repetition, and all the pieces which are put within the frame-plates. There is a distinction here between the wheels,—those of the movement, or which serve to measure the time, as the wheels B, C, D, E, F, and those of the repetition, which serve to regulate the interval between the blows of the hammer: such are the wheels *a, b, c, d, e, f*, whose assemblage is called the little wheel work or runners.

The spring of the movement is contained in the barrel A; B is the great or fusee wheel; C the centre or second wheel, whose arbor prolonged carries the cannon pinion on which the minute hand is fitted and adjusted; D is the third wheel; E the fourth wheel; and F the cylinder, 'scapement, or balance wheel. The fusee I is adjusted on the great wheel B, a spring-tight collet and pin keeping the wheel to its place on the fusee; the chain is wound round on the fusee, and holds likewise of the barrel. The hook O of the fusee serves to stop the hand, on the watch being full wound up, by the hook stopping against the end of the guard de gut stop (the name it got before the chain was put to the fusee; the modern name of it is the fusee stop,) C (Fig. 2.) attached to the other plate; its effect is the same as in the plain watch. Fig. 3. of Plate CCCII. represents the cylinder 'scapement, of which a description has already been given in p. 484.

B is the balance fixed on the cylinder; F is the cylinder wheel, which is represented as tending to act on the cylinder, and cause vibrations to be made by the balance. None of the pieces are drawn here, such as the cock, slide, curb, and pendulum or spiral spring, as they would have rather made the 'scapement part obscure. The wheel work, or runners of the repetition, is composed of five wheels, *a, b, c, d, e*, and of the pinion *f*, and of four other pinions. The effect of this wheel work is to regulate the interval between each blow of the hammer; so that if the first wheel *a* is made to have 42 teeth, the second *b* 36, the third *c* 33, the fourth *d* 30, and the fifth *e* 25; and moreover, if all the pinions into which these wheels pitch have six leaves or teeth; then, in the time that the first wheel *a* makes a turn, the pinion *f* will make 4812½ revolutions; but the ratchet R, which the first wheel *a* carries, is commonly divided into 24 parts, the half of which are afterwards taken away, in order that there may remain only 12 to strike 12 blows for the 12 hours. If, then, we divide 4812 by 24, we shall have the number of turns that the fifth pinion makes for each blow of the hammer, which gives 200½ turns of the pinion *f* for one tooth of the ratchet R.

The first wheel *a*, or great wheel of the striking part, carries a click and a spring, on which act a small ratchet, put under the ratchet wheel R, which forms click and ratchet work, like what has been seen in the first wheel of the repetition (Plate CCCV. Fig. 1.) which has the same use; that is to say, when we push the pendant or pusher, the ratchet R retrogrades, without the wheel *a* turning; and the spring which is in the barrel B (Fig. 2.) bringing back the ratchet R, on whose arbor *g*, the inner end of the spring is hooked; the small ratchet comes butt against the click, and turns the wheel *a*; and the ratchet R makes the hammer M to strike, whose arm *m* is engaged with the teeth of this ratchet.

The spring *r* attached to the plate (Fig. 2.) acts on the small part *n* of the arm *m* (Fig. 1.) The effect of this spring is to press the arm *m* against the teeth of the ratchet; so that when we make the watch to repeat, the ratchet R retrogrades, and the spring *r* brings always back the arm *m*, in order that the teeth of the ratchet may make the hammer to strike.—Let us now pass on to the description of the motion work.

Plate CCCVI. Fig. 3. represents that part of a repeater which is called the dial or motion work. It is seen in the instant where the button or pendant is just pushed home to make it repeat. In first taking off the hands, and then the screw which fixes the dial of repeating watches, we will see the same mechanism that this Figure presents. This is the kind of repeating motion work most generally adopted; it is solid, and of easy execution. P is the ring or bow to which the pendant shank or pusher is attached, and this enters into the socket O of the watch case, and moves within it its whole length, in tending towards the centre. It carries the piece *p*, which is of steel, and fixed in the pendant shank, both composing the pusher; the under side is filed flat. A plate of steel fixed to the case inside, prevents it from turning round about, and permits it to move lengthwise only. The end part of the steel in the pusher is formed so that it cannot come out of the case socket, this being also prevented by the small steel plate.

The end of the piece *p* acts on the heel *t* of the rack CC, whose centre of motion is at *y*, and at whose extremity *c*, is fixed one end of the chain *s s*. The other end keeps hold of the circumference of a pulley A, put by a square on the prolonged arbor of the first wheel of the runners. This chain passes over a second pulley B.

If, then, we push the pusher P, the end *c* of the rack will describe a certain space, and, by means of the chain *s s*, will cause the pullies A, B to turn. The ratchet R (Fig. 4.) will also retrograde, until the arm *b* of the rack comes upon the snail L; then the main spring of the repetition bringing back the ratchet, and the pieces which it carries, the arm *m* will present itself to the teeth of the ratchet, and the hammer M will strike the hours, of which the quantity depends on the step of the snail, which is presented to the arm *b*.

In order to have a better idea of the effect and disposition of this repetition, it is only necessary to look at Fig. 4. where the rack *y c* is seen in perspective; the hour snail L, and the star wheel E; the pullies A and B, the ratchet R, the wheel *a*, the part of raising *m n* of the hour hammer; and these are the principal parts of a repetition, which are drawn as if they were in action.

The snail L is fixed to the star E by means of two screws; they both turn on the pivot formed from the screw V, carried by the all or nothing piece T R, moveable on its centre T; the all or nothing piece forms with the plate a sort of frame, in which the star and hour snail turn.—Let us now see how the quarters are repeated.

Besides the hour hammer M, there is another N, (Plate CCCVI. Fig. 1.), whose arbor or pivot comes up within the motion work, and carries the piece 5, 6 (Plate CCCVI. Figs. 3, 4.) The prolonged pivot of the hour or great hammer passes also within the motion work, and carries the small arm *q*: these pieces 5, 6 and *q*, serve to make the quarters strike by double blows. This is the effect of the quarter rack Q, which has teeth at the ends F and G, that act on the pieces *q*, 6, and cause the hammers to strike. This piece or rack Q is carried about by the arm *k*, which the arbor of the ratchet R has on it, by a square above the pulley A, in such a manner, that when the hours are repeated, the arm *k* acts on the pin G fixed in the quarter rack, and obliges it to turn and raise the arms *q* and 6, and consequently the hammers.

The number of quarters which the hammers must strike is determined by the quarter snail N, according to the depth of the steps *h*, 1, 2, or 3, which it presents: the quarter rack Q, pressed by the spring D, retrogrades; and the teeth of the rack engage more or less with the arms *q*, 6, which get also a retrograde motion, and are brought back by the springs 10 and 9: The arm *k* bringing back the quarter rack, its arm *m* acts on the extremity R of the all or nothing TR, the opening of which at *x*, traversing against a stud fixed to the plate, allows R to describe a small space: the arm *m*, coming to the extremity of R, this last pressed by the spring *i x*, is made to return into its place, so that the arm *m* rests on the end R, and by this the quarter rack cannot fall or retrograde, unless the all or nothing piece is pushed aside. The arm *u*, carried by the quarter rack, serves to overturn or set aside the raising piece *m*, (Fig. 4.) (which is moveable on the arbor of the hour hammer,) whose pin 1, comes up within the motion work; so that when even the hours and quarters are repeated, the quarter rack still continues to move a little way, and the arm *u* turns aside the raising piece *m*, by means of the pin 1, which comes within the motion work, and by this it is put from having any holding with the ratchet R, so long as the all or nothing TR does not allow the quarter rack to retrograde or fall; which can only happen in the case when, having pushed home the pendant against the snail, the arm *b* of the rack CC presses the snail, and makes it describe a small space, at the extremity R of the all or nothing: then the quarter rack will fall and disengage the becs or lifting pieces, and the hammers will strike the hours and quarters, given by the snails L and N.

The great hammer carries a pin 3, Fig. 4. which comes up to the motion work through an opening marked 3, Fig. 3.: the spring *r* acts on this pin, and causes the great hammer to strike: this hammer carries another pin 2, which passes also through to the motion work by an opening 2, Fig. 3.; it is upon this that the small tail of the raising piece *q* acts, to make it give blows for the quarters: the small hammer has also a pin which passes through to the motion work by the opening 4; it is upon this pin that the spring 7 presses, to cause the quarter hammer to strike. The spring S is the spring jumper, which acts on the star wheel, E.

Figure 6. represents the cannon pinion and the quarter snail N, seen in perspective. The quarter snail N is

rivetted on the cannon pinion *c*, the end of which D carries the minute hand; this snail N carries the surprise S, the effect of which is the same as that for the repeating clock; that is to say, when the pin O of the surprise shifts the place, or causes the star to advance, and the jumper having done turning it, one of the teeth of the star comes to touch the pin O which is carried by the surprise, and causes the part of the surprise Z, Fig. 3. to advance, so that when the arm Q of the quarter rack falls on this part Z, and prevents it from falling on the step 3 of the snail; by this the piece repeats only the hour. The changing from one hour to another is by this way made in an instant, and the watch strikes the hour exactly as marked by the hands. The socket or cannon of the cannon pinion *c* D, Fig. 6. is slit, in order that it may move spring tight on the arbor of the second wheel, on which it enters with a degree of stiffness or friction, slight enough to be able to turn easily the minute hand to either side, by setting it back or forward according as it may be required, which sets also the hour hand to the hours.

It is proper here to undeceive those who think that they injure their watches in setting the minute hand backward. In order to convince one's self that there is nothing in this, it is sufficient to remark the position which the pieces must have in a repeating motion work, when it has to repeat the hour, when the pendant or pusher has brought back and set aside all the pieces which communicate with the snails L, N; for at this time there is no communication or connection between the pieces of the movement and those of the motion work, but that of the pin O of the snail or surprise, with the teeth of the star wheel E, which nothing can prevent from retrograding. If then the minute hand is made to make a complete turn backward, the pin O will also make one of the teeth of the star to retrograde; and if the watch is made afterwards to repeat, it will strike always the hours and quarters as marked by the hands. But it must be observed, that if the hands were turned in the same instant that the watch is made to repeat, they would then be prevented: it is necessary then, before touching the hands of a repeating clock or watch, to wait till it has repeated the hour, so that all the pieces shall have taken their natural situations.

It is easy to conclude from this, that since with a repeating watch, we can set backward or forward the minute hand, according as it may be required, we may with much greater reason do this in a plain watch, where no obstacle is opposed to it.

As to the hour hand of a repeating watch, it ought never to be turned without that being done by the minute hand alone; except in that case where the repeater does not strike the hour marked by the hour hand, when it would be necessary to put it to the hour which the repeater strikes.

When the repeater gets of itself deranged, by the hour hand not according with the hour which the watch strikes, this is a proof that the jumper S, or the pin O of the snail, do not produce well the effect they ought to have.

The returning or minute wheel, Fig. 6. is placed, and turns on the stud 12, Fig. 1.: this wheel pitches into the cannon pinion N, which has twelve teeth; the wheel, Fig. 6. has thirty-six; the cannon pinion then makes three turns whilst it makes one; this carries a pinion of ten teeth, which pitches or leads the hour wheel, Fig. 7. which has forty; the wheel, Fig 8. makes then four turns for one of the hour wheel; the cannon pinion consequently makes twelve turns for one of the hour wheel, and the cannon pinion makes one turn in an hour; the hour wheel takes then twelve hours to make one revolution; it is the socket of the hour wheel which carries the hour hand. The raising or lifting piece *m*, *n*, Fig. 2. can only describe a small arc, which permits the ratchet R to retrograde; and so soon as the mover brings it back, the arm 1 of the raising piece draws the hammer M.

Figure 5. represents the under side of the all or nothing, with the two studs; one *u* as a centre on which it moves, and the other *x* on which the star and snail turn, Fig. 9.: the hole *c* of this piece allows the square of the fusee of the movement to come through, and lastly, passing through the dial, serves for winding up the watch. W, Fig. 3. is the locking spring and bolt; this is what prevents the movement from opening out of the case.

Y is a small cock or bridge which keeps the rack to its place, and prevents it from getting away from the plate, permitting it to turn only on its own centre.

All the parts of the repetition or motion work, which have been described, are placed on the back of the pillar plate, and are covered by the dial; so that between the plate (Fig. 3.) and the dial there must be an interval, to allow sufficient play for the motion-work: It is for this purpose that a piece is destined, which is not represented here, and which is called the brass edge. This is a sort of circle, or ring, into which the circumference, or edge of the pillar plate, is sunk a little way, with which it is kept fast by means of keys, or griffs 13. and 14. The brass edge is covered by the dial, fixed after that of the brass edge, by means of a screw.

A repeater is made to strike the hour which it indicates the moment we press in the pendant; so that the machine must be contrived in such a way, that it may be easy to push in the pendant, and that the blows of the hammers may be the strongest possible. With respect to the first, that depends on two things; the given force of the spring, and the length of the pusher; that is to say, the space described, and the manner of making the pusher act on the rack. With regard to the last, the rack must be placed in such a manner, that the point of contact of the pusher follows the arc described by the rack, in such a way that the force shall not be decomposed, so that the action of the hand on the pusher shall act wholly upon the rack.

With regard to the pusher, its length depends on the point where it acts on the rack; that is to say, according as it acts farther or nearer the centre of motion. It is obvious, that if it acts near the centre, more force is required, and it will describe a less space, and *vice versa*. As to the force of the blow of the hammer, it is limited by the force of the repeating main-spring, and by the force that the runners require to move or keep them in motion; for it is clear, that it is only the excess of the force of the spring over the resistance of these wheels that can be employed to raise the hammer. The number of blows of the hammer, for one revolution of the ratchet, determines again the force of the blow.

## CHAP. IX.

### *On Compensation Pendulums.*

Compensation Pendulums are those which are constructed to counteract the effect of heat and cold, in lengthening or shortening a pendulum rod.

Godfroi Wendelinus, Canon of Condé in Flanders, who published a dissertation, in 1626, on the obliquity of the ecliptic, seems to have been the first who observed that, by change of temperature, metals changed their lengths.

Graham was the first person who thought of making a pendulum rod that should conteract the effects of heat and cold on it, by a combination of rods or wires of different metals, such as brass, silver, steel, &c ; but he never put it in execution, from the opinion that it would not be effectual enough in its operations. It occurred to him at the same time, that mercury, from its great expansion by heat, would be more adapted to the end he was in pursuit of. Having made a pendulum on this principle, it was applied to a clock, and set a-going. It is described in the *Philosophical Transactions*, No. 392, in a paper which was given into the Society in 1726. He says, " the clock was kept continually going, without having either the pendulum or the hands altered, from the 9th June 1722, to the 14th November 1725, being three years and four months." Some time previous to 1726, Harrison, being then at Barrow in Lincolnshire, was engaged in making experiments on brass and steel rods with the same view, and produced what is now called the " Gridiron Pendulum." See *Description of two Methods*, &c. by John Ellicott, F. R. S. London, 1753.

Some estimate may be formed of the advantages of a compensation pendulum, by comparing the going of a clock which had one with that which had a simple pendulum, as shewn in a letter from Mr Bliss, at Oxford, dated 12th July 1752, to Mr Short, in London. " I find, upon examining my book, that the greatest difference in the going of the clock, between the coldest weather of the two last winters and the hottest weather of the two last summers, is no more than one second per day; and this was occasioned by the levers being made too short, of which I advised Mr Ellicott above a year since: Whereas a clock with a simple pendulum and brass rod, made by Mr Graham, and which belongs to Dr. Bradley, in the coldest weather, lost above fifteen seconds per day, and in the warmest gained above thirteen seconds per day, and went very near the equal time in temperate weather." It is plain that Mr Bliss must have meant *gained* in the coldest weather, and *lost* in the hottest, otherwise there would be no analogy with the effect of the temperature in summer and winter on the brass pendulum rod. See Ellicott's pamphlet, already quoted.

### *Graham's Mercurial Pendulum.*

The mercurial pendulum, invented by Graham, having been the first that was applied to a clock for the purpose of compensation, we shall begin with the description of it, taking the others nearly in the order of their invention. This pendulum consists of a pendulum rod, which carries a large glass jar filled with mercury, so that the expansion or contraction of the rod may be counteracted by the opposite expansion or contraction of the mercury. To make this pendulum in the way which has hitherto been adopted, is attended with considerable trouble. From the nature of the material, the construction of such a pendulum must always be troublesome, because any filling in, or taking out of the mercury from the cylinder or glass jar, to bring about the compensation, will cause a change of place in the index point on the graduated arc or index plate, if such a thing is used. A pendulum which will remedy this evil will be afterwards described, so that we shall now proceed to give a description of one made in the common way.

The length of the pendulum over all, from the bottom of the sole to the upper end of the pendulum spring, was 43.95 inches; the inside bottom of the jar, .6 of an inch from the bottom of the sole ; and the height of the column of mercury in the jar, about 7.47 inches. From the upper end of the spring, take a length of 39.2 inches on the pendulum downwards, then 43 95 inches — 39.2 + 6, will give that part of the column of mercury below the centre of oscillation equal to 4.15 inches, and that above the centre 3.32 inches. The height of the jar outside, was 7.8 inches ; a wire put down inside measured 7.6 inches ; mean diameter inside, 2.018 inches ; weight 7.5 ounces. Although it would be still better to have it of a less weight, yet it is doubtful if it would be then strong enough to support such a column of quicksilver. The weight of the stirrop or cylinder frame was 1lb. 6 ounces, and was reduced 6 ounces ; that is, from the sole was taken 2.55 ounces, and from the top 3.45 ounces, both equal to 6 ounces. When the clock was set a-going after this alteration, with the pendulum the same length as before, it went slow, at the rate of 46 seconds in 24 hours, and when shortened by touching up the regulating nut, it was found to be about .15 of an inch less than the former length.

The length of the stirrup bars outside, including sole and part of the top, was 8.125 inches ; the breadth of the frame from outside of the bars, 3.25 inches ; the thickness of the pendulum rod and bars, 0 136 inch ; breadth of ditto, 0.384 inch ; thickness of sole outside, 0.515 of an inch ; distance from bottom of the sole to upper side of the jar cover, 8.187 inches ; jar sunk into the sole about or near to 0.25 inch ; distance from upper side of jar cover to under side of stirrup top, 1.25 inch ; height of stirrup top for flat of pendulum rod, 1.75 inch ; thickness of the flat, 0.220 inch ; diameter of the regulating screw, 0.218 inch ; ditto of the nut, 1.150 inch. The screw had 36.25 turns in an inch ; and the nut was divided into 30 prime divisions, each being equal to a second in a day. The prime divisions were subdivided into four.

| | Inches. |
|---|---|
| Length of stirrup bars inside | 8.05 |
| Thickness of sole outside | 0.515 |
| Length of stirrup top | 1.75 |
| From the stirrup top to the upper end of the pendulum spring | 33 485 |
| Length of the pendulum over all | 43.800 |

| | Inch. |
|---|---|
| Length of pendulum spring | .625 |
| Breadth of the double laminæ, including 164, the space between them, each lamina being .168 | .500 |
| Thickness of ditto | .007 |

| | lb. | oz. | drams. |
|---|---|---|---|
| Weight of quicksilver in the jar | 11 | 12 | 5.35 |
| Ditto of stirrup frame | 1 | 0 | 0 |
| Pendulum rod and spring, regulating nut, jar cover, &c. | 0 | 13 | 0 |
| Jar | 0 | 7 | 8 |
| Total weight of pendulum | 14 | 0 | 13.35 |

Before the pendulum was altered, the rate of the clock shewed that the compensation was not sufficiently effective, although the height of the column of mercury was 7.5 inches nearly, and the jar being full allowed no more to be put in: By reducing the weight of the jar frame or stirrup, the rod required to be shortened, as has been stated, .15 of an inch; whether or not this will be enough, remains to be determined. The daily rate for a month or six weeks was 0″.1 slow, when the temperature was from 36° to 40° of Fahrenheit's thermometer, and got gradually slower as the height of the thermometer increased. When between 60° and 66°, the daily loss was from 0″.37 to 0″.45 ; for about two weeks, when the weather was extremely cold, the thermometer at the freezing point and under, the clock showed a tendency of rather gaining.

Of late years, the mercurial pendulum has been adopted in some astronomical clocks, and it seems upon the whole to answer very well. The author of the *Elements of Clock and Watch-work* thought that it was not fit for this purpose, being too quick in its operations of expansion and contraction; but if the cover is well fitted to the top of the jar, we can venture to say, from the resistance made by the glass to any change of temperature, that the operations will be too slow; and for this reason, it is proposed to make such a pendulum with a thicker rod and stirrup bars, that they may not take heat and cold too hastily. A steel jar would perhaps answer the end as well as any other contrivance; but some would object to this, on account of the danger of magnetism. But even a jar of this kind, from its being made thin, (for it would be heavy were it as thick as the glass one,) would be easily affected by the changes of temperature; and mercury being still more susceptible of these changes, the operations of counteracting the effects of them might be too sudden.

It is of great importance that a pendulum-rod should, with the smallest quantity of matter, be as stiff and inflexible as possible; and although it was proposed to have thicker bars and rods, let us suppose the same quantity of matter is taken as before, but under a circular in place of a rectangular surface. It must in this form require more time to get heated and cooled, which is the end we now attempt to gain. The sides of the parallelogram were .384 and .136 of an inch, the sum of which, being doubled, will give 1.040 inch for the circumference of the bar. To find the diameter of a cylindrical rod containing the same quantity of matter as the parallelogram, say, as 355 is to 113, so is 1.040 to the diameter of the rod required, which will be found to be .33104 of an inch.

Let the improved jar frame, or stirrup, therefore, be composed of two round steel rods, .331 of an inch in diameter, and 8.85 inches in length, from shoulder to shoulder, at each of which pivots are formed. Those for the upper ends should be a quarter of an inch long, and of the same diameter, tapped so as to screw firm into the upper cross piece. The distance from the centres of the tapped holes, in the traverse or cross piece, requires to be 2.8 inches, in order to give freedom for the jar between the rods, the length of the cross piece over all should be 3.3 inches, and its breadth at the place where the rods are screwed in .450 of an inch. At the middle a circular part is formed, .5 of an inch in diameter, in the centre of which a hole is tapped, by which the regulating screw may raise or lower the jar, without changing the place of the index point. The cross piece may either be brass or steel, though the latter is perhaps preferable. The pivots on the lower end of the rods may be of the same diameter as those on the upper end, but a little longer, and tapped a little way in on the ends; when well fitted into the lugs of the brass sole, on which the jar rests, and sunk a little way down into it, nuts are screwed on to the ends of the pivots, and sunk in the lower side of the brass sole. Care must be taken to have the distance between the centres of the holes in the sole the same as in the cross piece, so as to make the rods stand parallel to each other. To go outside of the frame now described, another is made, to which is attached the pendulum rod, the regulating nut, and lower sole, in which is fixed the small steel index, which cannot change its place, after being once made for it. The upper cross piece for this may be of the same thickness as the former, and in length not less than 4 inches. A hole is tapped near to each of the ends, and their centres are distant from one another 3.56 inches nearly, and are wide enough to allow a round steel rod of .25 of an inch in diameter to pass freely through; the length of these rods, from the lower side of the cross piece, to the upper side of the lower sole, is nearly 10.6 inches. The lower sole may be a brass wheel, crossed into four arms, the centre part being large enough to have a hole tapped, so as to fix the steel index in it. The diameter of the wheel is the same as the length of the upper cross piece, which is 4 inches; and the thickness .25 of an inch, or a little more. This sole, in which the index is fixed, serves also as a resting part for the pendulum, when it happens to be taken from its place. The upper ends of the rods are formed into a sort of double shouldered screw; the tapped part is a little more than a quarter of an inch long, and as much in diameter; the length of the plain and tapped part of the screw is about .7 of an inch, and when screwed into the upper cross piece, it binds to it the lower end of the pendulum rod, which is formed into a shape something like a compressed $\lambda$, having lugs or soles, through which the screws for fixing it passes. The regulating screw has an untapped or plain part, which turns freely in a hole in the middle of this upper cross piece, formed in the same way as the upper cross piece for the jar frame; the nut or head of the regulating screw is shaped so as to lie under the hollow of the $\lambda$, at the lower end of the pendulum rod, and on the upper side of the cross piece; the lower ends of the rods of the outside frame are gently tapered, and fitted into holes in the brass wheel, through the edge of which are put pins to fix them and the wheel together; this outside frame has no part in the compensation. The brass cover for the jar has the lugs hollowed out a very little, so as to come in on the rods of the jar frame; the ends of the upper traverse, of which, as well as the lugs of the jar sole, are hollowed, and take in with a part of the rods of the outside frame, along which the jar frame is moved up and down. The height of the glass jar, outside, is about eight inches; and its weight and other dimensions nearly the same as those stated for the former pendulum; and the diameter of the rod and $\lambda$ part is .331 of an inch. A view of the improved mercurial pendulum is given in Plate CCCVII. Fig. 1.

Philosopers seem not to be agreed respecting the expansion of mercury relative to that of other metals; some making it 15 times, others above 16 times that of iron. In regard to the column of mercury for a mercurial pendulum, something depends on its diameter, as well as its height. Suppose the length of steel to be 43 inches, and the column of mercury 7.5 inches in height, and 2 inches in diameter, which were the dimensions used in a pendulum brought nearly to its state of compensation, we may then find how many times the expansion of this column is contained in the 43 inches. Say, as 43 inches is to 74, the expansive ratio of steel, so is 7.5 inches of mercury to its expansion for compensating the steel.

| | | |
|---|---|---|
| Length of steel 43 inches . . . . . | Log. | 1.6334685 |
| Ratio 74 . . . . . . . . . . . | Log. | 1.8692317 |
| | | 3.5027002 |

| | | |
|---|---|---|
| Height of column of mercury 7.5 inches | Log | 0 8750613 |
| Ratio 424.26 . . . . . . . . . . | Log. | 2 6276389 |
| | | 3 5027002 |

By this process, it appears that the expansion of the mercury is not quite 5.75 times that of the steel. A pendulum, whose vibrations are three or four degrees on each side of the point of rest, will require a column less in height than that which vibrates only one degree. Hence it is a very nice matter, to give precise rules for making a mercurial pendulum, that shall at once be perfect in its compensation.

If the steel rod *a b* and stirrup *b c* of a mercurial pendulum is lengthened by heat, the jar *d e* containing the mercury will, from this cause, be let lower down, and the centre of oscillation be carried farther from the point of suspension *a*; but the heat which lengthens the rod and stirrup, at the same time expands the mercury upward, and by this means the centre of oscillation is kept always at the same distance from the point of suspension, Fig. 1. When the rod and stirrup are contracted or shortened by cold, the mercury will also be contracted by it; and hence the lengthening or shortening of the pendulum rod by heat or cold, is compensated by equal and opposite expansions or contractions in the mercury.

*Gridiron Pendulum.*

The gridiron pendulum invented by Harrison, is composed of nine round rods, five of which are made of steel, and four of brass; and is represented in Plate CCCVII. Fig. 2. where the steel rods are distinguished from the brass ones by a darker shade. As it somewhat resembles the common gridiron in appearance, it hence probably received its present name. Not many years after this was produced, the French artists contrived a variety of compensation pendulums, but the gridiron seems to be the one now generally adopted by them. The first pendulum of this kind which we made was nearly thirty years ago; and knowing that Mr Cuming had some practice in this way, he was applied to, and very obligingly sent a drawing, and the different lengths for the brass and steel rods, which, on being tried some years afterwards, by means of a transit instrument, was found, on the whole, to be tolerably correct, but yet not quite so accurate in the compensation as could have been wished. From an abstract of the going of a clock with this pendulum, it appeared, that, during the temperature from 46 to 48 degrees of Fahrenheit's thermometer, it kept mean time. A temperature 10 degrees lower, made it gain at the rate of nearly half a second in a day, and 10 degrees higher made it lose about as much.

The lengths of the rods were, outside steel rods from pin to pin 29 5 inches; centre steel rod from upper end of the pendulum spring to the pin at the lower end, 31.5 inches; inside rods, from pin to pin, 24.25 inches; from the pinning of the lower end of the outside rods to the centre of the ball, 5 inches; making in all 90 25 inches of steel, to be compensated by the brass. Outside brass rods, from pin to pin, 26.87 inches; inside ditto, 22 25 inches, being in all 49.12 inches of brass. The length which the brass ought to have may thus be found by the inverse rule of proportion. As 90.25 inches is to 74, the number for the expansion of steel according to Berthoud, so is 121, that of the expansion for brass, to the length of brass required; that is, $90.25 \times 74 \div 121 = 49.4$ inches, the length required. Although the deficiency of brass here is very little, yet to remedy the compensation, a greater number of inches, both of steel and brass, must be taken, before this pendulum can be made complete. A description of such a one shall now be given.

The length of the outside steel rods, from pin to pin in the uppermost and lowermost traverses or brass cross pieces *a b*, *c d*, is 36 inches; the next or innermost steel rods, from their pinning in the second uppermost traverse *m*, to that in the second lowermost *n*, is 35 inches; the steel centre rod, from the pinning of it, in the third lowermost traverse *o*, to the upper end of the pendulum spring, is 37 inches and $\frac{5}{8}$ of an inch, or nearly 37.628 inches; the centre C of the ball below the pinning of the outside steel rods and index rod, is 3.94 inches; the outermost brass rods, from their pinning, in the uppermost traverse to that in the second lowermost, is the smallest quantity possible less than 35.5 inches; the innermost brass rods, from their pinning in the second uppermost traverse to the third lowest one, is 34.5 inches. The whole length of the steel is then 112.568 inches, and that of the brass 70 inches. The diameter of the rods is a quarter of an inch each. The distance from the centres of the two outside steel rods, is 2.5 inches. The rods are placed equidistant from one another, only there is a little more space left between the two brass rods nearest the centre and the steel centre rod, in order to give room for the fork to come in and clip the centre rod. The two outside steel rods are prolonged below their pinning in the lowest traverse, as seen below *c d*, about five or six inches within the ball, in order to keep it properly flat in the plane in which the pendulum should swing. In the centre of the lowest traverse *c d* is pinned a steel rod *e f*, somewhat more than a quarter of an inch in diameter, and about nine inches long. This rod goes through the centre of the ball, the index point *f* being on the lower end of it, and it is tapped for an inch in length at that part which lies near to the centre of the ball. A cross piece of brass is fixed to the inside of the ball before casting it, the lowest side of which is in a line across the centre horizontally. The ends of the two outer steel rods, and the centre or index rod, come easily through this cross piece of brass. A hollow tube comes up within the ball, as far as the under side of the inside cross piece, on the end of which, where the cross piece and ball rest, is fixed within it a tapped nut, which screws on the tapped part of the index rod. On the lower end of the tube is soldered a sort of flat conical head or nut *h*, nerrelled on the edge outside, and whose diameter may be an inch or an inch and a quarter. On the upper surface of this nut are traced two circles, in order to put divisions between them, and figures so as to correspond with the turns of the screw in an inch. A small steel index *i* is screwed on to the lower part of the ball, to point at these divisions. The lower end of the tube is a very little below the edge of the ball, that it may rest freely on the upper end. The total length, from the upper end *g* of the pendulum spring to the index point *f*, is 47.75 inches, a length of radius which will require the length of a degree on the index plate to be .833142 of an inch. The distance from the upper end of the pendulum spring to the centre of the ball, is 42 5 inches very nearly, so that the centre of the ball is about 3.3 inches below the centre of oscillation. The lowermost traverse *c d* may be about half an inch thick, and its length and breadth such, as to give it sufficient strength to receive the outside steel rods, and the centre or index rod: The uppermost traverse *a b* is nearly of the same dimensions. The second lowermost traverse *n*, and the second uppermost *m*, are nearly of the same size, and almost equal to that of the uppermost and lowermost; only they are a little shorter, having in their ends a sort of half hole, through which, in the second lowermost traverse, the outer steel rods pass easily; and through these, in the second uppermost traverse, the outside brass rods freely pass. This traverse is, of course, a little shorter than the second lowermost. In the second lowermost traverse is pinned the ends of the outermost brass rods, and in the second uppermost traverse are pinned those of the innermost steel and brass rods. In the third lowest traverse is pinned the innermost brass rods and the centre steel rod: The dimensions of this are nearly the same as the second uppermost and lowermost, only shorter, having a half hole at the ends, through which the inner steel rods pass freely. There is a hole in the middle of each of the two uppermost traverses, through which the centre rod can pass freely. Towards the lower ends of the centre steel rod, and those of the innermost brass rods, are two sets of holes, by which the third or lowermost traverse can be moved or shifted up either three or six inches, should the compensation be found in excess. It would be convenient, when shifting, to have a piece similar to the third lowest traverse, and three spare pins. This piece being like a half of the traverse, it may then be applied to the three rods, and pinned, but not to the place where the shifting is to be made. This piece will prevent the rods shifting away from one another, and will allow the traverse to be moved and fixed to the intended place. Two thin pieces of brass *p q*, *r*, *s*, must be provided, having nine holes in them, so that all the rods can move easily through them, the two outermost holes being kept rather a little tighter than the others. These pieces are intended to prevent any tremulous motion in the rods or pendulum, and are put at the same distance from the upper and lower traverses, as shewn in the figure. The pendulum ball is composed of two frustums of equal cones; the greater diameter is seven inches, the lesser four inches, and the height half an inch, giving, by calculation, 24 3474 cubic inches, the weight of which in lead is 9.997 lb. The ball, when filled with lead, together with the shells and inside cross piece, weighed 10 lb. 8 oz.: The weight of the brass and steel rods, traverse pieces, pendulum spring, and top piece, &c. was 5 lb. 13 oz.; in all, 16 lb. 5 oz. The clock to which this pendulum was applied was a month one, and was kept going by a weight of 7 lb. 7 oz. We cannot help thinking, that this pendulum is fitted up in a much better style than either Cuming's or Berthoud's.

The third lowest traverse being shifted up three inches, there will then be this quantity less for lengths of brass and steel than has been stated. The steel will be 36+35+37.628+3.94—3=109.568 inches, and the longest brass rods may be taken at 35.49+34.5—3=66.99. Their lengths and expansive ratios may be given thus:

| | |
|---|---|
| Steel 109.568 inches . . | Log. 2.0396838 |
| Ratio 74 . . . . . . . | Log. 1.8692317 |
| | 3.9089155 |
| Brass 66.99 inches . . . | Log. 1.8260100 |
| Ratio 121 . . . . . . . | Log. 2.0827854 |
| | 3.9087954 |

The difference in excess of compensation is here extremely small, and is on the side of the steel rods, being scarcely an inch too much. In taking into account the lengths of the rods, those on one side along with the centre rods are only taken; those on the other side serve as a kind of counterpoise, for giving an appearance of uniformity to the pendulum, and for preventing the weight of the pendulum ball from bending the rods, which it would do, were they all on one side. A considerable time after the gridiron pendulum was produced, some adopted zinc rods in place of brass; and, from their greater expansibility, fewer were requisite, three of steel and two of zinc being sufficient for the compensation; but such of them as we have seen, appeared to have the zinc rods of a greater length than they should have been, according to the comparative expansions of zinc and steel. There was also a large cavity in the upper part of the ball, for lodging the lower traverse, which took away much of its force; and the holes for shifting, to adjust the compensation, being at the upper ends of the rods, rendered it very inconvenient.

The following dimensions should answer very well for a pendulum of this sort. The length from pin to pin in the upper and lower traverses of the two outside steel rods should be 27 inches, and 5 or 6 inches more beyond the lower traverse, to go within the ball, for the same purpose that was mentioned in one having the brass rods; from the pin, in the lower end of the centre steel rod, which is in a traverse just above the lower one, to the upper end of the pendulum spring, should be 36.75 inches; from the pin in the lower end of the centre rod to the centre of the ball, 4.75 inches, being in all 68.5 inches of steel. The diameter of the steel rods should be .25 of an inch. In the upper traverse is a hole, through which the centre rod must pass freely. The length of the zinc rods, from the pin in the upper traverse to that in the upper of the lower traverses, is 25.34 inches, and their diameter .27 of an inch. There may be holes in the lower ends of the centre and zinc rods, for adjusting the compensation, as in the case of the brass rods. The ends of the upper and lower traverses must have half holes, taking in with the outside steel rods; pieces for tremulous motion, and manner of fitting up the pendulum ball, and regulating nut, &c. as has been already described.

The lengths and expansive ratios may be put thus:

| | |
|---|---|
| Steel 68.5 inches . . . . . . | Log. 1.8356906 |
| Smeaton's ratio for steel 138 inches | Log. 2.1398791 |
| | 3.9755697 |
| Zinc 25.34 inches : . . . . . | Log. 1.4038609 |
| Do. for zinc 373 inches . . . . | Log. 2 5717088 |
| | 3.9755697 |

The zinc which is used in these pendulums must always be understood to be that which is hammered half an inch per foot, which seems to have even more expansion than Smeaton has stated; but whether it expands as much as Ward makes it, still remains to be determined.

In taking into account, by this process, the comparative expansion of the brass and steel rods, it must be observed, that the steel rods have their expansion downwards, while the brass rods expand upwards; so that when heat expands the steel rod downwards, the brass rods acting in a contrary direction upwards, tend always to keep the centre of oscillation at an equal distance from the point of suspension; and hence the length of the pendulum is constantly the same. In like manner, if cold contracts the steel rods, it will also contract the brass rods, so as still to keep the pendulum at as invariable a length as can possibly be attained by any method that human ingenuity can propose. The comparative lengths of the brass and steel rods may be computed by any other expansive ratio than those of Berthoud's, which we have used; such as those of Smeaton, or of that ingenious artist Troughton. Their differences will vary a little from Berthoud's; but it will be very trifling. It will require long experience to know which are the best founded, as the going of astronomical clocks may be affected by other causes which have no connection with the compensation of the pendulum rod.

### *Ellicott's Pendulum.*

Not many years after Harrison's pendulum was known, Mr Ellicott, and some of the French artists, contrived compensation pendulums in different ways, most of them having the ball adjustable by levers, which can never be equal to those in which the expansion and contraction act by contact in the direct line of the pendulum rod. Mr Ellicott was a very ingenious artist of the old school, as appears from several of his works, and his pendulum evinces great ingenuity in its construction.

Ellicott's pendulum, shewn in Plate CCCVII. Fig. 3. consisted of two bars, one of which *a b* was of brass, and the other of iron or steel. Mr Cuming conceived, that where there were two bars only, a flexure and unequal bearing would take place, and therefore an exact compensation could not be effected. To remedy this, he constructed the pendulum with two steel bars and one bar of brass, as shewn in Fig. 4. No. 3. Into the lower end of the brass bar *a b*, Fig. 4. was let one half of the diameter of a small steel roller *r*, the other half being let into a moveable brass piece having two short arms 1, 2. These arms, by the levers *m o* 2, *n o* 1, moving round *o*, *o* as fulcra, make the roller press equally on the lower end of the brass bar. The steel roller marked *r*, has a fillet raised up on each end, for the purpose of keeping this part of the brass bar at an equal distance from the steel bars. The length of the brass bar *a b* should be 39 25 inches from the upper end, which is square, to the lower end, which is rounded, its breadth three quarters of an inch, and its thickness at least one-eighth of an inch. The steel bars are in length, from the upper square ends to the centre of the ball, nearly where the short arms of the levers act on the moveable brass piece, about 39.75 inches; and the bars are left broader here, so as to be about one inch and a quarter; and this breadth is prolonged below the end of the brass bar three quarters of an inch or more. The thickness of the steel bars is one-tenth of an inch, and their breadth three quarters. The back steel bar has no opening in it; but the front bar has one, which is represented in the drawing at A, Fig. 4. No. 2. In order to see the action of the levers on both arms of the moveable brass piece, a cavity *s s*, Fig. 3. is left for this purpose in the ball. A piece of glass is inserted in the opening, so as to prevent dust from getting into this part of the pendulum. This broad part of the steel bars serves as a kind of frame, on which are screwed two pieces of brass of the same figure as the steel bars, to connect them with that steel part of the lower end of the pendulum rod which goes through the ball, on which is a nut and screw, and a strong double spring *m n* in Fig. 4. for the purpose of taking off somewhat of the weight of the ball, according as it bears too much or too little on the short arms of the levers. The levers are shewn at No. 2, 3; the screws, and lower end of the pendulum rod in Fig. 4; the nut N, and double spring SS, in Fig. 3. The use of the nut and screw is to adjust the strength of the spring, as they have nothing to do in the regulation of the pendulum for time to the clock, which is done by an apparatus for this purpose at top, connected with the pendulum spring. In the brass pieces which are screwed on to the broad part of the steel bars, the pivots of the levers *a*, *a* turn. There is a piece of brass put on at top, formed so as to interpose a little way down between the brass bar and the steel ones, keeping them at a proper distance from one another. The sides near to the square ends of the bars and this piece of brass are firmly pinned or screwed together. It is in this piece of brass that the lower end of the pendulum spring is fixed; the upper end being fixed to a piece, which is moveable up and down in a fixed frame by a nut and screw. The pendulum is lengthened or shortened, according as the pendulum spring is let out or brought within that part of the frame through which the spring passes. The bars of the pendulum are connected by four or five screws, equal spaces being taken for their places between the centre of the ball and the square or upper ends of the bars. The back bar is tapped to receive the screws, which go through holes made in the front steel bar, to let them easily pass. On the shank or body of the screws, are fitted hollow cylinders either of brass or steel, and of such a length, that when the screws are put home there shall be no pinching of the front steel bar by the head of the screws. Rectangular openings are made in the brass bar, for the hollow cylinders to come through, whose length may be about equal to twice the diameter of the cylinders, and so that the brass bar may easily move on them, by any small motion they may have in contracting or expanding. On each of these cylinders is put two loose brass collets or washers, one between each steel bar and the brass bar to keep them free of each other. Their thickness should be at least .04 of an inch, so as to allow the air to pass freely between the bars. The small hollow cylinders through which the screws pass when connecting the bars, should go easily into the front steel bar, the lower base bearing on the inside of the back steel bar. The upper base should be above the surface of the front bar fully more than the thickness of strong writing paper, so that when the screw is put home the shoulder of it may not pinch the bar. The edges of all the bars should be chamfered off from each side, so as to form an angle in the middle plane of their thickness, for the purpose of giving them a lighter appearance, and making them less susceptible of the resistance of the air. The diameter of the pendulum ball may be seven inches and a half, and its thickness at the centre about two inches and a quarter. In the edges, and in the line of the diameter horizontally across, are placed two long and stout screws, *g g*, Fig. 3. whose heads have graduated circles on them, and are near the edge of the ball, and an index *i*, *i* to each. The inner ends of the screws shewn at *s*, *s*, are turned of such a shape, so as to apply by one point only on the long arms of the levers *m*, *n*, as seen in Fig. 3. The front shell of the pendulum ball is fixed on by four screws. It has been objected by some, that, from the weight of the ball, the brass rods in a compensation pendulum are compressed, and the steel rods stretched; a matter of no moment whatever, in our opinion. This may, however, in some degree, be remedied in Ellicott's pendulum, by making the brass bar of such a length, as to come through and below the lower edge of the ball, in place of the steel part, which was common to both steel bars, as has just now been described. This part of the brass bar is tapped, having on it the nut and strong double spring, which takes off a part of the weight, as has been noticed. A certain portion of the weight of the ball will in this case bear on the brass bar; supposing it one-third of the weight, the remaining two-thirds will be carried jointly by the steel bars. Although the brass bar is here carried through the ball, it is easy to put a piece to it, moveable on a pivot in the middle of the bar, having two lugs applying to the edges of the bar, on which the short arms of the levers *a*, *a* may act, as was the case in the other by the moveable brass piece.

Things being in this situation, let us suppose that the bars composing the pendulum rod are lengthened by heat, and that the brass lengthens more than the same length of steel does; then the brass bar *a b*, by its excess of expansion, will press down the short ends of the levers, *m*, *n* at *b*, and consequently raise up the ball, which, by the screws *s*, *s*, rest on the long arms *m*, *n* of the levers; and provided the ends of the screws press on the levers at a proper distance from the centres *o*, *o*, the ball will be always kept at the same distance from the point of suspension, notwithstanding any alteration the rod of the pendulum may experience from heat or cold. What this distance ought to be may very nearly be determined, if the difference of the expansion between brass and steel is known; for the proportion which the shorter arms of the levers ought to bear to the longer ones, will always be as the excess of the expansion is to the whole expansion of the steel. Instead of the brass heads of the screws being placed near the outer edge of the ball, they may be more advantageously placed within the ball, at the distance of about an inch and a quarter from the edge, as shewn in Fig. 3.

See *Phil. Trans.* 1751, p. 479, and a pamphlet which Mr Ellicott published in London 1753. For an account of the improvement made upon it by Mr A. Cuming, see his *Elements of Clock and Watchmaking*, p. 107.

*Smeaton's Pendulum.*

Mr Smeaton's compensation pendulum consists of a glass rod AB, half an inch or more in diameter, and 45.5 inches long. To the upper end is fixed the pendulum spring; to the lower a screw *s* and regulating nut *n*. A brass tube or ring *m*, Fig. 5. of an inch or so in length, is put to move easily on the lower end of the rod, having a fillet at each end, one bearing on the regulating nut, the other supporting the zinc, iron, and lead tubes, which compose what may be called the pendulum ball. The zinc cylinder or tube is $12\frac{1}{4}$ inches in length, $\frac{1}{8}$th of an inch thick, and fits easily on the glass rod, the lower end resting on the upper fillet of the brass ring. On the zinc tube is put another of iron, 12 inches long, and $\frac{1}{8}$th of an inch thick, easily moveable on the zinc tube, with a kind of bottom to it, in which is a hole for the glass rod to go freely through. The bottom is uppermost, and rests on the upper end of the zinc tube. The lower end of the iron tube has a fillet on its outside, on which rests a leaden tube of 12 inches long, and $\frac{1}{4}$th of an inch thick, and which goes easily over on the iron tube. The outside diameter of the leaden tube will be nearly two inches. Although this pendulum will not be thought elegant in appearance, yet it is said to have answered the purpose of compensation very well. A section of the rod is shewn in Fig. A.

As glass does not suffer much expansion or contraction from heat or cold, it will be the more easily compensated. The glass rod AB of this pendulum being supposed to lengthen in a small degree by heat, is compensated by a zinc tube of twelve inches and a quarter long, whose lower end resting on the lower end of the glass rod, would be carried down by the lengthening of the glass rod, but the same cause which produces this, will make the zinc tube expand upwards, which will carry up the iron and leaden tubes. The iron tube has in this case its expansion downwards, and the leaden tube compensates this by having its expansion upwards.

*Reid's Pendulum.*

Mr Thomas Reid's compensation pendulum is composed of a zinc tube AB, and three steel rods, *ab*, *cd*, *ef*. In order to obtain a proper tube, the zinc must be very gently fused into a bar about an inch square, and 24.25 inches long, and the mould into which it is poured should be upright, or nearly so. Let this be very carefully hammered to half an inch per foot, meanwhile keeping it pretty warm, to prevent cracking or breaking. After this operation, a hole is pierced straight through the bar, from end to end, and opened up by means of a clean cutting broach, until it is .450 of an inch, or so, in diameter. The outside may be turned down till it is .7 of an inch, or less. The length should be 25.34 inches, the same as the zinc rods were taken at. The steel rods must be a quarter of an inch in diameter; the length from pin to pin, in the upper and lower traverses of the two outside steel rods *c d*, *e f*, 27 inches, five or six inches more being prolonged to go within the ball. In the middle of the lower traverse *m n* is pinned a steel rod *g h*, somewhat more than a quarter of an inch in diameter, and nine inches long, which comes through the centre of the ball, which is fitted up in the same way in every respect as was described for the gridiron pendulum. The steel centre rod *a b* goes up inside of the zinc tube, from the pin which is in the lower end of it, which is in a traverse, a very little above the lower one, to the upper end of the pendulum spring, 36.75 inches; from the pin in the lower end of the centre rod, to the centre of the ball, 4.75 inches. A hole in the upper traverse *o p* allows the centre rod to pass freely through. The lower end of the tube rests on the traverse *g r*, in which the centre rod is pinned. The upper traverse bears on the upper end, both traverses having a part turned from them, about one-tenth of an inch in height, and of such a diameter as to go into the ends of the tube, for the purpose of keeping it to its proper place. The distance from the centre of the holes in the upper and lower traverses, about 1.25 inch, which will be enough to make the two outside steel rods stand clear of the zinc tube. A thin piece of brass, with three holes in it for the outside steel rods and tube, might be put half way between the ends of the tube, to prevent any bending, or tremulous motion, a thing, however, not likely to take place. It would be proper to have a few holes in the tube, for the purpose of admitting air more freely to the centre rod.

The centre steel rod *a b*, when lengthened by heat, will make the lower end B of the zinc tube, (which is supported by the lower end *b* of the steel rod *a b*,) descend with it, but the same cause which lengthens the steel rod *a b* downwards will expand the zinc tube AB upwards, and this will carry up the two outside steel rods with which the ball of the pendulum is connected; their expansion downwards, as well as that of the centre rod, is compensated by the upward expansion of the zinc tube. The length of the steel rods and of the zinc tube, has been shewn to be in proportion to their expansive ratios.

It is about fifteen years since we contrived and made this kind of compensation pendulum, which seems to do very well. The following is of another kind, but we never had it put in execution, although there is no doubt but it would serve the purpose extremely well, notwithstanding the risk arising from the brittleness of the glass.

Provide a white glass tube, whose outside diameter is $\frac{5}{8}$ths of an inch, its inside diameter $\frac{3}{8}$ths, and its length 54 inches: Such a tube may be supposed equal in strength to a solid glass rod, and will be considerably lighter. Make a zinc tube from a square bar, hammered, &c. in the same way as has just now been directed, its length being 16.3 inches, and its inside diameter $\frac{5}{8}$ths of an inch, or as much more as will allow it to move freely up and down on the outside of the glass tube. If the thickness of the zinc tube is $\frac{1}{8}$th of an inch, it ought to answer very well; if it is somewhat greater, it may answer better. There must be a core of brass fitted to each end of the glass tube, ground gently into the glass, and fixed in by some of the lime cements. To make the fixing more secure, a hole might be bored through the tube and core, about half an inch from each end of the tube, and a copper pin put through them. The core in the lower end must have a small cylindrical piece, or wire, formed from it of .3 or .4 of an inch in diameter, stretching 1.5 inch beyond the end of the glass tube, and tapped for the nut inside of the zinc tube to work upon. The regulating nut should be under the pendulum ball, yet a little free of it, as it would be difficult to get at it, were it placed near the lower end of the rod. The core at the upper end has also a part of the brass, a little way above the end of the tube, for the purpose of fixing in the pendulum spring. The zinc tube goes up to the centre of the ball, which rests on the end of it; the lower end, having the tapped nut in it, bears on the regulating screw. The nut may be either soldered into the tube or not, provided it is fast there. As both the glass rod and zinc tube are round, and go through the ball, it will be requisite to have something to keep the ball to its proper swinging position. For this purpose, let a brass tube of an inch and a half in length be fitted strongly spring tight on the glass rod, and put on above the upper edge of the ball. To the lower end of the brass tube or socket is fixed a traverse piece, into which are fixed two steel rods, a quarter of an inch in diameter, and 6 inches long. These go within the ball, in the same manner as the lower ends of the outside steel rods in the gridiron pendulum. The distance between the holes in the traverse should be 3 inches, that is, each rod should be distant outside 1.5 inch from the centre of the glass tube. When the traverse with the spring tube is once set, so that the ball may have its proper position, it cannot be easily altered. The length taken for the zinc tube is rather in excess for the compensation of the glass rod, and should it be found so, the tube can readily be shortened. As the glass rod is not very fit for the pendulum fork to work on, the following apparatus is proposed, and has been found in other cases to answer the end as well as could be wished. See Plate CCCVII. Figs. 7 and 8.

AA is a hollow cylinder of brass 1.5 inch long, which fits the glass rod rather more than spring tight. It is made a little thin near the ends, and at the middle it is left thick, having the appearance of a brass ring *a, a, a, a*, formed on the cylinder, into which are fixed two pivots *p p*, a piece of brass not very thick, .3 of an inch broad, being bent up nearly in a bow form, as at B, B, having a small hole at each end, *b b*, to receive the pivots *p p*. One of the ends must be screwed on, in order to get the pivots more conveniently into their holes. At the end or middle of the bow is a solid or round knob of brass C, in which is a hole tapped to receive the screw D, the head of which is nerrelled on the edge, and sunk on the outside, to receive the round flat piece of brass E, which snaps easily in like a barrel cover, and is not left so tight, but that it may be easily turned round in its place, without any risk of coming out, and supposed to have no shake outwards. Into the piece E is fixed a piece of brass, having a hole in it to receive the pin of the crutch. Two views of this piece are seen at F F. When these pieces are all combined to act in their places, it can easily be seen, that by turning the nerrelled head of the screw D, holding the piece F in its front view position, the crutch pin will be made to move out or in, according as the screw D is turned, by which the clock will be set in beat, to a degree of nicety which is not easily obtained by bending the fork or crutch shank.

There are other modes of putting a clock in beat, but they generally consist of an apparatus for that purpose, carried by the crutch or fork, which is a load on the cock pivot. The one which has been described has the advantage of being supported by the pendulum rod.

The glass tube having a length of 54 inches, will, when expanded by heat, carry down with it the zinc tube, whose lower end rests on that of the glass tube. The centre of the ball of the pendulum resting on the upper end of the zinc tube, will expand upwards from the same cause which lengthens the glass tube, and by this means carry the ball of the pendulum up, and keep the centre of oscillation always to the same distance from the point of suspension. The length of the glass tube rod, and its expansive ratio, will be found to be in just proportion to the length of the zinc tube and its expansive ratio.

### *Troughton's Tubular Pendulum.*

Mr Edward Troughton's tubular pendulum is a very neat and ingenious one, and is in every respect worthy of that celebrated artist, to whom science is so much indebted for the great perfection to which he has brought the division of astronomical instruments.

"Fig. 9. Plate CCCVII. says Mr Troughton, drawn to a scale of one-eighth of the real dimensions, exhibits the shape of the whole instrument, in which the parts of action being completely concealed from view, it appears, excepting the usual suspension spring, to be made of solid brass. This figure gives a front view of the pendulum. This form of the bob is used more on account of its being easy to make, and sightly, than from any other considerations; it is made of one piece of brass, about 7 inches diameter, 2.5 thick at the centre, and weighs about 15 lbs. avoirdupoise: the front and back surfaces are spherical, with a thick edge or cylindrical part between them. The apparent rod is a tube of brass, reaching from the bob nearly to the top. This contains another tube and five wires in its belly, so disposed as to produce altogether (like the nine-bar gridiron of Harrison) three expansions of steel downwards, and two of brass upwards; whose lengths being inversely proportioned to their dilatation, when properly combined, destroy the whole effect that either metal would have singly. The small visible part of the rod near the top is a brass tube, whose use is to cover the upper end of the middle wire, which is here single, and otherwise unsupported.

Reckoning from the top, the first action is downwards, and consists of the spring, a short wire 0.2 diameter, and a long wire 0.1 diameter; these, all of steel, firmly connected, reach down within an inch of the centre of the bob, and occupy the middle line of the whole apparatus. To the lower end of the middle branch is fastened the lower end of the interior brass tube, 0.6 in diameter, which terminates a little short of the top of the exterior tube, and produces the first dilatation upwards. From the top of the interior tube depend two wires 0.1 diameter, whose situation is in a line at right angles to the swing of the pendulum, and reach somewhat lower than the attached tube itself, which they pass through without touching, and effect the second expansion downwards. The second action upwards is gained by the exterior tube, whose internal diameter just allows the interior tube to pass freely through it: its bottom is connected with the lower ends of the last described wires. To complete the correction, a second pair of wires of the same diameter as the former, and occupying a position at right angles to them, act downwards, reaching a little below the exterior tube, having also passed through the interior one without touching either. The lower ends of these wires are fastened to a short cylindrical piece of brass, of the same diameter as the exterior tube, to which the bob is suspended by its centre.

"Fig. 9. No. 1. is a full size section of the rod, in which the three concentric circles are designed to represent the two tubes; and the rectangular position of the two pair of wires round the middle one, are shown by the five small circles. By copying this arrangement, from the elegant construction of your own half seconds pendulum, (*Phil. Journal* for August 1799,) I avoided much trouble, which must have occurred to me, unless, indeed, I had been impelled on the same idea, by the difficulty of contriving the five wires to act all in a row, with sufficient freedom and in so small a space. Fig. 9. No. 3. explains the part which closes the upper end of the interior tube: the two small circles are the two wires which depend from it, and the three large circles show the holes in it, through which the middle and other pair of wires pass.

" Fig. 9. No. 4. is designed to explain the part which stops up the bottom of the interior tube; the small circle in the centre is where the middle wire is fastened to it; the others the holes for the other four wires to pass through. Fig. 9. No. 5. is the part which closes the upper end of the external tube; the large circle in the centre is the place where the brass covering for the upper part of the middle wire is inserted; and the two small circles denote the fastening for the wires of the last expansion. Fig. 9. No. 6. represents the bottom of the exterior tube, in which the small circles shew the fastening places for the wires of the second expansion, and the larger ones the holes for the other pair of wires to pass through. Fig. 9. No. 7. is a cylindrical piece of brass, which shows how the lower ends of the wires of the last expansion are fastened to it, and the hole in the middle is that whereby it is pinned to the centre of the bob. The fastening of the upper ends of the two pair of wires is done by screwing them into the pieces which stop up the ends of the tubes; but at the lower ends they are all fixed, as represented by No. 7. I have only to add to this description, that the pieces represented in Fig. 9. have each a jointed motion, by means of which the fellow wires of each pair would be equally stretched, although they were not exactly of the same length.

" In the apparatus thus connected, the middle wire will be stretched by the weight of the whole; the interior tube will support at its top the whole, except the middle wire; the second pair of wires will be stretched by all, except the middle wire and interior tube; the exterior tube supports at its top the weight of the second pair of wires and the bob, and the second pair of wires are stretched by the weight of the bob only.

" The first pendulum which I made of the tubular kind had only three steel wires, and one tube above the bob; that is, two expansions down and one up; and the quantity which one of brass falls short to correct two of steel, was compensated for, by extending those branches of the rod below the bob, and bringing up an external tube to which the bob was affixed. There is an awkwardness in this construction, owing to the rod reaching about 13 inches below the lower edge of the bob, otherwise it is not inferior to the one first described."

*Ward's Pendulum.*

The rod of this pendulum consists of two flat bars of steel, and one of zinc, connected together by three screws, as shown in Plate CCCVII. Fig. 10. No. 2. which is a side view of the pendulum rod when the bars are together; " *hh*, *ii*," says Mr. Ward, " are two flat rods or bars of iron, about an eighth of an inch thick; *kk* is a bar of zinc interposed between them, and is nearly a quarter of an inch thick. The corners of the iron bars are bevelled off, that they may meet with less resistance from the air; and it likewise gives them a much lighter appearance. These bars are kept together by three screws *l*, *l*, *l*, which pass through oblong holes in *h h* and *k k*, and screw into *i i*. The bar *h h* is connected to the one *k k* by the screw *m*; which is called the adjusting screw. This screw is tapped into *h h*, and passes barely through *k k*; but that part of the screw which enters *k k* has its threads turned off. The bar *i i* has a shoulder at its upper end, turned at right angles, and bears at the top of the zinc bar *k k*, and is supported by it. It is necessary to have several holes for the screw *m*, in order to adjust the compensation. No. 3, 4, 5, are a side view of each bar separately. No. 6. shows the flat side of the zinc bar. Fig. 10. No. 1. is a front view of the pendulum rod when screwed together. The letters have the same reference to the different figures."

The front steel bar being lengthened by heat, and having its expansion downwards, will carry along with it the zinc bar, whose lower end is supported by a screw in the front bar; the zinc bar in this case will have its expansion upwards, and carry up the back steel bar, whose upper end rests by means of a knee on the upper end of the zinc bar. The pendulum ball hangs to the lower part of the back steel bar which has its expansion downwards; but the two expansions downwards of the steel bars, are compensated by the upward expansion of the zinc bar.

Mr Ward's pendulum must be allowed to be a very excellent one, as it possesses the advantage of permitting the compensation to be readily and easily altered. The description which has been given of it, in the Transactions of the Society for the Encouragement of Arts, &c. for the year 1807, and in the pamphlet which Mr Ward published at Blandford in 1808, contain sufficient details to enable any common clockmaker to copy it. We have only to add, that there should be a spare screw, for shifting the compensation; and that the screws connecting the two steel bars and the zinc one should never on any account be moved. It will be found of great advantage to have a spare screw, which may be put into that place which is supposed requisite to correct the compensation; and then release the one supposed to be where the compensation is thought to be too much or too little. Our experience with it soon led us to this contrivance. Having made one of these pendulums, we shall now give an account of its dimensions, &c. The distance from the upper part of the pendulum spring to the centre of the ball, is 40.75 inches; and to the lower end of the front steel bar, 2 feet 11.5 inches. From the upper end of the zinc bar, where the back bar of steel rests or hangs on, to the centre of the ball, it is 2 feet 6.25 inches. The steel bars are forged from cast steel, and annealed; their breadth is three quarters of an inch, and their thickness about one-tenth of an inch. The length of the zinc bar is 24.8 inches; and its thickness a little more than two-tenths of an inch. The centre of the ball hangs on the end of the tube of the regulating nut, where it was tapped, to work on its corresponding screw, made near the lower part of the back bar, formed here into a round rod, the lower end of which is a point, or index, to a graduated plate fixed to the back of the case, and 5.25 inches below the centre of the ball. The weight of the ball is 13lb. 2oz.; that of the zinc and steel bars, nut, pendulum spring, and connecting screws, 2lb. 13½oz.; weighing in all nearly 16lb. In making up steel bars or rods for any compensation pendulum, it is proper to heat or blue them after they are finished, which will dispel whatever magnetism they may have acquired in working them up. The zinc bar of this pendulum, when brought near to the length of compensation, was about 21 inches. Taking the length of steel to be compensated by this at 61.75 inches, we may find what the compensation of the zinc should be, if the steel is rightly taken at 138.

| | |
|---|---|
| Steel in inches 61.75 . . . | Log. 1.7906370 |
| Ratio 138 . . . . . . | Log. 2.1398791 |
| | 3.9305161 |

| | | |
|---|---|---|
| Zinc in inches 21 | Log. | 1.3222193 |
| Ratio 405.7 | Log. | 2.6082968 |
| | | 3.9305161 |

The expansive ratio here is greater than 373, as given by Mr Smeaton; but is not equal to 420, as given by Mr Ward, from trials made with his pendulum.

The three zinc pendulums which have been described have each their peculiar properties. The zinc rods of the gridiron one are very troublesome to make; but they are more exposed to the air, or to changes of temperature, and are adjustable by means of the shortest traverse, and the sets of holes which are in them and the centre rod. When this pendulum is well executed, it is perhaps the best of the three. The one with the zinc tube is the strongest, the bearing on it being more firm and direct than in either of the other two; only it has no means for adjusting the compensation, unless by shortening the tube from time to time. According as the excess of its compensation is shown, something might be contrived to adjust it, without taking it from its place, but this would be too complicated; so that the shortening of the tube by degrees is rather the better way. Ward's is much more easily made than the other two. Those who use gridiron pendulums should have a half traverse, with three pins on it, similar to the shortest one in the pendulum, which will be found very convenient, when it is necessary, to shift for compensation. The half traverse and pins should be put into the holes, where the traverse in shifting is not to come. This will keep the pendulum rods in their places, and serve in the same way as the spare screw proposed for Ward's pendulum.

## CHAP. XI.

### *On the Wooden Pendulum Rod.*

The wooden pendulum rod does not come under the class of those which have just now been described; nor can it be supposed equal to any metallic compensation one. Having a good opinion of it, however, we put to trial one of them made of a very fine piece of straight-grained deal, that, for the purpose of seasoning, had been kept for five years near a parlour fire, which was almost constantly lighted throughout the whole year. The rod, when dressed up and fitted to the ball, and the pendulum spring put to it, was well varnished, so as to exclude any possibility of its being affected by damp. It was then applied to the clock, which, when regulated, went for about sixty days, during the months of June and July, without any apparent deviation from time; the very dry weather made the fixings for the clock case shrink a little. When these were again made more secure, the clock, during a trial of many months, could not be brought to give the same satisfaction. Whether this was owing to the wooden rod, or to what cause, we shall not at present pretend to determine. On this pendulum being taken away from the clock, a mercurial one was put in its place, having the same pendulum spring which was at the wooden rod, and every thing else being in the same state as before. The difference in the good going of the clock after this became truly astonishing, and may be considered as a striking proof of the great superiority of the one pendulum over the other.

It must here be observed, that, although the comparative trial by the same clock with the mercurial and wooden rod pendulums was in favour of the former, yet this clock and another were fixed on two planks, exactly the same as those described in the next chapter, and strongly fixed to a stone wall, opposite the brick wall where the other two clocks were, which gave rise to the discovery of their pendulums affecting each other's motions. Not being aware of this at the time of trial, the errors of the going of the clock, while the wooden rod pendulum was used, and the good going of it when the mercurial pendulum was applied, may have arisen from various causes, such as the elasticity of the upper plank, or the pendulums being of unequal length and weight. This much may positively be affirmed, that they were not going under such circumstances as to have a fair trial. We propose, however, to repeat the experiment with the wooden rod pendulum, applied to another clock, placed in a more insulated situation. An eminent American philosopher says, that deal has little or no longitudinal expansion, making it less than glass, as may be seen in the Table under the article Expansion, in this work.

In the Astronomical Observations published at Cambridge in 1769, by the late Reverend William Ludlam, Professor of Mathematics in that university, he has described a very neat and ingenious method of fitting up a pendulum with a wooden rod, constructed for the purpose of preventing any gyratory motion from taking place, as well as to have some resistance from the air. This was effected by having the pendulum ball of an equal mass round the centre of a round wooden rod, and by a thin flat hard steel crutch, to give impulse on the hardened ends of two screws put through the rod, which screws were to keep the flat crutch as near as possible in the plane or line of the diameter of the pendulum rod, or at right angles to the middle plane of the pendulum ball. This ball was nearly of the form of a cheese, or the middle frustum of a globe. For a more particular description of it, see Ludlam's *Observations*, page 81, Plate v.

From the description given of this pendulum by Mr Ludlam, it appears to be a very complete one, and several persons were on that account led to adopt it; but, from our experience, it was found to be much inferior to what might have been expected, and to possess, rather in a great degree, the very defect which Mr Ludlam wanted to avoid. The lateral coming and going of the pendulum rod by heat and moisture, causes the screws to come and go from the crutch, sometimes to clip it hard, and at other times to allow it to have more freedom between the ends or points of the screws than is proper. Finding that it had a strong tendency to gyratory motion when the clock was set a-going, (which however diminished some time after,) arising from the mass of the ball being carried out from the centre towards the edge, and from a thick rod passing through the centre, we thought of the following pendulum, which was afterwards put in execution, where the greater part of the mass of the ball is kept at the centre, and where the least quantity possible is towards the edge. A drawing of this pendulum is given in Plate CCCVII. Fig. 11. No. 1. and 2. The ball is of a lenticular form, 7 inches in diameter, thickness at the centre 2.5 inches, as seen at AA, AA, having a round wooden rod of about .6 of an inch in diameter, or thereabouts. The rod may be either round, flat, rectangular, or elliptical. This last is perhaps the best form; the transverse diameter being 1.5 inch, and the conjugate 0.5 of an inch. *a a*, *a a*, No. 1. are two small round steel wires, whose diameter is less than .2 of an inch, or say .175 of an inch, the length from pin to pin about 8.5 inches. They might be kept shorter, if care were taken to regulate the length of the pendulum by the going of the clock before fixing their length; in which case, they need not project more than .2 of an inch beyond the diameter of the ball. The centres of these wires are one inch apart, each passing through the ball at half an inch from the centre ; *b* 1, *b* 2, Nos. 1. and 2. are two pieces of brass, into which the ends of the steel wires are fitted and pinned fast ; their shape is represented in the drawing. In one of them *b* 1 is a socket in which the lower end of the rod is fixed; and in the lower one *b* 2, the regulating screw *d* passes freely through : $x, x$ are two brass nerrelled nuts, tapped to receive the screw *d*, which has also a conical nerrelled head fixed on it; the lower end of the screw serving as an index for the arcs of the pendulum's vibrations. On the upper end of the screw, the lower edge of the pendulum ball rests; and when moved up or down by the screw, the nuts $x, x$ are screwed against the brass piece *b* 2, in order to keep all fast.

The advantages which this pendulum possesses are very obvious. The whole of the momentum of the ball is so near the centre, that it maintains a very steady motion; and should any lengthening or shortening of the rod and steel wires take place, this will in some degree be compensated by the ball. Should they lengthen, the same cause will make the centre of the ball get upwards, the edge meanwhile resting on the end of the regulating screw, and *vice versa*. A piece of flat brass is fitted and pinned into the upper part of the rod CC, as seen in the drawing. Behind the rectangular hole made in this piece of brass to receive the crutch pin, a part of the wood is taken away, in order that the crutch with its pin may get as near as may be to the piece of brass. The piece of brass in which the lower end of the pendulum spring is, is fitted to the top of the rod, having two pins through it, to make it fast there. The upper end is fixed to a piece of brass, which goes on a steel arbor, having pivots to rest on a cock, and turn freely on it, so that the pendulum may take its plumb-line when hung on.

It has been observed by some cabinet-makers, that from drawers, whose sides and bottom were of cedar, there issued effluviæ, that inspissated the oil at the locks, and thickened it so much, that the locks became of no use till they were taken off and cleaned.

Pendulum rods have sometimes been made of cedar wood, and are objectionable on this account, as the oil at the pivot holes of the clock becomes thickened by it. Perhaps if pendulum rods of cedar were strongly varnished, this might deprive the wood of this inspissating quality.

It is of the utmost importance to have the pendulums of clocks well fixed at the point of their suspension ; and the cock to which they are suspended should, at the same time, be strong and firmly fixed to the wall of the place where the clock stands. This requires to be particularly attended to in turret clocks, and still more so in clocks intended for astronomical purposes. These last ought to be placed upon an iron bracket, strongly fixed to as massy a stone pier as can possibly be got into the place where the clock is to stand. We have had an instance of a pendulum which was so well fixed up, that there did not appear a possibility of its being made any firmer, or that the motion of the pendulum could in the least affect the cock and suspension, yet the arc of its vibration was a little increased, after having made considerable exertions to put farther home the screws, &c. concerned with the fixtures of the cock and the suspension of the pendulum. The arc of vibration did not exceed two degrees on each side of the point of rest, so that its motion, or centrifugal force, could not be very great at the point of suspension ; yet, small as this force was, it is clear that it was sufficiently great to affect the cock there, as this cause made the arc of vibration of less extent than when the suspension was afterwards more firmly fixed. We have suspended the pendulum on a strong brass cock, which was either rivetted or screwed to an iron plate. This iron plate was screwed firmly to the wall, the clock case being between the plate and the wall, and sometimes a notch was left in the pillar plate to receive the end of the brass cock, by which means the clock frame and the pendulum suspension were made to keep together as nearly as posible ; and when every thing here was so far adjusted, a strong screw with a square head was put through the cock, binding it and the pendulum top-piece firmly together. Another way is, to have two brass supports screwed on to a very strong seat board. These supports may be about one inch broad and half an inch thick, and in height about six inches, more or less, according to the height of the bending of the pendulum spring above the seat board. Each support has a strong and broad sole, and these soles have a stout steady pin to go into the seat board, which is screwed, from underneath the seat board, by a strong iron or steel screw fast to the upper side. The supports at the top incline a little towards each other, and a thick and broad piece of plate brass is screwed to them behind, so as to connect them firmly together. The upper ends of the supports are made level, and parallel with the soles and seat board. Across these ends is made a triangular notch, to receive the pivots of a piece of steel, to which the pendulum is suspended. By means of these pivots the pendulum turns, so as to hang freely in a vertical position. The distance between the ends of the brass supports at the top need not be more than two inches, while at the bottom the distance may be four inches, or not quite so much, the inclination being about ten degrees or so from the perpendicular. The piece of steel should not be less than half an inch thick at the middle, where it should be circular, and about three quarters of an inch broad. In the middle is a hole of about three-tenths of an inch in diameter : the two conical arbors are formed from the circular part, so as to be in a line with the diameter of the hole. The pivots of these arbors, which turn in the triangular notches, may be about three-twentieths of an inch thick. In the hole, which is three-tenths of an inch wide, is fitted a steel pivot, having a shoulder on the under side, which comes so far beyond the upper side as to admit a stout brass collet to be pinned on it, and against the upper flat side of the circular part, besides a sort of screw head on the end, with a slit in it, by which a screw-driver can turn it about, so that the pendulum ball may be made to stand in the plane in which it ought to swing. From the shoulder, below the circular part of the steel piece, to the lower end, may be an inch long. To this the pendulum spring is fixed. This, in some respects, is a very convenient mode of suspension, but we do not think it so strong and so firm as the other.

When the astronomical clock, formerly mentioned, which goes six weeks without winding up, was planned, care was taken to have the weight kept at as great a distance as possible from the pendulum ball, as we conceived that the attraction of the weight would disturb the vibrations of the pendulum. This idea, which appeared to us new, had occurred, we have been told, long before to several very able artists and amateurs, such as Graham, Harrison, Lord Macclesfield, Sir George Shuckburgh, Troughton, and others. In the course of our trials with the clock, the arc of the vibrations of the pendulum, when the weight came as far down as the ball, was observed to suffer a sensible diminution, and this was imputed to their mutual attraction. Upon mentioning this afterwards to one or two persons, supposed to be competent to judge in an affair of this kind, they entertained some doubts respecting this explanation of the fact, and thought it might probably arise from some motion communicated to the air by the swinging of the pendulum. Without making any experiments in order to examine the action of the air on the motion of the pendulum, an account of the fact, which was ascribed solely to attraction, was published in Nicholson's *Phil. Jour.* October 1812, vol. xxxiii. octavo series. Soon after this, Mr Ezekiel Walker of Lynn, in a paper published in the same Journal, endeavoured to shew, that the cause of this disturbance of the pendulum, (which he says had been known to him 30 years before,) arose from the motion of the air communicated by the weight to the pendulum, which it certainly did, as we soon afterwards found from one or two experiments, which did not occupy much time. In a paper of Mr Walker's, in Nicholson's *Phil. Jour.* for May 1802, vol. ii. octavo series, p. 76. entitled "Methods for diminishing the irregularities of Time-pieces, arising from differences in the arc of vibration of the Pendulum," he has assigned several causes for the changes that take place in the arcs of vibration, and proposed different methods to prevent them. But no notice whatever is taken of the motion communicated to the air by the pendulum. M. Berthoud mentions, in the first volume of his *Essai*, published in 1763, No. 642, that the air put in motion by the vibrations of the pendulum, acts against the weight of the clock, so as to set it in motion, and that this will in its turn gradually diminish the motion of the pendulum until it stops it altogether. This takes place more readily when the weight hangs by a single ball than when it is suspended upon a pulley. This fact, it must be confessed, had either been overlooked by us, or had entirely escaped our memory. Month clocks, from stopping frequently, have long been very troublesome to clockmakers, who no doubt assigned for it a different cause from the true one. In the old month clocks, the weights are very large and heavy, and the momentum of the pendulum very small, so that they were extremely liable to be stopped. But in clocks where the pendulum has even a considerable momentum, this agitation of the air will be sufficient to stop them altogether.

Having been called upon to examine a good astronomical regulator of Graham's, which had stopped, and which belonged to a nobleman in the neighbourhood of Edinburgh, we informed the man who was sent to put it in order, that he would find the weight opposite to the pendulum, which was actually found to be the case.

## CHAP. XII.

### *On the Sympathy or Mutual Action of the Pendulums of Clocks.*

It is now nearly a century since it was known that when two clocks are set a-going on the same shelf, they will disturb each other;—that the pendulum of the one will stop that of the other; and that the pendulum which was stopped will, after a while, resume its vibrations, and in its turn stop that of the other clock, as was observed by the late Mr John Ellicott. When two clocks are placed near one another, in cases very slightly fixed, or when they stand on the thin boards of a floor, it has been long known that they will affect a little the motions of each other's pendulum. Mr Ellicott observed, that two clocks resting against the same rail, which agreed to a second for several days, varied 1′ 36″ in 24 hours when separated. The slower having a longer pendulum, set the other in motion in $16\frac{1}{3}$ minutes, and stopped itself in $36\frac{2}{3}$ minutes. It never could have been supposed, however, that when very strong fixtures were made, it was possible for any thing of this kind to take place. About three years ago, in a room where astronomical clocks were placed under trial, two strong deal planks were firmly nailed to a tolerably stout brick wall or partition, the ends of the planks being jambed between the adjoining partitions. The planks were 6 feet long, 6 inches broad, and $1\frac{5}{8}$ths of an inch thick. One of them was placed behind the suspension, and the other behind the balls of the pendulums. The pendulums were suspended on strong massy cocks, partly of brass, and partly of iron, and, with the back of the cases, (one of which was of very hard oak,) were firmly screwed to the upper plank, and also to the lower one, the bottom of the cases being free and independent of the floor. Two clocks, whose pendulums were nearly of equal length and weight, and whose suspensions were distant from each other about two feet, kept so unaccountably close together for the greater part of twelve months, as to become a matter of considerable surprise. When the cold weather commenced in November, they made a small deviation from one another for a few days, and then resumed the same uniformity which they had before. An account of this was published in Mr Tilloch's Philosophical Magazine, where the observations of M. de Luc, which seem to have been a very near approach to the cause, were inserted by way of reply. The pendulum which was at one of the clocks, was of Ward's kind. On its being taken away, a gridiron one was put in its place; but with this, which was longer than Ward's, the clocks could never be brought to the same time as before. Their arcs of vibration continually varied, and no satisfactory going could be obtained from them, although we were well aware that they were competent to have given a very different performance. The gridiron pendulum clock was one of the best possible in its execution, and had one of the best recoiling 'scapements we have ever seen or made. The clock was taken from its case, to have a 'scapement of a different kind put in. In the meanwhile, the pendulum being left hanging in its place, was observed to be in motion, which was at first imputed to some shaking of the house. On being stopped, it got again into motion, and upon observing it narrowly, it was found not to be in such a direction as any shaking of the house could produce, swinging quite in time with the pendulum of the going clock, the two pendulums mutually receding and approaching each other. The cure was instantly obvious; and after the upper plank was sawed through between the clocks, the pendulum became in a little while dead and still. The arc in which it vibrated was about twelve minutes of a degree on each side of the point of rest, which was nearly about the greatest extent of variation in the arcs of the two pendulums. It would be imposible to make two clocks go closely together, in any other situation than the one which has been mentioned.

After the plank was cut through, the going clock was observed to be losing nearly at the rate of a second and a half a day; and if the clock which kept so long in unison with it had been tried under the same circumstances, it is probable that the rate would have been found to be fast. The rate they had for a period of eight or nine months or more, when they were close together, did not exceed two-tenths of a second fast a day, and this may have been a mean of the natural rate of each pendulum, if it may be so expressed; that is, suppose one clock was going slow 1.5 second per day, the other fast 1.7 second, there will be two-tenths of a second left for the acceleration of both, which seems to be the only way of explaining this phenomenon.

## CHAP. XIII.

### *On Turret Clocks.*

We have frequently seen turret clocks put up in places where no advantage was taken of the length of fall for the weights, which either did not descend through the whole height, or if they did, the ropes had a second rewinding, as it were, on the barrel. Hindley, who was certainly a man of genius, and whose turret clocks were perhaps unequalled in regard to their execution, though defective from no advantage being taken of the fall, made them all with barrels of a small diameter, and of such a length as to admit almost any number of turns, so that they could be placed in any situation, whether with propriety or not. We shall therefore lay down such rules, that a clockmaker may fit up a turret clock suited to any given fall for the weights.

Suppose that the height of fall for the weights is 25 feet, and that the clock is required to go eight days without being wound up, and with a single line to the weight, that is, with no pulley for the weight to hang on. We may allow 12 inches for what the weight will take. This reduces the length of fall to 24 feet; allowing 16 turns of the barrel to give 8 days going, and dividing the 24 feet of fall by 16, we shall have during the length of the rope 18 inches for one turn of the barrel. To find the diameter of the barrel, we say, as 355 for the circumference is to a diameter of 113, so is the circumference 18 inches of the barrel to its required diameter, which will be found to be 5.73 inches nearly. But this diameter would be too large, since the diameter of the rope must be taken into account; for the true diameter, or that which is necessary to run out the fall, must be taken at the centre of the rope when wound round the barrel. Allowing the diameter of the rope to be half an inch, then taking this from 5.73 inches, we shall have for the proper diameter of the barrel 5.23 inches. Having now obtained the diameter of the barrel, its length between the ends may easily be found. Sixteen turns of the barrel, the number wanted to produce eight days going, and a rope of half an inch in diameter, will require eight inches; but as the coils of the rope cannot lie quite close to each other, we may allow, for freedom, one inch and a quarter; consequently, if the barrel is made 9 25 inches in length between the ends, it will be sufficiently long. For the striking part, a rope of half an inch in diameter will be strong enough, and as one of a considerably smaller diameter, even one-half, would suit the going part, the going barrel may be made shorter. If the clock should be made to go by a double line and pulley, then the diameter of the barrels will require to be the double of 5.23 inches, or 10 46 inches. Or if the fall is only 13 or 14 feet, then the barrels of 5.23 inches in diameter would do, by means of a pulley. The diameter of the pulley will in part lessen the length of the fall, and in place of 12 inches we may now deduct 16 inches, or so, from the fall, on account of the length taken up by the weight and pulley; but this trifling circumstance requires little accommodation on the part of the clockmaker. Taking then the diameter of the barrel at 10 46 inches, in order to ascertain what diameter the barrel ends and the great wheel ought to have, the rope being half an inch in diameter, twice this added to the barrel's diameter will make it 11.46 inches, but, for the sake of even numbers, let it be taken at 11 inches and a half for the diameter of the plain barrel end; an additional inch, or 12.5 inches in diameter for the barrel ratchet end ought to do, unless when the barrel ratchet is put on the barrel end, and within its diameter, as is sometimes done, in order to have the great wheel of a less diameter than it otherwise would be, when the barrel ratchet end is done in the usual way. The centre of motion of the ratchet end click need not be more distant from the top of the ratchet than half an inch, or at most .6 of an inch, and .75 of an inch more than this for the breadth of the wheel rim, including the teeth. The semidiameter of the barrel ratchet end is 6.25 inches; to this being added .6 of an inch, and .75 of an inch, we shall have for the semidiameter of the great wheel 7.6 inches, or its diameter 15.2 inches. The diameter of the great wheel being thus obtained, we may get the circumference by saying, as 113 is to 355, so is 15.2 to the circumference required, which is found to be 47.75 inches; this divided by 240, the double of the number of the teeth proposed to be put into the great wheel of the going part, we have for the breadth of each tooth and each space 0.199 of an inch, or nearly .2 of an inch. It is perhaps advisable to have the space a very small degree less than what is here given; the teeth will then be somewhat more than .2 of an inch in breadth. Taking small temporary segments of thin brass, having the same radius as the wheel, and cutting them from the proposed number on the cutting engine, will lead us to form an idea of the strength that the teeth may have. Indeed this, and calculation together, ought to go hand in hand, and is the way that any ingenious clockmaker ought to adopt, if his object is to have the best possible contrivance in the construction of any piece of work in which he may be engaged.

If it is proposed to have the pendulum of such a length as to swing 30 beats in a minute, the swing-wheel having 30 teeth, and the pinions 10 each; then the numbers for the teeth of the second and third wheels will be 60 and 50, and the length of the pendulum 156.8 inches; where twenty feet or upwards, for length of fall and strength of clock can be obtained, a shorter pendulum than this should never be adopted. The diameter of the second wheel may be made half of that of the great wheel, or even a little less; however, we may safely take it at the half, viz. 7.6 inches, as it is to be cut into half the number of teeth, and being considerably thinner than the great wheel, the teeth will, notwithstanding this, be sufficiently strong for the force exerted on them. The third wheel having 50 teeth, and the force exerted on them being considerably less than that on the second wheel, we may obtain the diameter of the third wheel, by first taking the proportion of 60 to 50, and then making the diameter somewhat less than the first proportion would give, because, were the teeth cut on this diameter as given, they would be as strong as those of the second wheel. We then say, as 60 teeth is to its diameter of 7.6 inches, so is 50 teeth to the diameter required, which is found to be six inches. Taking six inches in the compasses, and applying them to the legs of any sector that has a line of equal parts, both legs of the sector being extended till the points of the compasses fall exactly on 50, set the compasses to the number 45, which will give a distance equal to the diameter of the third wheel. This will be found to be 5.5 inches nearly, and if the spring wheel is made five inches in diameter, it will do very well.

The barrels both in the going and striking parts being made equal in diameter, and each performing a revolution in 12 hours, we now proceed to make out proper numbers for the striking part, and diameters for the great wheel, the pin wheel, and the tumbler wheel; this last we shall also make use of as a fly wheel. The diameter of the barrels being equal, the great wheels may also be equal, and the diameter of the striking great wheel will be 15.2 inches.

The number of blows which the hammer must make in 12 hours can be obtained by a very simple rule. The first blow 1 being added to the last blow 12, will make 13, and 13 multiplied by 6, half of the number 12, will give 78 for the number of blows required during one revolution of the great wheel and barrel. The great wheel of the striking part will require to have stronger teeth than that of the great wheel of the going part, because there is a stronger rope and a heavier weight applied against them, in order to raise as much weight of hammer as may be, so as to bring a sufficient sound from the clock bell. The pin wheel pinion being 10, and the wheel 64, having eight lifting pins in it for the hammer tail, the number of teeth in the great wheel which will be necessary, so that one turn of it may produce 78 blows, may be either 98 or 100.

Suppose we take 98 for the number of teeth; 98 divided by 10, the number in the pin wheel pinion, the quotient will be 9.8, which, multiplied by 8, the number of pins in the pin wheel, will give 78.4 for the number of blows for one revolution of the great wheel. If the great wheel should have 100 teeth, this, divided by 10, will give 10, and this again multiplied by 8, will give 80 for the number of blows during one turn of the barrel; either of these numbers for the teeth of the striking great wheel would do very well. If we take 98, and as the pin wheel is to have 64 teeth, we may find a proper diameter for it, so that the teeth may be nearly about the same size as those of the great wheel. Say as 98, the number of teeth in the great wheel, is to 15.2 inches, its diameter, so is 64, the number of teeth required in the pin wheel, to a diameter required for it, which will be found to be 9.9 inches.

The pin wheel, having 64 teeth, and 8 lifting pins in it, the tumbler wheel pinion, which makes one revolution for every blow of the hammer, must have 8 teeth or leaves in it. The diameter of the tumbler wheel must be considerably smaller than that of the pin wheel, and this will depend on the number of teeth it ought to have, on the number of leaves in the fly pinion, and on the number of the revolutions which the fly pinion is to make for every blow of the hammer. The less the number of revolutions given to the fly pinion during one blow of the hammer, the less will the striking part be under the influence of oil. But few turns in the fly require it to be considerably extended in the wings or vanes, and this demands some ingenuity and address in the clockmaker to carry them out, so that they shall be conveniently clear of every part of the clock. When the arms of the fly are extended, the wings or vanes can be considerably diminished in surface; and a little weight may be given them, so that when once the fly is set in motion it will not easily stop. The construction of the fly, and fly pinion, has hitherto been injudicious. The flies commonly applied to turret clocks were too heavy, the wings or vanes were too broad, they made too many revolutions, and the fly pinion was not so properly sized as it might be; for it must be considered that it acts not merely as being driven, but it must sometimes act as a leader. For although the tumbler wheel, or fly wheel, which turns the fly pinion, acts as a driver, yet, from the nature and application of the fly pinion and fly to regulate the velocity of the striking, the fly pinion, from the acceleration which it will acquire, must sometimes act as a leader, so that the size of the fly pinion ought to be a mean between the size of a leader and that of being driven. If the pinion is made too large, or the size of a leader, the wheel teeth in driving it would be apt to butt on the pinion, and if made too nicely, as it were, to be driven, it could hardly ever act as a leader, as here the pinion would butt on the wheel teeth; this then is the reason of keeping it to the mean size of the two, which will be found to have a good effect. The arms of the fly may be about twenty-six inches.

The number of the revolutions of the fly pinion for one blow of the hammer is arbitrary; in some clocks the fly may make twenty revolutions, in some more and in some less. When the revolutions are few, and the acceleration of the fly fit to carry forward in a small degree the striking, it may appear to strike faster towards the end of a long hour, but it will require a nice ear to perceive it. We have made the fly pinion to have only four turns for one blow of the hammer, which answered extremely well, so that the tumbler wheel will require 40 teeth, supposing the fly pinion to have 10. If we take the ratio of the pin wheel of 64 to its diameter 9.9 inches, then the tumbler wheel of 40 would have its diameter 6.25 inches, the teeth would then be of the same size or strength with those of the pin wheel; but this is not requisite, as they will bear to be considerably diminished in size, and if the diameter of the tumbler wheel is nearly 5.5 inches, the teeth will be sufficiently strong. In the striking part there is no fly wheel and pinion.

The locking of the striking part of turret clocks requires safe and good mechanism. That which Hindley used is very ingenious, and was adopted in the clock made for St Andrew's Church in Edinburgh; yet, from foulness of oil or dirt, it is liable to misgive, and in attempting to rectify it, the ignorance or carelessness of workmen is apt to increase the evil. The nicety of this locking lies in the pins of the count-wheel, whose office is to raise up the locking-lifter, and pass it at the same time. The locking which is here proposed, is by means of two pins or detents on the fly pinion arbor, one of which is for locking on, and the other is a detainer while the striking is on warning. In this motion work, we have a rack, having teeth on the inside as well as on the outside; the tumbler raises the rack by means of the inside teeth, the rack-catch acts by those on the outside, and is concentric with the hour-lifting arm, or that which discharges the striking; but both move freely and independently of each other. When the rack is on the lifting of the last tooth by the tumbler, a pin which is in the rack carries forward the end of a lever or arm. Concentric with this arm, and fixed with it, another arm presents itself (at the same instant when the pin in the rack has carried the arm forward) to a pin or detent on the fly pinion arbor, and here the striking is locked. The pin in the minute wheel, on raising up the hour lifting arm, raises at the same time the rack catch, and consequently allows the rack to fall, and the pin from the fly pinion arbor, which before this was locked, gets disengaged; and here the striking would go improperly on, but another arm, which is connected with the hour-lifting arm, presents itself to the other detent on the fly pinion arbor, and detains it till such time as the lifting arm drops off from the pin in the minute wheel, and then the striking being at liberty goes on, and is again locked when the pin in the rack is made to move one of the locking arms forward. This locking is sure and safe, and very easily executed.

The pins of the pin wheel ought to be pretty stout, and one half of their diameters should be cut away, so as to allow the hammer tail to drop off freely, causing as little loss as possible of the force of the weight. Some have made very slender pins, and strengthened them by their opposite ends being fixed in a small circular rim or ring over them; but small pins are apt to tear and wear away the acting part of the hammer tail. The hammer tail may be so constructed, that it begins to raise the hammer head when the lever by which it acts is at its maximum length, the head having then a more horizontal position than when it is afterwards raised up. The principle laid down here of the striking, &c. was adopted and put in execution in the two turret clocks which were made by Mr Reid for the royal burgh of Annan, and which are not equalled by any turret clocks in the island. The frame of these clocks is so constructed, and the wheels so disposed, that any wheel can be separately lifted out of the frame, without either taking it to pieces, or removing any of the other wheels.

The diameters of the wheels and the length of the barrels being determined, we may thence fix upon the length and breadth of the clock frame, which is proposed to be rectangular, and the wheels lying all nearly in a horizontal position, making it of such dimensions as not to pinch any part of the work, nor yet to have a superabundance of room. Beginning, then, with the going part:—The great wheel being 15.2 inches in diameter, and having 120 teeth, and the pinion which it drives 10, we know that the distance of their centres will be 8.081, or 8.1 inches nearly. We also know, that in the case of the second wheel of 7.6 inches in diameter, and 60 teeth, driving the third wheel pinion of 10, the distance of their centres must be 4.273 inches. In like manner we get the distance of the centres of the third wheel, and swing wheel. The diameter of the third wheel is 5.500 inches; the swing wheel pinion being 10, we have for the distance of their centres, 3.158 inches. By taking these distances, and adding them together, with the semi-diameters of the great and swing wheels, we shall have the space that would be required to contain the going part.

| | Inches. |
|---|---|
| From the centre of the great wheel to that of the second wheel, . . . . . . . | 8 081 |
| From the centre of the second wheel to that of the third wheel, . . . . . . . | 4.273 |
| From the centre of the third wheel to that of the swing wheel, . . . . . . . | 3 158 |
| The semi-diameter of the swing-wheel, . . | 2.5 |
| The semi-diameter of the great wheel, . . | 7.6 |
| Inches, | 25.612 |

So that it requires 2 feet, 1 inch, 6 tenths, and a very little more, to contain the going part.

By proceeding in the same manner, we shall find the distance of the centres of the wheels in the striking parts to be as follows:

| | Inches. |
|---|---|
| From the centre of the great wheel to that of the pin wheel, . . . . . . . | 8.1875 |
| From the centre of the pin wheel to that of the tumbler wheel, . . . . . . | 5.6815 |
| From the centre of the tumbler wheel to that of the fly pinion, . . . . . . . | 3 2544 |
| Semi-diameter of tumbler wheel, | 2.75 |
| Ditto of the great wheel, . . . . | 7.6 |
| | 27 4734 |
| To which add the space required for the going part, . . . . . . . . | 25.612 |
| Gives for inches, | 53.0854 |

The length, then, required to contain the going and striking parts, is about 4 feet 5 inches, being the inside length of the frame.

The width inside of the frame depends on the length of the barrels, the thickness of the ends, and of the great wheels, &c. The striking barrel being the longest, we must take the length given for it, which was determined to be 9.25 inches between the ends. Allow one quarter of an inch or so for the thickness of the plain end, and half an inch for that of the ratchet end, and about 3-4ths of an inch or so for the thickness of the great wheel, these being 1.5 inches, which, added to the length of the barrel, makes 10.75 inches. The pin wheel is supposed to run behind the great wheel, having a proper freedom between them, the pins for lifting the hammer tail being on the opposite side of the pin wheel, and the plain barrel end having a sufficient freedom of the front bar of the clock frame. We shall call this freedom about .3 of an inch, and as much for the freedom of the pin wheel and great wheel; the thickness of the pin wheel about .4 of an inch, or a very little more; the height of the pins from the surface of the pin wheel about .6 or .7 of an inch.

| | Inches. |
|---|---|
| The length of the barrel, with its additions, was, | 10 75 |
| Freedom of plain barrel end, . . . . . | .3 |
| Ditto of great and pin wheels, . . . . | .3 |
| Thickness of pin wheel, . . . . . . | .45 |
| Height of pin wheel pins . . . . . | .7 |
| And take the distance of their tops from the side bar of the frame at . . . . . . | 1.25 |
| Inches, | 19.75 |

By this it appears, that the distance between the bars of the frame inside will require to be 13.75 inches. The side bars, one on each side of the frame, are of forged iron, about four inches in breadth, and .4 of an inch thick, having at the ends a sort of thickness left there, so as to form a shoulder, and beyond the shoulders are tenons, not quite so thick nor so broad as the bars themselves; these tenons, about 4.5 or 5 inches long, are fitted into a rectangular hole, in the cast iron part of the frame, which compose the ends of it. The ends of the tenons are sometimes formed into two screws, each having nuts to bind them against the shoulders, and with the cast iron ends: or having sometimes slits in them to receive a strong iron wedge to bind the shoulders; either of them will do very well. The length from shoulder to shoulder of the side bars need not be quite so much as that which has been allowed for containing the going and striking wheels. If this length is 4 feet 4 inches, it will be sufficient; the space given by the cast-iron frame ends will more than compensate what has been deducted from the calculated length. The cast-iron ends are composed of two sorts of pillars, connected by a rectangular bar, near 5 inches broad, and about half an inch thick; the length of the rectangular bar such as to allow the side bars, when the tenons are into the square part of the pillars, and in the rectangular hole which is made there to receive the tenons, that the inside of the side bars shall be only distant from one another 13.75 inches. The middle part of the pillars is a square of about 3 inches, and 6 inches long; the upper and lower ends of the pillars are turned into such a figure or shape, as the taste or fancy of the artist may suggest. The middle of the rectangular hole which receives the tenons may be distant from the lower end of the pillar about 12 inches; the top of the upper end may be equally distant. This frame, if constructed in the manner which has been directed, will be found to be strong, firm, and stiff, and very handy and convenient, while going about the making of the clock. Should it be thought that the side bars from their length may yield a little, a foot can easily be attached to each, near to the middle of the bar, or any other convenient place.

Nothing about a turret clock requires more skill and ingenuity, than to construct properly the wheel work for setting off and carrying the hands to the different dials, more especially if there are more than two. The wheels for this purpose should be as few in number as possible, having the least allowable shake between the teeth, and a sufficiency of freedom in the end shakes of the arbors, and in the conducting rods. Turret clocks, with four dials and hour and minute hands to each, were formerly but very seldom made. The town clock of Edinburgh has four dials, with hour and minute hands to each, which we put to it in the year 1795.. It is an excellent specimen of this sort of mechanism. Hooke's joint has been found very useful in the conducting rods for the dial work; but where any oblique direction is given to the rods, Hooke's joint will make the hand rather to go irregular, making the hand more forward at one part, and more behind at another, than it ought to be. In large turret clocks, which have minute and hour hands, the wind and weather give a very severe trial to the dial-work and wheels, and such clocks are in general very much exposed to such trials. In the clock which we have been planning, the second wheel pinion making one revolution in an hour, is that which must conduct the dial work. Let that pivot of it which comes through the fore side bar be left pretty thick, and prolonged three or four inches beyond the bar outside. Two ways have been adopted, to prevent the hands from changing their place by any force or violence, arising from winds or any other cause. One of them consisted of a pretty stiff or strong circular spring, keyed on behind the minute wheel; the other consisted in putting on the minute wheel arbor a wheel, with square or unrounded off teeth, into which teeth a click from the conducting wheel passed into the space or spaces. We propose to adopt the first of these two methods at present. On the thick pivot of the second wheel pinion, outside of the front bar, let a square be made of .3 of an inch long; on this let the square socket of the circular spring be well fitted, and the side or angle marked to correspond, so as to know at all times that which it has been originally fitted to: this spring may either be of steel or brass, and the diameter equal to that of the minute wheel less by the teeth. From the square part of the pivot let this arbor be turned down, but hardly more than what is necessary to form an arbor nearly cylindrical; the square sides must not be completely turned out, otherwise this might render the arbor too small. The diameter of the minute wheel may be about 4.5 inches, and cut into 40 teeth; on the same socket with the minute wheel, let there be a bevelled wheel of 5.5 inches in diameter, and having 50 teeth, the distance of the back of the bevelled wheel from the nearest side of the minute wheel being about half an inch, or .6 of an inch. This space is to allow the hour lifting arm to come in between them, so that the lifting pin in the minute wheel may freely get hold of it; the whole length or height of the socket may be about 3, or 3.5 inches, and turns on the cylindrical part, or arbor, of the prolonged pivot. Two other bevelled wheels of the same number and diameter as the other are cocked on the front bar, so as to pitch with the first; their arbors are disposed horizontally, and at right angles to the socket of the first bevelled wheel, so that they may be connected with the dial wheels on the two opposite dials, whose wheel and minute hands they will conduct. Over the first bevelled wheel, and pretty near the inside of it, is placed a round brass dial, having minute divisions and figures on it. A minute hand on the socket, having a collet against them pinned by the end of the arbor, will keep the minute wheel tight on the arbor by means of the spring behind it. When there are four dials, then, in place of the two wheels, with their arbors horizontally placed, let there be one arbor placed perpendicularly, on which are fixed two bevelled wheels, the upper one of which pitches with the first bevelled wheel; the lower one, whose lower pivot or arbor may be connected with that of another, which carries a bevelled wheel, turning four others, all of them in the same frame: The four wheels, if properly placed, will turn the four minute arbors at the dials all in their proper course or direction. This frame will require to be placed a little below that of the main frame of the clock. It is seldom that four dials are wanted, and in most instances the two opposite generally suffice. To lead the snail wheel, or what is generally though improperly called the hour wheel, let another flat minute wheel of the same number of teeth and diameter as the first be pitched with it, and whose arbor goes through the main frame; and near the edge of the going great wheel, a little below, on the left hand side, a cock on the fore bar receives the wheel pivot, and the arbor is free on the fore bar: The other pivot, which is left pretty thick, turns in the back bar; on the end of this pivot, which is prolonged a little way beyond the bar, is formed a lanthorn pinion of 4 or 6, or such a number as may suit the number of teeth in the snail wheel; or a pinion of a proper number having a prong to it, may be twisted in a hole made in the arbor to fit and receive it. A lanthorn pinion of four will lead about the snail wheel and snail, having a common socket; the wheel having 48 teeth and 7 inches in diameter, and turning on a stud in the back bar; the rack is also on a stud here. The pivot required to have a lanthorn pinion formed on the end of it, for a wheel of 48 teeth and 7 inches diameter, would be rather too thick; so that by keeping the pivot of a moderate size, or sufficiently thick to have a hole in it to receive the prong of a pinion of 6, and the snail wheel 72, may be a better way than that which we first proposed. The hour lifting arm and the detaining one may be formed or not from one and the same piece, and fixed on an arbor which lies above the great wheel, whose pivots must run in cocks attached to the main frame; cocks are also required for the hammer, the verge, and the pendulum. The length of the pendulum which we have proposed for this clock, may be thought by some rather inconveniently long, which is a matter that can very easily be got the better of, by assuming any other lengths, say 6, 7, or 8 feet: either of these lengths will have perhaps dominion enough over the clock; but these will require other sets of numbers for the second and third wheels, allowing the pinions to remain 10 each, and the swing wheel to have 30 teeth. The second wheel having 75 teeth, the third wheel 60, the pinions 10 each, and the swing wheel 30, the vibrations in a minute are 45, and length of pendulum required is 5 feet 9.7 inches. If the third wheel of this set is made 70, all others remaining the same, the vibrations in a minute will be 42, and the length of the pendulum 6 feet 8 inches: 40 vibrations in a minute would require the wheels to be too disproportionate in numbers, unless we were to make one of the pinions 12 in place of 10; the wheels in this case would be 75 and 64. In the other they would have been 80 and 50. The length of pendulum is 7 feet 4.2 inches; the vibrations in a minute 38; the pinions 10 each, and the swing wheel 30. The wheels are 75 and 64, the length of pendulum 8 feet, 1.73 inches. Wheels 80, 72, and 30, and pinions of 12, will give 40 vibrations in a minute.

. It is certainly not requisite to give any more examples of constructing turret clocks. The one which has been given is sufficient to enable any intelligent artist to proceed in this way, whether with clocks going eight days, or with those which require daily winding up. There are often great objections made against the trouble of daily winding up a turret clock; but when this trouble can be submitted to, a clock of this sort is decidedly preferable to those which go eight days. Turret clocks which strike quarters are sometimes made, some of which are done by a quarter rack and snail, and others by a count wheel. For the description of a thirty hour clock of this kind, put up in the town-house of Paris in the year 1782, we refer to Berthoud's *Histoire de la Mesure du Temps par les Horloges.* This is perhaps one of the finest public clocks in Europe. It was constructed with much care and expense, and is the only one which has enamelled dials, one of which is above 9 feet in diameter.

Although not in its proper place, we may here remark, that where four sets of dials and dial work are required, it would hardly be safe to trust them to a young tight collet behind the minute wheel. We would therefore propose, that the pivot of the second wheel pinion be squared down, and a little longer beyond the fore bar than what was proposed for the square of the spring; this is for the particular reason of getting easily at a bolt pin when at any time setting the hands. On this square of the pinion let the squared socket of a plain wheel be very well fitted. This wheel is about 3.6 inches in diameter, and in thickness about one-fourth of an inch. The minute wheel must have a sink in it, so as to receive the plain wheel, but the sink must be more extended in diameter, to admit a skeleton sort of a rim of a wheel with forty teeth cut inside of it. This rim must fit well the inside of the sink in the minute wheel, and be fixed to it, either by soft solder, or some other means. The minute wheel, in this case of the sink in it, will require to be thicker than in the case of the spring collet. A bolt may be lodged under a dovetail slit made in the plain wheel; in this slit, and lying close to the sink, the bolt can be made to move out or in to the inside teeth on the minute wheel; on the end opposite that of the locking end of the bolt is fixed a stout round pin or knob, for the finger to pull out when occasionally setting the hands; this pin serves also for a stout spring to push the bolt into its place between the inside teeth.

In fitting up the dial work immediately behind the dials, it may be recommended to adopt that which was contrived and put in practice in the different dial works of St Andrew's church clock; on the minute arbor, just by the lower end of the hour wheel socket, is a loose steel washer, which lies close to the fore-plate of the dial work frame; and should the wind press the hour hand and hour wheel socket down, it affects no other part, but only presses the washer against the plate. Inside of the dial work frame, and on the minute arbor, are washers, to prevent any binding on the ends of the hour-wheel socket.

In the town clock at Paris, the revolutions of the fly striking the hour are eight, for every blow of the hammer; the fly of the quarter part makes four revolutions for every quarter hammer blow, there being ten lifting pins on each side of the great wheel, making 20 lifts, the amount of the quarter blows in an hour. The wings or vanes of the flies in this clock are pretty broad and long, and can be set to take more or less hold of the air. The fly of Hindley's clock in the Orphan Hospital makes 4.57 turns for every blow of the hammer; but, from the imperfect construction of the clock, no adequate weight of hammer can be raised, and hence a sufficiency of sound cannot be obtained from the bell. It has been said, that the weight of the hammer for this purpose should be 5 pounds weight for every 100 pounds in the bell. Turret clocks in general must either have their bells too large for this proportion, or the clocks have not been made to raise a heavy enough hammer. The arm of the hammer, when at rest, should hardly make an angle of elevation above 20 degrees, or 24 at most; and in order to get as much mass of matter in the hammer head, the tail by which it is raised should be pretty long, and give a rise from the bell as little as possible. But this distance of rise from the bell must depend, among other things, on the length of the arm, and on the angle or length raised by the pin wheel and hammer tail.

It was formerly proposed to fix on the fore bar the small dial, to which the minute hand is set at, when setting those of the principal dials; but it matters not whether a dial is fixed and the minute hand is moveable, or the minute hand is fixed and the dial moveable. Suppose that, by means of three small and short brass pillars, fixed inside of the bevelled wheel, we now screw on the tops of them a light round dial, having the minute divisions and figures on it, and the minute index fixed to the fore bar, we can here make the bevelled wheel be turned about, till the minute index points to the proper minute. This mode will, besides, allow us to have more conveniently three sets of dial work, that is, two by the bevelled wheels, whose arbors are laid horizontal, and the third by connecting it with the socket of the first or front bevelled wheel.

Where turret clocks are of a large size, and have very heavy weights applied to the barrels, they require much force and strength to wind them up. In order to remedy this, an apparatus of much the same nature as that which is commonly applied to cranes has been used. This consists of a wheel, with rather strong and coarse teeth, fixed on the barrel end, opposite to that where the great wheel is. A pinion of any number, on whose arbor is a square to receive the winding up key, is attached to the clock frame, by means of a cock, &c. so as to pitch with the wheel on the barrel end; and by this means, a considerable weight can be raised with ease, requiring much less exertion, but more time, than when the winding up was performed by the barrel arbor. The clock in the town-house of Paris is wound up in this manner, which is represented in the drawing of Vick's clock, Plate CCC. Fig. 1. The size of the wheels and strength of teeth may be regulated according to the weight to be wound up. The weight of the going part is in all cases light, when compared with that which is necessary for the striking part, in most of these clocks. Besides the advantage of winding up a heavy weight with ease, this method has another, which is, that the barrel arbor pivots can be used, either in conducting the hands, discharging the quarter and striking parts, or turning count wheels, &c. The old way of the division of the hours striking by the count wheels and locking plate, and locking on the hoop wheel, does not yield in ingenuity to any thing which has been since introduced in its place by modern clockmakers. The only great objection to the old way was, the trouble of making the clock strike a round of eleven hours, when the striking of the hour corresponding with the hands took place from any accidental discharge. It may not be out of its place to observe here, that the application of the cord or rope for the weight should be on that side of the barrel which lies next to the pinion into which the great wheel acts, especially in turret clocks, as this relieves the barrel pivots of a great degree of friction, which they would otherwise undergo, were the course of the rope and weight on the opposite side.

## CHAP. XIV.

### *On the Method of fitting up Astronomical Clocks.*

Although the example of calculation which we have given for the different parts of a turret clock, is applicable to any clock; yet, in order to make the calculation more familiar and easy, we shall apply it to an astronomical clock, intended to go 32 days without winding up, performing the computation in the most rigid manner, as these clocks ought to be made as perfect as possible in all their parts.

From the inside bottom of the intended case to the under side of the seat board is supposed to be 4 feet 10.7 inches, the seat board one inch thick, and the distance from the upper side of it to the centre of the dial 3.125 inches, or $3\frac{1}{8}$ inches. From these, to obtain a proper diameter for the barrel, which is to have sixteen turns on it, we propose that the length taken up by the pulley and weight shall not exceed 6 inches, and that the weight shall be about 10lb. or perhaps even less. Four feet 10.7 inches diminished by 6 inches will be 4 feet 4.7 inches, and this doubled will be 8 feet 9.4 inches; which divided by 16, the number of turns proposed for the barrel, we shall have 1054 tenths of inches, which, divided by 16, will give 65.875 tenths for one turn round the barrel. From this, to find the diameter of the barrel, say as 355 is to 113, so is 65.875 to the diameter required, which will be found to be 2.0968 inches. The diameter given here for the barrel must be lessened by a diameter of the gut. The diameter of the gut, which we had 24 years at a month clock, and which carried a weight of 24lbs. was .045 of an inch; it might have even supported it much longer, but a different weight was afterwards hung on. It is very thick gut at .080 of an inch, and .060 of an inch is about the diameter of common sized gut, which we shall take for our estimate in the diameter of the barrel; then 2.0968 inches *minus* .060 of an inch, will give for the true diameter of the barrel 2 0368 inches. The diameter might be kept even a little larger than this, since the cutting of the screw upon the barrel for the gut to ride in will lessen it a little. The depth of the screw cannot be much more or less than .020 of an inch, at which we shall take it; 2.0368 + 0.20 will then make the diameter of the barrel 2.0568 inches. It is more than 40 years ago since we proposed that the trade in general should adopt for all their work gages, inches and the lowest subdivisions of an inch. Had this been done, it would have made all the communications between the different branches of the art extremely simple and easy; and yet, however simple this may appear, it has never been done. It must be observed, that every branch, such as movement-maker, enameller, glass-maker, spring-maker, verge-maker, &c. have all their own gages, no one of which corresponds with that of his neighbour's, and all these gages have numbers applied to them. On what these numbers are founded, it would puzzle very much both the makers and owners of the gages to tell.

To get the length of the barrel between the ends, let us take the diameter of the gut at .080 of an inch, in order to allow freedom between the turns on winding round the barrel. This .080 multiplied by 16, the number of turns proposed, will give 1 28 inch, or very near 1 inch and $\frac{3}{10}$ths of an inch, for the length of the barrel between the ends. The barrel, or great wheel, making a revolution in 48 hours, we must see what the number of teeth for it, and the second wheel pinion which it drives, ought to be, and likewise the number of teeth for the second wheel, and that of the centre pinion, so that this last shall make 48 turns for one of the great wheel. Let us assume 24 for the number of the second wheel pinion, and 20 for that of the centre pinion. If we take 6 times 24 for the number of the great wheel teeth, and 8 times 20 for the number of teeth in the second wheel, then the centre pinion will be turned 48 times round for once of the great wheel, as $6\times8=48$. Having assumed the pinions to be 24 and 20, these multiplied into one another, and the product multiplied by 48, the last product will be such a number, as when divided by a number for one wheel, the quotient will be a number for another wheel, $24\times20=480\times48=23040$, which divided by 144, the number for one wheel, the quotient will be 160 for the number of teeth of the other wheel. Or if we take 25 for the number of the second wheel pinion, and 20 for the other, these multiplied together, and the product again by 48, will give such a number, as when divided by 150, the number for one wheel, the quotient will be 160 for the number of the other wheel, $25\times20=500\times48=24000\div150=160$. The numbers for the teeth of these wheels may be obtained in the same way which we make use of to find the numbers of the teeth of the wheels for clock and watch movements. If we take 26 for the second wheel pinion, and 20 for the centre pinion, and multiply them into one another, and if the product is again multiplied by 48, the number of turns of the centre pinion for one of the great wheel, we shall have a number, which being subdivided till there is no remainder, its multiples will form such sets of numbers as may be given for the teeth of the two wheels. Thus $26\times20=520\times48=24960$, the multiples of which will be seven 2's, one 3, one 5, and 13, which give the numbers 156 and 160 for the wheels. For the subject of our astronomical clock, we shall adopt the number 144 for the great wheel, and 160 for the second wheel, and its pinion 24, and 20 for the centre wheel. The object is to have as high numbered wheels and pinions as can be conveniently got in. The diameter of the great wheel is assumed to be such, as will allow the teeth proposed for it to have strength enough to bear the exertion put upon them, which we shall take at 3.520, and for that of the second wheel 3 300. In other words, these are 3.5 inches, and .020 parts more of an inch, and 3.3 inches for the other. The pinions for the third and swing wheels are to be 16 each, the number of teeth for the centre wheel 128, and for the third wheel 120. For the sake of saving trouble to those who may be inclined to make such a clock, we shall give the diameters of the wheels and pinions, and the distance of their centres.

| | Teeth. | Diameter. | Distance of Centre. | Pinion. | Diameter. |
|---|---|---|---|---|---|
| The great wheel . . | 144 | 3520 | 2021.7 | 24 | 614 |
| Second wheel . . . | 160 | 3300 | 1830 | 20 | 437.2 |
| Centre wheel . . . | 128 | 2600 | 1437.2 | 16 | 349.3 |
| Third wheel . . . . | 120 | 2300 | 1280 | 16 | 329 |
| Swing wheel . . . | 30 | 2000 | | | |
| Wheel concentric with the second ditto . | 20 | 743.6 | 1322 | | |
| Wheel carrying the hour hand . . . | 60 | 2032.5 | | | |

The wheel of 20 is concentric with the second wheel, which, making three revolutions in 24 hours, carries the hour-hand wheel of 60 once round in that time. The hour circle will have the 24 hours marked on it, that is, from 1 to 24, being intended for a sidereal time clock. There is no other dial-work than the wheels of 20 and 60, which will require to have the hour-hand turned about by itself,* when at any time the clock is set by the minute hand. From the centre of the dial to the centre of the hours and seconds circles, is 2.5 inches to each. The centre of the great wheel is on a line below the centre of the dial about

* This cannot be considered as inconvenient by those who wish to have the most perfect mechanism for the dial-work.

1 inch, and to the left of the perpendicular line, in the centre of the dial, 2.9 inches. The centre of the third wheel is also to the left of this line, a little more than half an inch, say .519 of an inch. The 'scapement we would propose to be the same as those which we have made to astronomical clocks, after the principle of that of Mudge's time-keepers; only the pallets might be made longer, and the springs of course a little stronger. The angle of 'scapement might be reduced to 15 minutes on each side of the point of rest, and yet the pendulum may be made to vibrate about 1.5 degrees on each side. The unlocking here would be as near the lowest point as possible, or when the pendulum had its maximum force.

## CHAP. XV.

### *On Chimes and Bells.*

Chime, in its general meaning, is applied to the sounding of bells, such as change-ringing by church bells, or the striking quarters of the hour by a clock on two or more bells, or to tunes played by a clock on a series of nine, twelve, or sixteen bells, tuned to their respective notes on the scale. Clocks that play tunes on bells are called musical clocks; when hour quarters are chimed or struck by the clock itself, for example, on six or on eight bells in octave, it is called a quarter clock, and sometimes a chime clock; and when the quarters are struck by a string being pulled, it is called a pull quarter or a repeating clock, whether the quarters are struck on six or eight bells, or whether they are given by a double blow on the hour-bell, as in the repeating watch. A time piece, or going part, and having no hour striking part, but having a repeating part, is by some called a silent pull.

Various ways may be adopted for pricking tunes on the music barrels of clocks. The earlier mode of doing this was by taking a piece of writing paper of such a size as to cover exactly the surface of the barrel, and in a direction perpendicular to the axis of the barrel, to draw as many lines parallel to one another as there were notes in the tune to be laid down on the barrel, the lines being equidistant, and corresponding perfectly with the hammer tails as they stood in the hammer frame. They were marked at each end with the letters or notes they were to represent in the gamut or scale of music; and, according to the number of bars in the tune, as many spaces were made by lines drawn equidistant and parallel to each other, intersecting the others at right angles. The junction of the ends of the paper, when applied round the barrel, represented one of these bar lines. The length or breadth of the spaces (which might be either squares or parallelograms) contained between the bar and note lines, was again divided on the note lines into as many parts or spaces as the number of crotchets in a bar, and for notes of lesser value a less space was taken. While the paper was lying on a table, the notes in the tune proposed to be laid on the barrel were marked by a black ink dot on their respective lines, and in the same order as the bars of the music lay. After this was done, the paper was pasted on the barrel; the note lines now appeared like so many circles traced round the circumference of the barrel, while the bar lines lay longitudinally on the surface of it. By this means the black ink dots were transferred and marked on the barrel by a punch or finger drill. This mode might answer very well where large barrels were used, and only one tune laid on; but in smaller work, and where several tunes were to be put on the same barrel, it is neither sufficiently neat nor accurate.

We are not acquainted with the method adopted by those workmen in London who practise the pricking of music on clock barrels; but having had occasion to construct some musical clocks above thirty years ago, and having no opportunity of getting the music pricked on the barrels by any professional person, it became necessary to contrive some method for this purpose. One way consisted in applying the barrel concentric with the arbor of a wheel cutting engine, whose dividing part consisted of an endless screw and wheel; and having fixed other apparatus on the engine for this purpose, different numbers of turns of the endless screw were taken for the longer or shorter notes, and the tunes were as accurately put on the barrel as could be wished. Another way consisted in placing the barrel and its train of wheel work and regulating fly in the frame. A force was applied to turn the barrel, wheel work, and fly round, in the order of lifting the music hammer tails, and an apparatus was used to mark the dots on the barrel. The fly made 360 revolutions for one turn of the barrel; or, should this be thought too quick a train, it might be made by altering the numbers of the wheel teeth to make 250 or 260 revolutions for one turn of the barrel; the train or revolutions of the fly being fixed, was made use of in the same way as the endless screw in the former way, by taking a greater or a smaller number of turns of the fly for the longer and the shorter notes. Knowing the number of bars in the tune, and the crotchets in a bar, by calculation, the number of turns of the fly was obtained (and parts of a turn, if necessary) that a crotchet required, so that the tune might go round the barrel, leaving a small space for locking and running; this was all that was required to be known: quavers and semiquavers came to have their proportion according to the value of the crotchet. Although the process of putting tunes on barrels answered very well by both these methods, yet it was rather tedious, and attended with some trouble and embarrassment in the operation; and a more simple and easier method of doing this was afterwards contrived and adopted, by which we could lay on a tune with the greatest accuracy and expedition in nearly ten minutes.

Although bell music is not of a favourite kind, yet, for the benefit of such clockmakers as may be disposed to construct music clocks, and have not the opportunity of getting the music pricked on the barrel by those whose profession it is to do this sort of work, we shall give a description of the tool and its apparatus, which will be found very well adapted for this purpose, and also of the manner of using it.

Having a good strong turn-bench, such as those used by clockmakers for their larger sort of work, to the standards or heads of it let there be attached supports on each side; to the supports on the side nearest the workman, let there be fixed a straight cylindrical rod AB, about ten or twelve inches long, and in diameter a quarter of an inch, or even three-tenths of an inch. A spring socket CD must be made for this rod to slide easily and steadily along it, somewhat like the socket which slides on the upright stalk or rod of a watchmaker's glass stand. In the thick and strong part of this socket E is fixed a steel arm EFG, bent into a curve, which lies over and above the music barrel when in the turn-bench, as shewn in Plate CCCVIII. Fig. 2. at EFG. The steel rod AB may at pleasure be placed at any distance from the barrel, about an inch or rather more, and should stand parallel to the barrel arbor MN, and nearly in the same plane with it, but rather a little above this than otherwise. On the outer end of the curved arm is fixed a flat piece of steel G, a little more than half an inch long, in breadth not quite so much, and about one-tenth of an inch thick. The lower and front edges of this flat piece of steel should be neatly and smoothly rounded off, so as to allow it to come easily and freely into the notches *a*, *b*, *c*, &c. which are on the edge of a thin brass scale, whose use will come afterwards to be explained. To the supports attached to the turn-bench heads, and on the opposite side to that where the round steel rod is placed, let there be fixed a slip of brass XY, about ten or twelve inches long, an inch and a half broad, and nearly a tenth of an inch thick, the inner edge of which must be made to stand parallel with the barrel, and the flat side to stand nearly in a plane between the upper surface of the barrel and its centre, the edge being placed so as to stand clear of the tops of the teeth of a high numbered wheel WW screwed on to the end of the barrel. Near the ends of this slip of brass slits are made, through which screws *s*, *s*, pass that screw it to the upper side of the supports; the slits serving to allow it to be moved a little occasionally lengthwise when required. On the upper side of the slip of brass is fixed another, but not quite so thick, the length being about that of the barrel, and breadth one inch and three quarters. On the inner edge of this are made as many notches *a*, *b*, *c*, &c. as there are hammers, bells, or notes, to be used in the tune or tunes to be marked on the barrel. These notches are equidistant, and the middle of them should correspond to the middle or line of the hammer tails; their width being such as to admit the flat steel piece G on the end of the curved arm EFG; the depth of them cut on the edge of the brass should be about one quarter of an inch. The edge of this piece of brass, or music scale as it may be called, must also stand parallel with the barrel, and at a little distance from it, not nearer than three-tenths of an inch, so that the flat steel piece on the end of the curved arm may have room to get in a little way, and to pass through at the same time to a cetain degree of depth. On the upper side of this brass slip the letters of the scale of music or gamut are marked to those notches which correspond with the hammer tails, and hammers intended to strike on the bells the notes so marked, but in an inverted order to the usual way in which they are marked in the scales of music, the lower notes being on the right hand side, and as they rise going to the left. This is done to suit the way in which the bells are commonly, though not necessarily, placed in music clocks (See Plate CCCVIII. Fig. 3); for a clockmaker of any ingenuity might contrive the barrel to turn any way he thought proper, and place the bells to stand in the order of the music scale, if there was any advantage to be derived from it. In the curved arm EFG, Fig. 2. is fixed a punch *f*, having a very fine and sharp conical point, at the distance of four inches or so from the centre of the sliding socket, and not quite an inch from the outer end of the flat steel piece; the punch when applied to the barrel should stand upright, and directly over the centre of it. This apparatus being all adjusted as we have directed, it is evident that, when the curved arm is raised up a little way, the socket can then be made to slide easily along the steel rod, and by this means bring the outer end of the flat steel piece very readily into any notch required, and the point of the punch is brought at the same time with the greatest precision to the place of the note on the barrel, leaving the flat steel piece for the time in the notch: The point of the punch touching or resting on the barrel, a stroke from a very small hammer on the top of it will cause the point to make a pretty deep mark or conical hole on the surface of the barrel.

It now remains to be shewn how the time or the lengths of the different notes are determined. Long or slow, short or quick notes, such as the minim and demi-semiquaver, are not well suited to bell-music, and, of course, are seldom introduced into tunes chosen for it; the crotchet, quaver, and semiquaver, forming the greatest part of the composition: the minim and demi-semiquaver may, however, be brought in at some parts. It may be unnecessary to state, what is pretty generally known, the proportional value of the notes to one another; suffice it to say, that a minim is equal to two crotchets, a crotchet to two quavers, a quaver to two semiquavers, and a semiquaver to two demi-semiquavers. The time in which the barrel turns, after striking or lifting a hammer-tail, to strike any note on a bell, must be in the same proportion with the notes, according to their respective character. Let a wheel of 250 teeth, for example, be fixed on the end of the barrel, and let both be placed in the turn-bench, with the apparatus which has been described: To the turn-bench is now attached a steel or brass spring, having a knee or bending at one end, so that it may fall into the spaces of the wheel-teeth. The tune of the Jolly Young Waterman (See Plate CCCVIII. Fig. 5.) being proposed to be laid on the barrel, will, by inspection, be seen to contain 20 bars of three crotchets each, being 60 crotchets: if 250 the number of the wheel is divided by 60, the number of the crotchets, we shall have four for the quotient, and ten for the remainder; shewing that we may take four teeth or spaces for every crotchet, ten, the remaining part of it, serving as a run for locking, and the other part for a run at unlocking, for a tune to be played. Now as a crotchet is equal to four spaces, a quaver must be equal to two, and a semiquaver equal to one. In the tune proposed, the first note is F ♮; the curved arm is brought to the left hand, and the flat steel piece put into that notch; the punch is then made to mark the barrel; and this being a semiquaver, or the fourth part of a crotchet, the spring index is shifted into the next space of the wheel teeth, and the curved arm moved to the next note, which is G, on the left hand, and the flat steel piece being put into the notch corresponding to G, the punch is made to mark it on the barrel. This being a semiquaver also, the spring is shifted into the next space, and the curved arm moved to note A on the left; the steel piece is put into the corresponding notch, and the punch marks this on the barrel. A is here equal to a quaver and a half; therefore the spring index must be moved over three, or into the third space, and the curved arm moved to the next note, being B, on the left hand; the steel piece being put into this notch, the note is marked on the barrel; and as it is a semiquaver, one space is taken for it, and the arm moved to G. This being marked, and as it is a quaver, two spaces are taken, and so on. When crotchets are marked, four spaces are taken after marking them. In the tune which we have used, nine bells or notes are all that is required; and three more, or a dozen, would give such a compass as to take in almost any tune that might be required. In place of the spring index, it would be better to have a single threaded endless screw to work into the wheel teeth, one turn of which would be equal to a tooth or space. The arbor of the screw being squared on one end, and a small handle for turning it being put on, there would be less danger of making mistakes with the screw than with the index. On the arbor of the screw there might also be put a hand or index, to point to a circular space or dial of eight or ten divisions. This would give room to make parts of a turn, where great nicety is required. After one tune is laid on the barrel, either it or the music scale must be shifted a short space when the next one is to be put on. To shift the music scale is perhaps the preferable way of the two; and the spaces for shifting should be marked on the top of one of the supports, and close by one end of the long slip of brass; or they might be marked on a short line drawn longitudinally on the surface of the barrel, at or towards one of the ends of it; or by taking both methods, the one would serve as a check on the other. The length of shifting depends on the distance between the hammer tails and the number of tunes to be put upon the barrel. For example, if the distance between the hammer tails is four-tenths of an inch, and it is proposed to put eight tunes on the barrel, then, if we divide four-tenths by eight, we shall have half a tenth for the length or space to shift for each tune; and this is taking advantage of the whole space between the hammer tails, a circumstance which is frequently overlooked; for where the shifts have been confined to a less space for shifting than might have been got, so much room is lost. The distance between the hammer tails depends on their number, and on the length of the barrel. We have made the distance a quarter of an inch, where the number of hammers were eleven, and the length of barrel about three inches and a quarter, the number of tunes put on the barrel seven, the spaces for shifting were three hundred parts of an inch, or thereabouts, and where the clock of itself shifted the tune. When the hammer tails are thin, a number of tunes could be made to have their shifts in a very short distance between the tails; the diameter of the lifting pins must also be taken into account, being of some consideration where the spaces for shifting are extremely limited. Although we have taken the number of the wheel teeth for dividing the notes at 250, yet either a greater or less number may be assumed; all that is required is to proportion the number of turns of the endless screw, and parts of a turn, to the number of bars in the tune, and to the notes in each bar, and to have the tunes to go nearly round the barrel, so that a small part of a revolution of it, after the tune is played over, may be left for what is called locking and running. If the dividing wheel was taken at 128 teeth, and the tune being supposed to have 20 bars, each bar having three crotchets, as in the former example, 128 teeth divided by 60, the number of crotchets, the quotient would be two, and the remainder would be eight; so that each crotchet would require two teeth or turns of the endless screw, a quaver one turn, and a semiquaver half a turn, and the remaining eight teeth would serve for locking and running. When the tunes are all marked on the barrel, each mark must be drilled to obtain holes for the lifting pins to be driven into them. Great care should be taken to have a stiff and excellent drill, so as to run no risk of breaking, which would occasion a great deal of trouble; and it should be of such a temper, and well and judiciously whetted up, so that it may drill all the holes without requiring to be once sharpened up: the object here is to have all the holes of the same width, so that the lifting pins may be all of the same diameter. The holes being drilled, and the barrel polished, a number of pins should be prepared into lengths of half an inch or so each, and a very little tapered at one end. The stronger and harder the brass wire for the pins is, so much the better; some of the best kind of pins used in the female dress are very fit for this purpose. In placing the pins in the holes, if they should be found too long for knocking in by the hammer, they should be shortened by the cutting plyers before the hammer is applied, which will prevent bending, and allow the pins to have a more secure hold of the barrel rim. After all the pins are put in, they must now be shortened to an equal and proper length or height. For this purpose prepare a hard cylindrical steel collet, having a hole in its centre sufficiently wide to allow it to be put readily on the pins; the lower end of it hollowed, the upper end rounded, and the height of the collet about one-twentieth of an inch or a little more; the height depending on the size of the barrel and the diameter of the pins. The collet being placed on a pin, the cutting plyers are applied to cut the pin just over by the rounded end; a small touch of a file takes away the burr made by cutting, and as the hardness of the collet prevents the file from taking any more away from the height of one pin than from another, they must be all of an equal height. This operation being finished, the small burrs made on the top of the pins by the file must be taken off; this is done by a piece of steel wire, about six or seven inches long. The end where it is twirled about by the fore finger and thumb should, for the length of an inch or so, be made into an octangular form, for the more readily turning it round back and forward. On the face or point of the other end, two notches are made across each other, which may be either angular or round at bottom; the latter may be the better of the two, if rightly executed, and should be made with the round edge of a flat file, whose thickness should not be more than the diameter of the pins. The point where the notches are cut should be hardened, and the inside and bottom of the notches polished, so that a sharpness may be given to take away the burrs easily from the top of the pins.

The shape of the hammer tail is such as is represented at Plate CCCVIII. Fig. 3, a form which makes the hammer easy enough to be drawn, and the tail takes little or no room when falling; and should two pins or notes succeed each other rather rapidly, the nib or point of the hammer tail will not be interrupted by the succeeding pin. In the first musical clocks, and even in those made long afterwards, the bells were all placed on one strong iron bell stud, the opposite end of which was supported by what may be called an auxiliary stud, which occasioned a crampness that prevented the bells, when they were struck by the hammers, from vibrating, or giving out that full tone which they might have otherwise been made to produce; and the improvement made on this, as well as on the quarter bell studs afterwards, was effected by placing each bell separately on its own bell stud, which was made of well hammered brass, having some degree of elasticity. The sweetness given to the tone of the bells by this method was truly surprising. The bells in this kind of music may be sounding at the time that a succeeding note is struck out and sounding too, which may not be so pleasant to a very nice ear. This can be prevented by having a double set of hammers, and having every tune pinned twice over on the barrel, one set of the hammers having the heads of buff leather, or having a brass head with a piece of cloth sewed over it. These, when they strike the bell, will damp the sound of the note which is last struck. The buff hammer should fall on the bell to be damped, at the same instant that the brass hammer strikes the succeeding note on its bell. This improvement, however, must greatly increase the expence on such a clock; but the effect of buff or cloth hammers is so striking, that the additional price ought not to be grudged.

In Plate CCCVIII. Fig. 3, AA is a circle representing an end view of a clock music barrel, and a few of the lifting pins. The dart shows the direction in which it turns. The letters *a*, *a*, *a*, *a*, *a*, represent a section or end view of a brass piece thus shaped. The length depends on that of the barrel, and the number of hammers to be let into this brass piece, which is called the hammer frame, the length of it being sometimes three or four inches, sometimes ten or twelve. The flat part of the hammer tails fills up the thick part of the hammer frame, into which slits are made to receive the hammers. Near to the outer and lower angular part at *a* of the frame, a hole *h* is made through the whole length of it, not drilled, but ploughed, as the workmen call it, and this is done before any slits are made in it for the hammers. A wire is put through this hole, and through corresponding holes in the flat part of the hammer tails. This wire is their centre of motion, and the holes in them are made so as to have freedom on it, and the flat part of the hammer tails are also made to have freedom in the slits made to receive them. On the under side of the hammer frame at *b*, the hammer springs *c*, *c* are screwed, one for each hammer, acting on that part of the hammer tail just where it comes out of the thick part of the hammer frame. When the pins in the barrel raise up any hammer by the nib, and carrying it away from the bell, at the instant the pin quits the nib, the spring *c*, *c*, by its returning force, makes the hammer head give a blow on the bell, to elicit the sound. To prevent any jarring in the bell by the hammer head resting or touching it after having given the blow, each hammer has a counter-spring, acting near the lower end of the shank, and inside of it. All the counter-springs are made to project from one slip of well hammered brass, and screwed on the top of three kneed brass cocks, fixed to the upper side of the brass frame. *d d* is a view of the side of one of the cocks; and *e e* an edge view of one of the counter-springs. *f f* is a side view of one of the bell studs, which are also screwed on the upper side of the hammer frame: an edge view is seen at *f f*, Fig. 4. *g*, *g*, *g*, *g* are edge views of the bells. *g*, *g*, Fig. 4. is a side view of one of them as fixed to its stud. In some musical clocks, in place of the barrel being made to shift for change of tune, the hammer frame is made to shift, carrying with it all the hammers and bells. The change, or shifts of the barrel, is either done by hand or by the clock itself. The mechanism for this commonly consists of a wheel fixed on a steel arbor, on the square of which a hand is put, which points to the name or number of the tune marked on a small dial, at which the barrel for the moment stands. The diameter of this wheel is about one inch and a half, and sometimes more or less. The rim is a strong and thick hoop or contrate form, having as many steps on it as there are tunes set on the barrel, the height of the steps being equal to the space from one tune to another. On these steps rest the kneed end of a double lever about four inches long, whose centre of motion is in the middle, and is either upon strong pivots run into a kind of frame, or upon a stout pin, which goes through the lever and the brass stud in which the lever moves. The other end of the lever bears on the end of one of the pivots of the music barrel, which is pressed against it by means of a pretty smart steel spring, acting against the end of the opposite pivot. Concentric with the hoop wheel, and fixed on the same arbor, is a star wheel of a number according with the steps on the hoop wheel, a jumper with a pretty strong spring works into the star wheel, by which means the barrel is kept always to its place, by the lever bearing at one place on every step. Although the Figures which have been given to represent the hammer frame, hammers, springs, and counter-springs, bell studs, and bells of music striking, are not exactly like those which are commonly made to strike quarters in clocks, yet they are equally well calculated for the purpose; only the nibs of the hammer tails need not be so far from their centre of motion, being less confined by the pins in the quarter barrel, which are fewer in number than those on a music barrel. A quarter barrel need not be much in diameter, if five quarters are only to be put on it. If ten is intended to be put on, then the diameter should be double that of the other.

After having described the method of laying down the tunes on a music clock barrel, it may be thought unnecessary to explain the method of putting on the quarters of a clock quarter or chime barrel. But, simple as it is, we conceive it will be both interesting to the general reader, and acceptable to workmen who may not be in the habit of contriving for themselves, or who may not have had an opportunity of seeing it executed by others.

Quarters are commonly struck on a set of eight bells, from G to G in octave, or they may be numbered 1, 2, 3, &c. on to 8. The quarter barrel may have eight circles faintly turned on it, so as to correspond to the quarter hammer tails. Five, and sometimes ten, quarters are put on the barrel; we shall, however, in this instance only lay five on the barrel. Take a wheel cut into 50 teeth not rounded off, and screwed temporarily on the end of the barrel; provide an index, and a piece of brass bent so as to apply to the barrel when in the turn bench, in the manner of a straight edge, and the index spring tight in the teeth; take a point, and make a slight trace across the circle, which corresponds to high G or No. 1, then move the index a tooth, in the direction the quarter barrel turns when moved by the wheel work; make a trace across the circle intended for the second hammer, and so on. When the eighth circle has been marked, move the index two teeth for the first hammer of the succeeding quarter, and so on till the whole is completed; the barrel may then be drilled and pinned accordingly. Should the intervals between the quarters be thought too little for locking, the wheel, in place of 50, may be cut 55, and this will allow three teeth in place of two for the intervals. G, A, B, C, D, E, F G, may also be represented by the figures 1, 2, 3. 4, 5, 6, 7, and 8. No. 1. being the high G, and 8 the low G The changes given in the following set of chimes or quarters, will exhibit how to proceed in putting them on the barrel, after what has been already said.

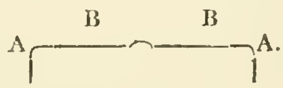
*A set of Chimes for Clock Quarters; the barrel making two revolutions in the hour.*


With the number of 8 bells and hammers for the quarters of a chime or quarter clock, a great variety may be produced; and where it may be preferred to have the chime or quarter barrel to make one revolution for the ten quarters which are given in the course of every hour, we shall give a specimen of a set of chimes which may be put on such a barrel.

*A set of Chimes for Clock Quarter Barrels, which make one revolution in an hour.*


*On Bells.*

It is still a point undetermined, whether the common shape of the bell, or that which is called the dish-form, and used chiefly in house clocks, is the best. The great expence which attends experiments on bell founding will probably keep this point long undecided. Being in possession of a manuscript, containing some of Professor Ludlam's remarks on the subject of bell founding,* which we conceive to be very valuable, we shall lay them before our readers. "I saw a great deal of the art of bell founding," says Mr Ludlam, "in the time of the late Mr Thomas Eayre of Kettering, a man who had a true taste for it, and spared no expence to make improvements. Much of tone depends on minute circumstances in the shape; and Mr Eayre had crooks or forms cut on thin boards, carefully taken from the inside and outside of all the good bells he could find. This county (Cambridge) and Northampton abounds with the best bells I ever heard, cast by Hugh Watts of Leicester, between 1630 and 1640. Ringers in general, who are commonly constituted the judges of bells, (and as such are feed by the bell founder,) regard neither tune nor tone. The hanging of the bell is all they regard, that they may show their dexterity in change-ringing. That shape of a bell that is best for tone, (a short one,) is not the best for hanging, so tone is utterly disregarded; to please the ringers, and to get money, is all. In my opinion, the thinner the bell and deeper the tone the better, provided it is not shelly, that is, like a thin shell, with such a tone as the fragments of a broken Florence-flask will give. A deep tone always suggests the idea of a great bell, is more grave, and better suited to the slow strokes of a church clock, and is heard farther. The clock in St Clement Dane's church in the Strand, London, strikes the hour twice—once on the great bell in peal, and again on its octave or 12th, I know not which; listen to them, and you will perceive which is most agreeable and best heard. The son of Mr Thomas Eayre, who was a good bell founder, cast a dish-bell of five or six hundred weight, for the church clock at Boston, in Lincolnshire, the tone of which was very deep and wild. Mr Thomas Eayre, very early in life, made a curious chime for Sir T. Wentworth, afterwards Lord Malton, and father of the Marquis of Rockingham, which had thirteen dish-bells, the biggest about two hundred weight. This is at Harrowden, near Kettering. Thomas Eayre, his son, and his brother Joseph, being all dead, to their bell-founding business one Arnold succeeded, who had worked with Joseph Eayre, and is now at St Neot's, Huntingdonshire. Arnold I believe to be a much better bell founder than the White Chapel bell founders, though by no means equal to old Thomas Eayre. Romilly always would confound Thomas Eayre with Joseph Eayre, and so imputed the faults of the one to the other. Romilly was so conceited when at Leicester, where there is undoubtedly the best peal of bells in the kingdom, (partly old Watt's and partly Thomas Eayre's,) that he would not so much as deign to hear them. I cannot help thinking that a bell of five or six hundred weight, of the dish form, might be cast far fitter for your purpose, than one of the church form. But who will do it? Who has had any experience of bells of this form? It must also be observed, that small differences, in the form, in the shape or thickness of the sound-bole of a church bell, will make great differences in the tone. All I can say is, it is not the weight of metal, but something resulting from the shape of the bell, that gives both freedom and depth of tone, as I can prove by many instances. What that shape is that makes a bell so willing to speak, is a question which a good bell founder ought to be able to answer. It is a known and undoubted fact, that a bell speaks much better, when both the clapper and the bell is hammer hardened, and when they are worked in to touch each other in many points. I now recollect, that above 40 years ago, Thomas Eayre made a large turret clock, with quarters, for Lady E. Germain, (now Lord G. Germain's,) at Drayton, near Thrapton, Northamptonshire, all the bells of which are *Dish-Bells* of a large size. I know not their weight exactly, but suppose the biggest four hundred weight—they are heard a great way."—"There is an instrument brought from China, called a gon or gong, made of hammered brass, or of some sort of a metallic composition, about 16 inches over. The drawing is a section of it.




What I call the sides AA are about four inches deep, and seem to supply the office of the sides of a drum, while the flat part BB answers to the stretched parchment; only there is a round part in the middle to stiffen it. On this raised part you beat with a ball of packthread of four or five inches diameter, fastened to the end of a stick. The metal, at a mean, is about one-eighth of an inch thick, but unequal, the whole form being manifestly raised out of a flat plate by the hammer. The tone is amazingly deep, clear, and sonorous. The note of that I saw, and had some time in my possession, was F, an octave below the F faut cliff in the bass." See our article GONG.

That music which is produced by clocks with organ barrels must be greatly preferable to that of bells, and the apparatus for marking the tunes on clock barrels is equally suited to do the same on barrels intended by machinery to work or to sound the pipes of an organ; the

* These remarks are contained in a series of unpublished letters written by that eminent Professor, and copies of which are in the possession of the writer of this article. See p. 480, col. 2. of this article.

difference consisting in marking off on the barrel the spaces of the longer and shorter notes, as in place of pins they have staples or bridges of various lengths, according to the length of the note, or the time which the pipe should be allowed to sound it: The very short notes are by pins of different thicknesses. When an organ part is put to a clock, considerable power or force of weight or spring is required; small as the organ may be, or its wind chest, some force is required to work the bellows, so as to keep the wind-chest full, and no more. To work the bellows, that is, to move the lower board of them up and down, on the inside of which is an air valve that opens on the board being moved downwards, and on the motion upwards it shuts, and the air being then compressed, it is forced into the wind-chest by a communication between them for that purpose, and is ready to give sound to any of the organ pipes the moment when any of their valves should open. This operation with the bellows, though of a different shape, is just the same as with the common bellows when blowing up a fire. The bellows is worked by means of a short crank fixed on one end of the arbor of an endless screw, which works into a trundle of a high numbered pinion, which is on the end of the organ barrel, and nearly of the same diameter with it. On the other end of the endless screw arbor is fixed a small jagged pulley, over which is put an endless silken cord, which being continued, goes round another jagged pulley on the end of a pinion arbor of one of the quick running or fly wheels in the organ train. These wheels are regulated by a fly, by which the velocity of the organ barrel in turning is brought to keep the time required for the music. The wheels, on being impelled by the moving power, which is considerable, (being greater than that used in bell music,) communicates their motion by means of the endless cord, and turns the organ barrel. The pins, bridges, or staples, on the barrel turning, act on the tails of levers nearly similar in form to the hammer tails of the bell musical clock, only they are a little longer, and equally moveable on a centre or wire. The other arms of these levers are in an opposite direction, and are about the same length as those which are lifted by the staples on the barrel when turning, and are a little broad and flattish towards the end, where the under side (on the opposite ends rising) press down on the upper ends of the slender rods, whose lower ends then by this means open the valves of the organ pipes, and the sound is prolonged according as the lift is pins or bridges. What has been described constitutes the chief machinery in an organ clock. Many ways may be contrived to set the organ barrel in motion, and at the same time while playing, and at the end of a tune, to make the clock of itself shift the barrel from one tune to another.

Within these two or three years, a new species of music by steel springs has been invented at Geneva. From the smallness of the machinery which plays the music, it is very surprising and curious, as it has been put into rings, seals, watches, and snuff boxes. Two ways are used to lift the ends of the springs which give the different notes; one is by a very small barrel, the other by a plate wheel. The last, being more adapted to take up little room, is chiefly used in watches. The space for the springs falling, after being bent up, is short. A double set of springs for giving the same notes is made, without which the beauty of the music could not be produced. The number of springs varies, for the most part, from sixteen to twenty-four, or upwards. Those springs which are lifted by the barrel pins are straight, while those which are lifted by the pins in the plate wheel have a sort of part projecting from the end at one side; and this side edge of the spring lying over the top of the pins is taken away, so as to clear them. The projecting part at the end of each spring corresponds with its own lifting pin. As the pins are on both sides of the plate-wheel, this allows a greater variety of notes than the barrel can perhaps admit. The springs on the upper and under sides of the plate-wheel are sometimes sixteen or seventeen on each side. On the plate-wheel are traced 16 or 17 concentric circles, for the pins to meet their corresponding notes in the springs, whose ends come each to their corresponding circle both above and under the plate-wheel. An apparatus on a small scale being made like that which has been described, will serve to put or mark the places for the notes both on the barrel and the plate-wheel; the only difference is, that the barrel will require to be marked by a curved arm sliding on a steel rod. The concentric circles on the plate wheel must have short and faint traces across them: This is regulated by a thin straight edge, laid in an oblique direction across the circles, and the intersections are afterwards marked by a point. The springs may be easily tuned to their respective notes, as the least thinning or shortening them will make a very sensible alteration on the tone. The tongue of a steel trump, or Jew's harp, shews, in some degree, what may be done in this way by steel springs. The train which regulates this very minute musical machinery, as may very easily be conceived, must be composed of a few very small wheels, the motive force being proportionably small. It must be a great effort of patience and ingenuity to make them play two or more tunes. However beautiful and ingenious the machinery of these small contrivances is, they can only be considered as toys for amusing children.

For further information on subjects connected with Horology, see Longitude, Organ, Pendulum, Timekeeper, and Watches.

HORSE. See Mammalia.

HORSES, Diseases of. See Veterinary Medicine.

HORSEMANSHIP. See Manege.

HORSLEY, Samuel, one of the most eminent theologians in modern times, was born in October 1732, and was the eldest son of the Rev. Mr Horsley, minister of St Martins in the Fields. He received the classical part of his education at Westminster School, from which he was removed to the University of Cambridge, where he applied himself principally to mathematical studies. After having taken his degree as master of arts, he went to Oxford, in the capacity of private tutor to the Earl of Aylesford, where he received the degree of doctor of laws. On leaving this university, he came to London, where he was elected a fellow of the Royal Society, of which he was chosen secretary in 1773. He published several valuable papers in the Transactions of that learned body, and continued to discharge the duties of his office in a very distinguished manner, till the resignation of the president Sir John Pringle in 1778. Soon after his having settled in London, he accepted the office of chaplain to Bishop Lowth, one of his greatest patrons, who presented him to the rectories of St Mary Newington and Albury in the county of Surrey; appointed him Archdeacon of St Albans in 1778; and, in 1782, conferred upon him the valuable living of South Weald in Essex. In 1788, he was raised to the bishopric of St David's by the interest of Lord Thurlow; and, in 1794, was translated to the see of Rochester, holding at the same time the deanery of Westminster. In 1802, he was promoted to the see of St Asaph; and is generally understood to have had his Majesty's promise of the Archbishopric of York. He died at Brighton on the 4th of October 1806.

These numerous promotions, and high prospects as a dignitary in the English Church, were fairly earned by the eminent services which he rendered to the cause of sound principles and sacred literature. In 1769, while residing at Oxford, he published a valuable edition of Apollonius, and discovered his thorough qualifications for illustrating the works of the ancient geometers. In 1799, he produced an edition of Newton's Works, in five volumes 4to, with commentaries and separate dissertations; an undertaking, in which he is generally allowed to have done more than could reasonably have been expected from one, whose acquirements on other subjects were so diversified and distinguished; but, at the same time, to have failed in that full illustration of his author, which the improved methods of calculation and analysis might have accomplished. In 1778, he published a sermon on the consistency of the doctrine of Divine Providence with the free agency of man, in which he combats the necessitarian tenets with great ability. In 1789, he collected and printed in one volume the tracts which he had written during the preceding six years, in his celebrated controversy with Dr Priestley on the Unitarian system; a discussion in which he is now generally acknowledged to have had a decided superiority, both in learning and argument, and in which his productions must always be read as standard works, and admired as models of clear and powerful reasoning. In 1790, he published a pamphlet without his name, entitled "A Review of the Case of the Protestant Dissenters," in which he vindicates in a highly nervous style the high church principles on the subject of the test laws. In 1796, appeared from his pen a very learned dissertation on the Latin and Greek Prosodies; in 1800, a critical disqusition on the 18th chapter of Isaiah, in a letter to Lord King; in 1802, a new Translation of the Prophet Hosea, with critical and explanatory notes. Besides many smaller pieces, he was the author of an Elementary Treatise on the fundamental principles of Practical Mathematics, which appeared in three volumes in 1801 and 1803, and of a Critical Essay on Virgil's Two Seasons of Honey, and his Season of Sowing Wheat, with a new and compendious method of investigating the Rising and Setting of the fixed Stars. There have been published, since his death, three volumes of his Sermons, a volume of his Charges, a volume of his Speeches in Parliament, and a Translation of the Book of Psalms with notes. He has also left in manuscript, a Treatise on the Pentateuch, and on the Historical Books of the Old Testament; and a Treatise on the Prophets, containing Notes on Isaiah, Jeremiah, Ezekiel, Joel, Amos, and Obadiah; which are announced to be in a state ready for the press, and which, it is to be hoped, will not be suffered to be lost to the Christian world by any want of encouragement on the part of the public. His son, the Rev. Heneage Horsley, proposes to publish an uniform edition of all his father's works, with a biographical account of the author.

The name of Bishop Horsley stands unquestionably in the first rank of the scholars and divines of the present age. His intellectual powers were of the highest order, and of so versatile a nature, that wherever he applied his attention, he was generally sure to take precedence. He possessed an almost inexhaustible activity of mind united with an ardent spirit of research, and a capability of constant exertion, which, had his pursuits been less various, might have raised him to a still higher point of eminence. In the mathematical and physical sciences, he held a respectable station. In metaphysical acuteness and research, he had few superiors. In classical attainments, and particularly in a critical knowledge of the sacred languages, he occupied the very foremost rank of excellence. In the most recondite theological erudition, he was not surpassed by any of his contemporaries. And, in the church of which he was so distinguished an ornament and support, he was pre-eminent for his consistency and decision, as the champion of a sound and scriptural creed. In public speaking, his voice was sonorous and commanding, and his whole elocution distinct and impressive. In the duties of his Episcopal office, he was eminently exemplary; and, in the see of St David's particularly, he strenuously exerted himself to accomplish a regular system of improvement in the qualifications and condition of its clergy. He examined in person the candidates for holy orders, and inspected carefully the titles which they produced. He treated them, at the same time, with paternal kindness, encouraging them to visit him, assisting them with his advice, and ministering, with a bountiful hand, to their temporal necessities. In his progress through his diocese, he preached frequently in the parish churches, and bestowed liberal donations on the poor. In the House of Peers, he supported the character of an enlightened and eloquent senator; and took a part in most of the important discussions of his time. In his political and ecclesiastical sentiments, he must be classed, and readily classed himself, among high churchmen (a term, which we profess to use not as vituperative, but merely as descriptive;) but it has never been doubted, that his zeal was conscientiously sincere; and it is certain, that, on many occasions, he discovered a greater degree of genuine liberality and practical toleration, than many who were louder in their pretensions. He was a systematic opponent of the slave trade; and is understood, on good authority, to have been anxious to enter into a parliamentary enquiry into the claims of the Irish Catholics, with a view to grant them whatever privileges might have appeared compatible with the security of the Protestant succession and the Protestant establishment. He was an earnest advocate for mutual forbearance between the two most respectable parties in the Church of England; and the decision of his comprehensive mind on the points in dispute deserves to be emblazoned in every vestry of the English and Irish establishments. "The Calvinists contradict not the avowed dogmata of the church; nor has the church in her dogmata explicitly condemned or contradicted them." He has been charged with harshness and dogmatism in his character and manner, especially as a controversialist, and it would not be easy to exculpate him wholly; but much of this intolerance, often more apparent than real, evidently arose from his zeal for the truth which he defended, and his high sense of its importance. His language, at the same time, however strong, was always dignified; and his works in general rather display an undisturbed liberality of judgment and expression towards the advocates of conflicting opinions. Even his sternest polemical tracts contain many expressions of the most magnanimous candour, of which the following conclusion of one of his letters to Priestley may be given as a striking specimen. "The probability, however, seems to be, that, ere those times arrive, (if they arrive at all, which we trust they will not) my antagonist and I shall both be gone to those unseen abodes, where the din of controversy and the din of war are equally unheard. There we shall rest together, till the last trumpet summon us to stand before our God and King. That whatever of intemperate wrath and carnal anger hath mixed itself, on either side, with the zeal with which we have pursued our fierce contention, may then be forgiven to us both, is a prayer which I breathe from the bottom of my soul, and to which my antagonist, if he hath any part in the spirit of a Christian, upon his bended knees, will say, Amen." See *Preface to Horsley's Sermons; Monthly Magazine*, 1806, vol. xxii. p. 401.; *Gent. Magazine*, 1806, vol. lxxvi. p. 987, &c. Montucla, *Hist. des Mathematiques*, tom. iii. p. 13. edit. 1803; *Phil. Trans.* vol. lvii.—lxvi.; and *Public Characters* for 1807. (*q.*)

# HORTICULTURE.

1. By the term Horticulture, is to be understood the whole management of a garden, whether intended for the production of fruit, of culinary vegetables, or of flowers. The formation of a garden may be included also, to a certain extent, under this subject: draining, inclosing, and the forming of screen plantations and hedges, may be considered as parts of horticulture; while the general situation of the fruit and the flower gardens, in regard to the mansion-house, and the position of some of their principal component parts, as shrubberies, hot-houses, parterres, and walks, belong more properly to Landscape-*Gardening*; which see.

It is evident, that the horticulture of every country must vary in its nature and objects, according to the climate. The great end of this article will be, to exhibit as correctly as possible the present state of gardening in Britain, noticing particularly the improvements which have recently been introduced, especially since the close of the 18th century. After a general prefatory account of the rise and progress of horticulture in this country, we purpose to give a short view of the different kinds of gardens now existing; and then to treat of some general matters, such as situation, soil, manures, enclosure-walls, &c. After this, the fruit garden will be particularly attended to; the various kinds of fruit-bearing plants will be mentioned, and the most esteemed varieties of each; and here the different kinds of forcing-houses will claim attention. The kitchen garden will fall next to be discussed, in the same minute way. After which, the flower garden will be considered; but here abridgment must be studied; for to speak of *all* the ornamental plants cultivated would be an endless task: the delicacies of Flora will not, however, be neglected, and the sorts called "florists' flowers" will be enlarged upon. A few remarks on the diseases of plants, and on their prevention or cure, will conclude the whole.

Without detaining the reader with trite remarks on the antiquity of gardening, or discussions concerning the celebrated groves of the Hesperides, the hanging terraces of Babylon, or other gardens of remote ages, we shall at once proceed to give some short account of the rise and progress of modern horticulture. In doing this, it will be necessary to confine our attention almost exclusively to our own country. To discourse of the progress of the art in other countries would not only swell this part of the article to an improper size, but would be an unprofitable undertaking. Nothing can be more evident than the fact already hinted at,—that the practice of gardening in one country cannot be applied to any other, unless that other greatly resemble the former in climate. Useful hints may no doubt be occasionally drawn, from observing the modes in other countries. But it is scarcely necessary to remark, that in warm climates the practice must differ very widely from that which obtains in the temperate or the cold. In the former, the plants, which require to be fostered in our stoves, either grow spontaneously, or are cultivated in the open fields; while the greater part of our common pot-herbs* refuse to flourish in sultry regions. Again, the far northern countries of Europe, Sweden, Norway, and Russia, possess peculiarities of climate: snow covers the soil throughout the winter, and the summers are uninterruptedly bright and warm. Even in Britain, such is the difference of climate between the favoured counties of the south-west of England, and that part of the island which lies to the north of the Cheviot Hills, that the same rules cannot be applied to both, without very considerable modification. The horticulture of the north of France, of Belgium, Holland, and Denmark, may in general be considered as approaching to that of South Britain; and these countries may frequently afford mutual lessons to each other, each availing itself of the other's discoveries, and adopting its improvements.

2. The origin of British horticulture is completely involved in obscurity. It may in general be asserted, that most of our best fruits, particularly apples and pears, were brought into the island by ecclesiastics, in the days of monastic splendour and luxury, during the 12th, 13th, 14th, and 15th centuries. Gardens and orchards ("orti et pomaria") are frequently mentioned in the earliest chartularies extant; and of the orchards many traces still remain, in different parts of the country, in the form, not only of enclosure-walls and prepared fruit-tree borders, but of venerable pear-trees, some of them still abundantly fruitful, and others in the last stage of decay. Of the state of horticulture previous to the beginning of the 16th century, however, no distinct record exists. Till then, it is generally said, that some of our most common potherbs, such as cabbages, were chiefly imported from the Netherlands, their culture not being properly understood in this country; but of this there is no distinct evidence, and the thing seems unlikely. From the "Itinerary" of Leland it appears, that even greenhouses were not then unknown in England.

3. During the reign of Henry VIII. rapid steps of improvement were made in horticulture. According to some authors, apricots and musk-melons were introduced by that monarch's gardener; and different kinds of salad herbs and esculent roots were, about the same time, first brought into the country from Flanders. Henry had a fine garden at his favourite palace of Nonsuch, in the parish of Cheam in Surrey. Here Kentish cherries were first cultivated in England. The garden wall was fourteen feet high; the wilderness occupied ten acres; "lelacke trees which beare no fruit, but only a plesaunte flowre," are mentioned among the rarities contained in it; as are also yew and lime trees. In the year 1534, Fitzherbert, the father of horticultural writers, published his "Booke of Husbandrye."

4. Queen Elizabeth was both a horticulturist and a florist, if we may believe a poet celebrating majesty:

*Cultor herbarum, memor atque florum.*†

During her reign, Dydimus Mountain published the "Gardener's Labyrinth;" Hyll, the "Profitable Arte of Gardening;" and Leonard Mascall, (the introducer of several good pippins,) the "Arte and Manner how to

* By the term *pot-herbs*, gardeners and green-grocers frequently understand only aromatic plants used for seasonings: we use it, correctly, to signify the *olera* in general.

† *Archæologia*, vol. vii.

plant and graffe all sorts of trees," &c.: While Barnabe Googe, Esq. translated the "Foure Bookes of Husbandrie of Conradus Heresbachius." All of these works are printed in black letter, and have become extremely rare. With the exception of the first mentioned, they are, generally speaking, little more than compilations from Varro, Columella, Palladius, Cornelius Agrippa, Cardanus, and some old French and Italian writers. In Elizabeth's days, carnations were, it is said, first cultivated by the Flemings at Norwich, and nearly at the same time tulip roots were brought from Vienna to England. Orange and lemon trees now became known. The "Herball, or Historie of Plants," by John Gerarde, first appeared in 1597; and a second edition, enlarged and improved by Johnston, came out about forty years afterwards. It may, in passing, be remarked as somewhat curious, that so distinguished a writer as Gerarde, and a piece so well known and frequently quoted as his "Herball," should not be mentioned by Professor Martyn, in his chronological list of authors and books on gardening. Towards the close of the 16th century, Sir Hugh Platt published "The Jewel-House of Arte and Nature," a little book not destitute of merit; and early in the following century appeared a posthumous work of his, called "The Garden of Eden."

5. A fine garden was formed at Theobald's, near Waltham Abbey, by James VI. (I. of England). In the year 1640, about thirty years after the formation of this garden, it was described by Mandelslo* as a large square, surrounded with fruit-tree walls, containing also espalier trees on some sort of trellises, and ornamental arches of trees; besides a parterre for flowers.

6. His son Charles I. seems to have patronized gardening. He appointed the celebrated Parkinson his herbarist. In 1629, appeared the first edition of this man's great work in folio, entitled "*Paradisi in sole Paradisus terrestris;* or a Garden of all sortes of pleasant Flowers, with a Kitchen Garden of all manner of Herbs and Roots, and an Orchard of all sort of Fruit-bearing Trees," &c. This may be considered as the first general book of English gardening possessing the character of originality. From his lists of flowers, shrubs, and fruits, the state of our gardens at that period may be pretty accurately guessed. The laurel or bay-cherry was then very rare, and considered as a tender plant, being defended "from the bitterness of the winter by casting a blanket over the top thereof;" and the larch tree was only nursed up as a curiosity. For the culture of melons, he recommends an open hot-bed on a sloping bank, covering the melons occasionally with straw,—the method practised in the north of France at this day. Cauliflowers, celery, and finochio, were then great rarities. Virginia potatoes (our common sort) were then rare; but Canada potatoes (our Jerusalem artichoke) were in common use. The variety of fruits described, or at least mentioned, appears very great. Of apples, there are 58 sorts; of pears, 64; plums, 61; peaches, 21; nectarines, 5; apricots, 6; cherries, no fewer than 36; grape vines, 23; figs, 3; with quinces, medlars, almonds, walnuts, filberds, and the common small fruits. The number of approved apples, pears, plums, and cherries, at the present day, is not nearly so large. Of florists' flowers, he mentions about 50 varieties of hyacinth; above 60 anemonies; but only 20 ranunculuses.

7. In the time of the Commonwealth, Walter Blith produced rather an ingenious work, with the quaint title of "English Improver improved, or the Survey of Husbandry surveyed;" and Ralph Austen published a "Treatise of Fruit Trees," also a book of merit.

8. After the Restoration, Charles II. brought over Le Nôtre, the favourite gardener of Louis XIV. and designer of the gardens of Versailles, to lay out and plant St James's and Greenwich Parks, which still remain very creditable monuments of his taste. Rose, who was gardener to Charles, had studied the art in France. It is remarked by the Honourable Daines Barrington, that at the installation dinner at Windsor, 23d April 1667, cherries, strawberries, and ice-creams, were produced, shewing that the king possessed both hot-houses and ice-houses, and that his gardener was an adept at forcing, for strawberries require considerable nicety of management.

9. From about the middle to the end of the 17th century, the well known John Evelyn, Esq. was the chief promoter of almost all horticultural improvements, forming an era in the history of British planting and gardening. Soon after returning from his travels on the continent, he translated "*Le Jardinier François*, instructing how to cultivate all sorts of fruit-trees and herbs for the garden." In 1664 appeared his celebrated "Sylva, or a Discourse of Forest Trees; with Pomona, an appendix concerning fruit-trees; Acetaria, a discussion of salads," &c. His "*Calendarium Hortense*, or Gardener's Almanack, directing what he is to do monthly throughout the year," was also at first added to the Sylva, but was soon afterwards published separately, and went through many editions. This useful manual laid the foundation of the successive *Gardener's Calendars* which have been published by Miller, Abercrombie, and Nicol. In 1693, his translation of Quintinye's "Complete Gardener" made its appearance, in folio; and, six years afterwards, he ushered into the world an octavo edition, "abridged and improved by George London and Henry Wise," two of the most distinguished gardeners and nurserymen of their day, and whose names have been consecrated by Addison, in his paper on gardening, in the "Spectator," (No. 477.) They had both been apprentices of old Rose, and succeeded him in the office of royal gardener. They converted an old gravel pit in Kensington Gardens into a picturesque hollow of foliage, producing an effect in gardening which the critic compares to the sublime in epic poetry, and exclaims, "Wise and London are our heroic poets!" It is curious, that while the labours of Evelyn justly placed him at the head of the improvers of his time, he should have missed an opportunity, fairly placed within his reach, of handing down his name as the greatest horticultural benefactor of Britain. In March 1662, it was proposed to the Royal Society to recommend the cultivating of potatoes, with the view of preventing the recurrence of famine; Evelyn was particularly consulted, and was requested to mention the proposal at the end of his Sylva, then announced for publication. He does not seem to have complied with this request, nor to have paid any attention to the culture of the plant: he merely mentions it in his Acetaria, and dismisses it with apparent indifference. This American plant, however, has proved a treasure to this country, "compared with which the mines of Potosi are worthless."

10. During the period of which we are speaking, several books on gardening came out, some of them countenanced by Evelyn, and others in which he took no share. One of the earliest of these was the translation of an essay on the management of fruit-trees, by the Sieur Le Gendre, curate of Henonviile, "wherein is treated of nurseries,

* Travels by John Albert de Mandelslo, near the end. In the English translation, the account of King James's garden, &c. is omitted, as uninteresting!

wall-fruits, hedges of fruit-trees, dwarf-trees, high standers," &c. He wrote from the experience of a long life, the leisure of which had been spent in the "ordering of fruit-trees." He was one of the first who attended to the proper training and pruning of wall trees; he boldly condemns the absurd taste, then prevalent, of cutting fruit-trees into the shape of lions or pyramids, but he was not able to divest himself of the doctrine of the moon's influence, and the necessity of planting and pruning only at certain periods of her waxing and waning. About the same time, Dr Robert Sherrock published "The History of the propagation and improvement of vegetables by the concurrence of art and nature;" a work containing a reasonable portion of information, disguised with a good deal of pedantry. Soon after, John Rea, gent. published his "Flora, or a complete Florilege," folio, in three parts: "1. Flora, treating of the choicest plants, flowers and fruits, that will endure our winters; 2. Ceres, containing such plants or flowers as are yearly, or every other year, raised from seeds; 3. Pomona, treating of the best garden fruits, of evergreens, and flowering shrubs." This was followed, first, by a "*Systema Agriculturæ*," and then by a "*Systema Horticulturæ*," by J. W. (John Worlidge) gent; and by the publication of the "English Gardener," by Leonard Meager, "above thirty years a practitioner in the art of gardening." This last contains a good deal of useful information: it is divided into three parts; 1. Of planting stocks, fruit-trees, and shrubs; 2. Kitchen garden; and, 3. Garden of pleasure.—The second volume of Sir William Temple's Miscellaneous Works, it may be mentioned, contains a curious account of the state of gardening in England in the close of the 17th century.

11. King William and Queen Mary appointed Dr Plukenet, a man distinguished for botanical knowledge, and author of a Phytographia and other works, to be their herbarist; and, under his directions, collectors were dispatched to the Indies in search of ornamental plants.

12. Early in the 18th century, Lawrence published "The Clergyman's Recreation, shewing the pleasure and profit of the art of gardening." But Richard Bradley, F. R. S. and Professor of Botany at Cambridge, soon eclipsed all other writers of this period, both for the number and the influence of his horticultural publications. They exceeded twenty in number, and were generally written in a popular style: several of them, as might be expected, are mere compilations, and others are avowed translations. The writings of Switzer, however, about the same time, also acquired a share of celebrity. They extend to six volumes in octavo, embracing, besides "*Ichnographia rustica*," a "Practical fruit gardener," and a "Practical kitchen gardener."

13. In 1724 appeared, in two octavo volumes, the first edition of the "Gardener's Dictionary," by Philip Miller, of the Botanic Garden at Chelsea. He professes to collect and digest the labours of his predecessors; but the book partakes largely of the character of an original work, and it soon attracted general notice. He asserts that gardening never arrived to any considerable pitch in England till within thirty years last past, *i. e.* from 1690 downwards. Seven years after the publication of the octavo edition, which is now very scarce, the first folio edition came out. In the preface he gives some account of ancient gardens, and also of English gardens, in the time of Charles the Second and William and Mary. The descriptions of numerous plants introduced into England, chiefly from America, during the first half of the 18th century, with details of horticultural improvements of different kinds, gradually swelled the work to two volumes in folio. In each successive edition (as observed by Dr Pulteney*) it received such improvements and augmentations, as have rendered it in the end the most complete body of gardening extant. In evidence of the estimation in which it is held on the Continent, it is enough to mention, that there are French, German, and Dutch translations of it, and that some of the continental writers bestow on the author the title of *hortulanorum princeps*. Till the seventh edition, the system of Tournefort was followed. In this the names and system of Linnæus were adopted. In the eighth edition, being the last published by Miller himself, he informs us, that the plants then cultivated in England (1768), were more than double the number known when the first folio edition appeared (1731.) In this edition the plants were first distinguished by the short *trivial* names, invented by Linnæus to supersede the tedious *specific* denominations previously in use. The Gardener's Dictionary, it may here be added, has since been enlarged and improved by the late Professor Martyn of Cambridge, and brought before the public in four volumes folio, forming, as he very modestly styles it, "a digest of what was known in gardening and botany at the end of the eighteenth century." This great undertaking occupied the learned and laborious professor for nearly twenty years; but it is a work which will long maintain the horticultural reign of the name of Miller, and which is calculated at the same time to establish his own fame.

14. In the early part of Miller's time, Batty, Langley, and Ellis, published various horticultural works of some merit. In 1755 Thomas Hitt produced his "Treatise on Fruit-Trees;" and in it he proposed an improved mode of training wall-trees, by regular horizontal branches, with upright bearers. This is a work well deserving of attention; and the author has not, it is believed, received all the praise to which he is entitled. While practical works, such as those now mentioned, engaged the attention of horticulturists in general, some philosophical pieces also appeared, and justly acquired celebrity for their authors; particularly, "Vegetable Statics" by Hales, and the "Principles of Agriculture and Vegetation" by Dr Francis Home, father of the present distinguished professor of Materia Medica in the University of Edinburgh.

15. From the middle to the end of the 18th century, one of the most popular and useful writers on horticultural subjects was John Abercrombie, who, either from diffidence or some other motive, at first published his writings under the borrowed name of *Thomas Mawe*. It is said he was patronized and encouraged by the celebrated Dr Oliver Goldsmith. He was the son of a market-gardener near Edinburgh, and had gone into England when a young man, and after acting as a workman for some years at Kew Gardens, had been enabled to begin business as a nurseryman at Hackney. The work entitled "Every Man his own Gardener" has passed through at least twenty editions. This is formed on the plan of a calendar, containing practical instructions under detached monthly heads. Before his death, which happened in 1806, he had prepared another work, entitled "The Practical Gardener," in which the systematic method is adopted, of connecting under one article every thing relative to the culture of the same plant. This last has been published in the form of a thick duodecimo volume. He wrote also, "The British Fruit Gardener," "The complete Forcing Gardener," and "The Complete Kitchen Gardener, and Hot-bed Forcer," and still other books of similar import. It is

* Sketches of Botany in England, Vol. II.

perhaps to be regretted, that he was induced by booksellers to multiply his publications so much, this circumstance having tended to bring upon him the imputation of book-making, and to excite some degree of prejudice against him. In point of fact, however, he understood the business of gardening extremely well, and his writings altogether afford a very complete view of horticultural operations.

16. Another deservedly popular work on horticulture remains to be noticed. It is written by the Rev. Charles Marshall, a clergyman of the church of England, who is evidently a very zealous amateur gardener. The title is, "An Introduction to the Knowledge and Practice of Gardening." A great deal of correct information is here condensed into little space, and conveyed in perspicuous and unaffected language. There is subjoined to it a compendious *calendar*, better calculated, we think, to be useful as a remembrancer, than any one published since the time of Evelyn.

17. The "Dictionary of Gardening," bearing to be written by *Alexander Macdonald*, *gardener*, in two volumes 4to, is an expensive work, which has not acquired much reputation. It appears to be little more than a compilation, and is certainly not the work of a practical gardener; but it necessarily includes a great deal of useful information. Of late years, the culture of the vine and of the pine-apple has been very well treated by Speechly, in separate works. Forsyth's "Treatise on Fruit-trees and their diseases, with a particular method of cure," first appeared in 1791, in 4to. The royal patronage, kindly bestowed on an old and meritorious servant, secured to this work a considerable degree of attention, and even procured for the author the extraordinary distinction of a parliamentary reward. Many excellent remarks are to be found in the book. In 1802 it was republished, with improvements, in an octavo form.

18. Curtis's "Botanical Magazine" was begun in 1787; and it has been continued in monthly numbers, with little intermission, ever since; Dr Sims having edited the work since Mr Curtis's death. Important hints are frequently thrown out as to the habits, mode of cultivation, and uses, of the plants described and figured. Maddock's "Florist's Directory," appeared in 1792; and it is still the standard book of instructions for the cultivation of the hyacinth, tulip, ranunculus, anemone, auricula, carnation, pink, and polyanthus, the favourites of the *florist*, strictly so called. The "Exotic Gardener," by J. Cushing, foreman to Messrs Lee and Kennedy of Hammersmith, is the latest and best treatise on the management of the hot-house, green-house, and conservatory, and on the soils suitable to tender exotics in general.

19. In the Philosophical Transactions for 1795, the first of Mr Thomas Andrew Knight's horticultural papers made its appearance: it is entitled, Observations on the grafting of trees. In the Transactions for 1799, 1801, and 1803, are contained his ingenious papers on the fecundation of fruits, and on the sap of trees. His excellent little "Treatise on the Culture of the Apple and Pear," was published in 1797. He has presented several interesting communications to the Horticultural Society of London, which are published in the Transactions of that society, to be afterwards noticed.

In the hasty sketch which has now been given of horticultural writers in England, many have been passed over, some of whom would deserve notice, and perhaps commendation, in a more detailed account.

20. Scotland has been more distinguished for producing excellent practical gardeners than good publications on the art of gardening. There does not appear to have existed any Scottish system of gardening, as a separate book, till the beginning of the 18th century, when "The Scots Gardener" was published by John Reid, gardener to Sir George Mackenzie of Rosehaugh. The work is divided into two parts; the first treating of contriving and planting of gardens, orchards, avenues, and groves; the second, of the propagation and improvement of forests and fruit trees, kitchen herbs, roots and fruits; with a gardener's calendar; the whole adapted to the climate of Scotland. The style is very inaccurate; but the matter evinces not only an acquaintance with previous horticultural works, but a practical knowledge of the subject. About thirty years after the publication of Reid's book, there appeared "The Scots Gardener's Director, by James Justice, F. R. S. and one of the principal clerks of Session," (*i. e.* of the Court of Session or supreme civil court of Scotland.) This is characterized, by Professor Martyn, as "an original and truly valuable work, founded upon reflection and experience." Nearly at the same time Dr Gibson published an anonymous octavo volume on fruit-trees, containing many useful remarks, and some curious notices concerning the history of the most esteemed apples and pears of Scottish origin, or which are generally supposed to be of Scottish origin. In 1744, there appeared a small octavo volume, entitled "The Planter's, Florist's, and Gardener's Pocket Dictionary, by James Gordon, nurseryman at Fountainbridge near Edinburgh." It is avowedly a compilation; but the author, being a practical gardener, occasionally gives his own opinions and practice. It has already been seen, that several of the Scottish gardeners who have settled in England have attained distinction as authors. We allude, in particular, to Abercrombie, the voluminous writer lately spoken of, and to Forsyth, the author of the Treatise on Fruit-trees.

21. Among the recent Scottish writers on gardening, one remains to be mentioned, who will long hold a distinguished place,—the late Mr Walter Nicol. He was the son of the gardener, who planned and executed the extensive pleasure-grounds of Raith in Fifeshire; and here he received his horticultural education. He afterwards acted for some time as gardener to the Marquis of Townsend at Reinhamhall in the county of Norfolk; but he left England in order to take charge of the fine gardens and grounds of General Wemyss of Wemyss-Castle in Fife, the improvements there having been conducted under the directions of his father. Here he observed a praiseworthy practice, now too much neglected by head-gardeners,—that of instructing his young men or assistants, not only in botany, but in writing, arithmetic, geometry, and mensuration. He used to remark, that he thus not only improved his scholars, but taught himself, and made his knowledge so familiar, that he could apply it in the daily business of life. In this way he gradually became qualified to communicate his information to the public. In 1797 the first of his works appeared, under the title of "The Scots Forcing Gardener," in one volume octavo. About this time he changed his mode of life, and dedicated his whole attention to the planning and improving of ornamental grounds. In 1803 he published the "Practical Planter," a book which both increased his reputation as a writer, and extended his employment as an improver. In 1809 appeared the "Villa Garden Directory," a little book which soon acquired the high character which it still retains. The "Gardener's Calendar," in one large volume octavo, came out in 1810, and forms at this day one of the best books on horticulture in our language. In the same year he undertook an extensive journey through England, visiting all the principal seats and plantations in that country; and on his return he made some progress in

composing a "Planter's Calendar." But after a few weeks illness he died, on the 5th March 1811. His last work just mentioned, has since been completed and published by his friend Mr Edward Sang, nurseryman at Kirkcaldy in Fife.

22. In 1805, a Horticultural Society was instituted at London, under the patronage of Earls Dartmouth and Powis, Sir Joseph Banks, and other distinguished characters. The first volume of its Transactions appeared, in 4to, in 1812, containing several useful and scientific communications, by Mr T. A. Knight, Mr R. A. Salisbury, and other ingenious horticulturists. In 1809. the Caledonian Horticultural Society was established at Edinburgh, by the individual exertions of that venerable physician and excellent amateur gardener Dr Andrew Duncan, senior, Professor of the Institutes of Medicine in the University there. The Society has been fostered by several of the Scottish nobility and gentry, particularly the Duke of Buccleuch, the Earl of Wemyss and March, the Earl of Leven, Sir James Hall, Sir George Stewart Mackenzie, Sir George Buchan Hepburn, and others. It publishes Memoirs, in the octavo size, in detached parts or numbers, two parts generally appearing in the course of the year; and some important enough papers have in this way been brought before the public. A desire of improving their knowledge of gardening has thus been excited among gentlemen; and the intelligence and zeal of practical cultivators is thus, in the most unassuming way, made known to the world.

23. Perhaps no fitter place may occur for warning gentlemen of the value of the services of an experienced gardener, and of the propriety of employing only, one who has made himself acquainted with all the parts of his business; as well as for inculcating on gardeners themselves, the necessity of their diligently and practically studying every branch of their profession. A well informed and judicious gardener, instructed by experience, is a treasure which every gentleman should prize. Numerous as are the books on gardening, and excellent as some of them undoubtedly are, there are many parts of the gardener's duty for which no general rules can possibly be laid down: like the physician, he has to deal with the living principle, and his treatment of his trees, especially, must vary, according to a thousand nameless circumstances. Much must depend at all times on his own sagacity and observation; but very much is to be learned by a young gardener, from practising under the eye of an experienced master. A gardener ought to have some knowledge of chemistry, particularly of the doctrines of heat, of the nature of water, and of vegetable physiology. All good practical gardeners, indeed, become chemists to a certain extent, without knowing it.

The profession contains different departments. The cultivator of rare plants, or the botanical gardener, may excel in his own department, and yet be very little acquainted with the proper management of fruit-trees. The fruit-gardener generally possesses a knowledge of the culture of kitchen vegetables: but a great proportion of the common order of workmen, who have acquired a competent knowledge of the last-mentioned branch of horticulture, are extremely ill informed concerning the treatment of fruit-trees. 1. The business of the botanical gardener implies, as already remarked, the cultivation of all sorts of rare plants, either in the open border, in frames, in the green-house, the conservatory, or the stove; the adapting of the soil and artificial climate to the respective kinds of plants; a discriminating eye, and an acquaintance more or less familiar with the characters and names of the genera and species of plants, as described by Willdenow, at least of such as are contained in the Hortus Kewensis, or the Cambridge Catalogue. To these qualifications must be added, general taste in the disposing of plants in borders, and in the forming and keeping of ornamental grounds. 2. The fruit-gardener should have a correct knowledge of the different kinds of fruit-trees, and the principal *varieties* of each kind; he must be familiarly acquainted with the method of training and pruning suited to each sort, and must at the same time possess judgment and experience, to enable him to adapt the degree of pruning or mode of training to the peculiar circumstances of the individual tree. He must understand the formation of fruit-tree borders, the operations of grafting and budding, and the preserving of blossom. The peach-house, the vinery, and the pine-stove, belong to his department, as well as the melon frames, and some other subordinate matters. Much may be learned from authors; from Miller, Forsyth, Hitt, Speechly, and others; but an intimate acquaintance with the proper training, and the proper pruning and disbudding of wall trees, is to be acquired only by observation and practice, as they vary continually, according to the soil, aspect, luxuriant or weakly state of the tree, and even according to the season. 3. The kitchen-gardener's duty is generally thought to be very simple and easy; but he who can perform it neatly, and with success, may be accounted a good general gardener. The rearing of several culinary articles requires particular attention; such as asparagus, celery, sea-cale, mushrooms, and, above all, melons and cucumbers. Great assistance may be derived from books,—from Abercrombie's Practical Gardener, and Nicol's Calendar; but a person who has never witnessed nor practised any of the nicer parts of the kitchen-gardener's duty will be but ill qualified to attempt them.

The public nurseries are useful seminaries to young gardeners. The overseers of these establishments are generally well informed persons, and dexterous workmen, having been selected on account of possessing these qualities. Many very useful parts of the profession may here be acquired; such as the level-digging of ground, and neat finishing off of beds or borders,—apparently simple matters, in which, however, many gardeners are extremely deficient. In some nurseries, extensive collections of hardy and green-house plants are kept, and a knowledge of the culture of these may thus be acquired. Nor is the knowledge of the modes of raising from the seed, and rearing in nursery-beds, of the various forest-trees, an inconsiderable matter: in many places, indeed, the head-gardener is required to maintain a nursery of seedling forest-trees, for the use of his master's estate. In the public nurseries, a knowledge of the processes of grafting and budding may be acquired; but the gardener, who has studied only in this school, will afterwards discover how much he has to learn as to the proper wood to be used for grafts, as well as to the size and quality of the stocks. Under any of the first rate market-gardeners, a young man may learn many parts of his profession with great advantage, particularly the raising of all sorts of pot-herbs and salads, and the forcing of many of them. But here too he will labour under disadvantages; for in few such gardens can he acquire any knowledge of the management of fruit-trees, particularly peaches, apricots, and the finer sorts of pears.

A young gardener, who has spent his time in places where the proper management of fruit-trees was not attended to, or where no opportunity of attending to it existed, may possibly be willing to accept lower wages, in order to compensate for the defect of his education. But the proprietor of the garden will soon find himself a loser by the injudicious economy of employing him: and if it were a general rule, steadily followed by gentlemen, not to employ, as their gardeners, persons who had not duly sought opportunities of gaining an acquaintance with the different branches of their profession, young men of merit would, instead of grasping at the situation of head-gardener immediately upon the expiry of their apprenticeship, be convinced of the necessity of *practically* studying every department of their "multifarious and numerous employment," as Evelyn happily styles it. In Germany, it may be remarked, a gardener has not only to serve a long apprenticeship, but to pass certain examinations, before he can be recommended to a situation as head-gardener. In this country there is no such regulation; and the greater necessity, therefore, for the employer being able to judge of his gardener's qualifications.

24. Scotland has long been distinguished for producing gardeners in greater numbers than any other country of Europe; and several of them have risen to the highest eminence in their profession. At the present day many of the nobility and gentry of England employ Scottish head-gardeners; while the numbers of those of an inferior order, to be found in every county south of the Tweed, is quite surprising. Some of the causes of the very great number, and of the real excellence, of the Scottish gardeners, have been assigned in the 9th chapter of the "General Report of Scotland." One is to be found in the early education secured to the children of the labouring class in that country, by the ancient and most laudable institution of parish schools: another, in the hardy mode of life and sober disposition of the young men, which have very generally gained them the esteem of *English* masters; and a third, in the tendency which struggling with a very variable climate at home, has to call into action all the powers of the mind, and to create a habit of unceasing attention to the duties of the station. It may here be mentioned as a striking and very honourable trait in the character of the Scottish master-gardeners of the last age, (already mentioned, § 21) that it was a common practice among them to spend a part of the evening in instructing their apprentices in different branches of education, particularly arithmetic, mensuration, drawing of plans, and botany. Even at this day, there are still in some places of Scotland to be found the remains of this praiseworthy custom. A turn for reading and study was thus created among young operative gardeners; and to this, their rise in life might in many instances be traced. The taste for reading was perhaps never more prevalent among gardeners than at this day. Nor do they entirely neglect geometry, though it must be admitted that this kind of knowledge is on the decline among them. It is not, indeed, now nearly so necessary as formerly to the professional gardener, grounds being no longer planned into regular mathematical figures, and topiary work being altogether exploded.

25. We have little fear of being accused of partiality when we give a favourable report of the character of Scottish gardeners, the justness of their claim of merit being universally recognized: but, without enlarging farther on the topic, we proceed to give some very general account of the different kinds of gardens now existing in Britain. All of them, we think, may be arranged under one or other of the following divisions. a. Royal gardens, and public botanic gardens. b. The gardens of noblemen and gentlemen of great opulence. c. Villa gardens. d. Cottage gardens. e. The public nurseries, which, especially near London, may without impropriety be ranked as gardens. f. Market gardens. On each of these heads, a few examples and observations seem necessary for illustration, and at the same time they may prove not unentertaining.

*Royal Gardens.*

26. The Royal Gardens at Kew, on the banks of the Thames near London, are perhaps the first in the world for variety of plants. They were originally planned by that distinguished character Frederick Prince of Wales, father of King George III. The extent is about 120 acres. The surface is flat; but owing to the tasteful disposition of trees and shrubs, the grounds exhibit a considerable variety of scenery. They are nearly surrounded by wood, amidst which rises a pagoda, or Chinese temple, to the height of 160 feet: this was designed by Sir William Chambers, who afterwards published a description of the gardens and palace of Kew, in folio. The exotic garden was established about the year 1760, after the Prince's death, chiefly by the influence of the Marquis of Bute, a great encourager of botany and gardening. He placed it under the care of Mr William Aiton, who had long been assistant to the famous Philip Miller at Chelsea. The principal green-house and orangery is 145 feet long, 25 high, and 30 broad. About 1794, a large green-house, 110 feet long, was erected, for the reception of African and Cape plants only. There are twelve other hot-houses of various descriptions. Adding together the lengths of all the hot-houses, the garden contains no fewer than 839 feet in length of glass; and besides this, about one-half of the houses have covered borders in front, for the protection of different kinds of bulbs, and alpine plants, during winter. One of the hot-houses is appropriated to the palm and fern tribe, displaying the gigantic species of warm climates almost in their native luxuriance and beauty. Another is devoted to the plants of New Holland, which have a character of foliage peculiar to themselves, so that the botanical visitor finds himself suddenly carried, as it were, into a new world. A third contains chiefly the plants of China, and of these the collection is very rich, a magnificent assortment having some years ago been procured from Canton, accompanied by a Chinese gardener to take care of them. A catalogue of the plants of the garden, entitled "Hortus Kewensis," was first published in 1768 by Dr Hill. A more scientific work, under the same title, was given to the public in 1789, by Mr Aiton, the superintendant, assisted by Dr Solander; this extended to three volumes octavo. Between 1810 and 1813, an improved and enlarged edition, in five volumes, octavo, was published by Mr William Townsend Aiton, who had succeeded his father: he was assisted in the first three volumes by the late Mr Dryander, and, after the death of that botanist, in the remaining two volumes, by Mr Robert Brown, author of the "Prodromus Floræ Novæ Hollandiæ," and justly considered as one of the very first botanists of the age.

The Royal Gardens at Hampton Court were laid out by London and Wise, already mentioned as nursery-men and gardeners of eminence in the reign of King William. A labyrinth in the wilderness quarter, and some other remains of the old style, are here still to be seen, having in some strange way or other escaped during the revolutions of taste, and the desolating improvements of Kent and Brown. The winding walks of the labyrinth are about half a mile in length, although the entire space occupied by it does not exceed a quarter of an acre. In a grape-house on the south side of the palace, is a Black Hamburgh vine, which has been much spoken of: the stem is more than a foot in circumference; one principal branch, trained back, measures 114 feet in length; and the plant has produced, in one season, 2200 bunches, weighing on an average 1lb. each.

The gardens at Kensington have long been celebrated, They were greatly improved by the late Mr Forsyth, who certainly succeeded in renovating the fruit-trees, and rendering them productive of excellent fruit. Too much was probably ascribed to the composition, now generally known by the name of *Forsyth's plaster*, and it was no doubt injudicious to bring such a matter before the British parliament. The effect of the preeminent degree of patronage bestowed seems unluckily to have been, to excite an undue prejudice against the practices recommended in the Treatise on Fruit-trees.

The gardens at Frogmore near Windsor have been formed chiefly under the direction of Charlotte Queen of George III. and of Princess Elizabeth, one of their daughters. The gardens display much taste, and are kept in excellent order. They are the private property of her Majesty.

*Botanic Gardens.*

27. The Botanic Garden at Chelsea is supported by the Worshipful Company of Apothecaries of London. The ground was granted to them in the end of the 17th century by Sir Hans Sloane, on condition of their presenting to the Royal Society, annually, fifty new plants, till the number should amount to 2000. In the middle of the garden there is a marble statue of Sir Hans, by Rysbrack. On the north side of the garden is a large greenhouse, and close by it a stove, also of considerable dimensions. Over the greenhouse is a botanical library. On the south side of the garden, near the Thames, are two wide spreading cedars of Lebanon, planted so long ago as 1683; at present (1816) the circumference of one of them, three feet from the ground, is somewhat more than thirteen feet, and of the other almost thirteen feet. The laborious and well informed Philip Miller was superintendant of this garden for many years, and here his admirable *Gardener's Dictionary* was composed. Since the death of Miller, the garden has been rather on the decline, the soil being much exhausted, and the hot-houses having fallen into disrepair. Of late, however, the Company has, at much expence, restored every thing to a state of more than former excellence, the improvements having been conducted by Mr William Anderson, an eminent practical gardener and botanist. Botanical instructions are here given during the summer months by a demonstrator appointed by the Company of Apothecaries.

The botanic garden at Oxford is of considerable antiquity; but the collection of plants is not extensive; and in that famed city of theological and classical learning, no great encouragement seems to be given to the votaries of Flora and Pomona.

The botanic garden at Cambridge has long had a higher character in the botanical world. The collection, however, cannot be accounted very extensive. The many editions of the *Hortus Cantabrigiensis*, published by the late Mr James Donn, the curator, tended greatly to spread its fame. Not that it is to be imagined that *all* the plants enumerated in the Cambridge catalogue are to be found, at any one time, in a living state in the garden; if they were ever cultivated there, it is enough. The catalogue was printed in the shape of a pocket volume, and formed a convenient companion to the garden or greenhouse: in fact, it long regulated the nomenclature of plants in this country. Now, however, many give the preference to the *Hortus Kewensis*, as a more accurate performance; and an abridged pocket edition of this has also been published.

The botanic garden at Liverpool was established by subscription, under the auspices of the patriotic Mr Roscoe. The suite of hot-houses is perhaps the finest in Britain, and the whole establishment is highly creditable to that opulent commercial city. The collection of plants is great, and the many opportunities of procuring seeds from ships, constantly arriving from every quarter of the world, are eagerly embraced by an active and intelligent superintendant, Mr William Shepherd. Here Sir James Edward Smith, the celebrated author of the *Flora Britannica*, and President of the Linnean Society, has occasionally delivered a course of lectures on botany.

A public botanic garden has recently been set on foot at Hull; it is on an extensive scale, and can already boast of a very ample collection of plants. For it the public are in a great measure indebted to William Spence, Esq. well known not only as a naturalist, but as a writer on some questions of political economy.

28. At Dublin, there are now two botanic gardens; one belonging to the Dublin Society, and another to Trinity College.

The former was established about the year 1798. It contains twenty-four acres (Irish). The collection of plants is very extensive. The general arrangement of the hardy herbaceous kinds is according to the system of Linnæus; each Linnean class standing separate in a large grass lawn, and an alley leading from one class to another. Aquatics are necessarily placed by themselves; and near the Aquarium, there is a piece of marshy ground for bog plants. Shrubs form another division, and trees a third. The collections in all of these departments are very extensive. In one part of the garden there is an arrangement, on a small scale, according to the method of Jussieu. Plants indigenous to Ireland are brought together, so as to exhibit the Flora of the country at one view; but they occur likewise in their places in the general arrangement. They have in this garden what are termed *cattle gardens*, containing plants which different animals are supposed to eat or to refuse. There is a piece of ground set apart for making experiments on the different gramina, and also on what are called artificial grasses, such as clovers, trefoils, saintfoin, lucern: this department, if properly attended to, is evidently calculated to be very useful. The stoves and greenhouses are extensive, and contain a numerous collection.

The College botanic garden was established only in 1806. It occupies no more than three acres and a half. It is enclosed by a wall twelve feet high, the south-east aspect of which is faced with brick, and on this the more delicate of the hardy climbing shrubs, and others which require shelter, are trained. Here, for instance, Metrosideros lanceolata flowers every year, and here may be seen the finest specimen in the three kingdoms, perhaps, of Ligustrum lucidum, or the wax-tree of China, and which escaped unhurt in this situation, during the severe winter of 1813, when the original plant from which it was taken perished in England. There is in the garden a general arrangement of herbaceous, perennial, and biennial plants; the annual plants and the gramina being each kept separate. Although the space is small, there is not only a Fruticetum, but an Arboretum; and, with equal taste and judgment, the principal part of this last is so contrived, as to serve for a screen to give shelter to the rest of the garden. There is an extensive collection of the hardy medicinal plants, arranged according to Jussieu's method. There is only one stove and one greenhouse; but the exotics cultivated in these are curious and numerous. Upon the whole, this small botanic garden contains a richer and more varied collection than is perhaps to be found any where else in Europe within the same compass. It does honour to the liberality and public spirit of the heads of the College; and they seem to have been peculiarly fortunate in their gardener, (Mr James Townsend Mackay, originally from the Botanic Garden at Edinburgh), who has here proved, that, to a thorough knowledge of practical horticulture, and extensive acquisitions in botany, he adds an acquaintance with the principles of landscape gardening.

29. The Royal Botanic Garden of Edinburgh was planned, in 1767, by Dr John Hope, then professor of botany. The collection of plants, both hardy and tender, formed by Dr Hope, was uncommonly great; and some of the rarer trees and shrubs planted by him now afford admirable full grown specimens: the Constantinople hazel, (*Corylus colurna*,) for example, now appears as a fine and lofty tree. The assafœtida plant was here first cultivated, by the Doctor, in the open air in this country. The quarter where it grew was sheltered by a yew hedge, and saw-dust was generally laid over the root of the plant during winter. There are two hot-houses, a dry stove, and a large greenhouse; all of them at present in a state of decay; but likely soon to be rebuilt in a magnificent style, and on an extensive scale. Dr Hope was a zealous disciple of Linnæus, and on the death of that illustrious botanist, he placed in the garden a square monument, surmounted by an urn, with the simple inscription, "Linnæo posuit Jo. Hope, 1779." It deserves to be recorded, that in the dry stove a dragon's blood tree (*Dracæna draco*) planted by the Doctor, attained the height of thirty feet, exactly double that of the largest specimen of the plant at Kew; but this invaluable plant, which ought to have been the pride and boast of the Scottish capital, absolutely perished, owing to the want of funds for raising the glass-roof of the house! In this garden lectures are delivered by Dr Daniel Rutherford, Professor of Botany in the University of Edinburgh. The herbarium of the late Dr Hope is kept at the garden. The present superintendant is Mr William Macnab, who was bred at Kew Gardens, and who is at once an excellent cultivator of plants and an acute botanist. Under his management the collection of hardy herbaceous plants has been so greatly enlarged, that it is now excelled only by that at Kew Gardens.

*Private Gardens.*

30. Many of the private gardens in this country are, it is believed, superior in some respects to those of any other. They are maintained in a more liberal style; and the products are not only plentiful, but every kind of fruit and culinary vegetable is of the first quality of its kind. It may be affirmed, that in Britain a gentleman may derive from his own garden, with the aid of glass and of fire-heat, a more varied and richer dessert, throughout the year, than is to be met with on the most luxurious table in any other country. To prove this assertion, it will be enough to run over the fruits successively afforded throughout the year, by a well-conducted British garden. Strawberries, planted in pots and forced in a hot-house, produce their fruit about the middle of April, and forced cherries are ready at the same time. These are followed by early melons, about the beginning of May. In June the first forced grapes and peaches are ready for the table, with the luscious pine-apple: may-duke cherries on good exposures now ripen, and different kinds of strawberries in the open ground are abundant. These, with early melons, grapes, peaches, nectarines, and pine-apples, continue plentiful till August, when the currant and gooseberry come in. By the middle of August the early pears are ready, and the later houses of peaches, nectarines, and grapes, are in perfection, with melons; and by September, the open wall crops of peaches, apricots, and nectarines, green-gage plums, and jargonelle pears, with the late preserved gooseberries and currants, and the early jenneting and oslin apples, swell the dessert. In October, late crops of melons and grapes, with peaches, nectarines, and figs, join themselves with the ripening apples and pears; till, towards the end of it, the careful horticulturist gathers and stores the remaining fruits of his labours, that he may possess a supply during the winter season. The autumn pears, such as the beurré and the crassane, are in season till the new year; when the colmart, St Germain, and chaumontel, still prolong the succession of pears: then many varieties of keeping apples present themselves, till the season revolve, when *early* strawberries, cherries, and melons, may again be procured. Several fruits, not generally cultivated, such as oranges and shaddocks, have not here been enumerated; and our nuts, such as filberds and walnuts, are intentionally omitted.

The general extent of the walled garden is from two to five acres. It is to be observed, that a walled garden of three or four acres, at the present day, affords as much space for the production of fruits and kitchen vegetables, as did a garden of perhaps five or six acres at the end of the 17th or beginning of the 18th century, when the garden was invariably connected with the mansion-house; so that the portion next the house was naturally laid out as a parterre, and large spaces were occupied by arbours, fountains, and grass-plats for statues or obelisks. A very few only of our modern fine gardens can here be particularized. In all of them, fruits and vegetables are cultivated with great care, and with remarkable success. In most of those to be now specified, besides these more ordinary productions, there are rich collections of curious and ornamental plants.

31. To begin with England. The gardens at Chiswick House, the seat of the Duke of Devonshire, near Kew Bridge, are very extensive, and remarkable for containing a most magnificent range of hot-houses. At White Knights, near Reading, the Marquis of Blandford has a very complete garden, distinguished more especially for a choice collection of ornamental plants. Spring-Grove, near Blackheath, the seat of the illustrious President of the Royal Society, Sir Joseph Banks, affords a very fair example of a well kept English garden. Here, in the open air, grows a noble specimen of the Chili pine, (*Araucaria imbricata*,) the most admirable, perhaps, of the many plants discovered and brought home by Mr Archibald Menzies: of this Spring Grove specimen the venerable owner is justly proud. Wormly Bury, the seat of Sir Abraham Hume, near Enfield, may also be noticed; it is particularly remarkable for its hot-houses being stored with fine specimens of the rarest tender exotics. Other gardens well deserve notice, such as Lord Tankerville's near Walton; the Duke of Northumberland's at Syon House, Brentford; and Earl Mansfield's at Caen Wood, Hampstead.

32. Scotland can boast of some first-rate gardens. The Duke of Buccleugh's at Dalkeith contains, within and without the walls, 13 acres. Every thing here is in a princely style: the gravel walks of the place are about fifty miles in extent. Though the soil of the garden was originally bad, and the subsoil is still unpropitious, the whole has been brought to a most productive state by the ingenuity and judgment of his Grace's gardener, Mr James Macdonald, as will afterwards be more particularly mentioned. The Earl of Eglinton's garden at Eglinton Castle, Ayrshire; the Duke of Montrose's at Buchanan, in Dun-

bartonshire; the Earl of Mansfield's at Scone, in Perthshire; and Mr Ferguson's of Raith in Fifeshire, may also be named.

33. In Ireland there are many excellent private gardens. In the vicinity of Dublin, the Lord Lieutenant's deserves notice, as well as the Chief Secretary's Lord Castlecoote's, and the Lord Chief-Justice Downe's. The garden of the latter at Merville, two miles south of Dublin, besides producing fruit and kitchen vegetables in perfection, is distinguished for abounding with rare flowers of every description, collected with great taste and assiduity. There is here a separate collection of American natives. At Collon, in the county of Lowth, the Right Hon. John Foster has the richest and most varied plantations of trees and shrubs of every kind, to be seen in Ireland, and probably among the best in Britain. Mr Latouche's garden at Bellevue, in the county of Wicklow, likewise deserves to be mentioned as of the first rank, both for fruit and for a general collection of plants. At Castle Forbes, too, in the county of Longford, the Countess of Granard has a fine collection of flowers. Scottish head-gardeners, it may be remarked, are equally prevalent in Ireland as in England. Three out of the four principal gardens in the vicinity of Dublin, above specified, are under the management of Scotsmen.

*Villa Gardens.*

34. These are innumerable; some of them are kept in the highest style of excellence. They are generally about an acre in extent; but many are nearly twice that size. Under this head, are included all the gardens attached to the country houses of those in the middle ranks of life: a few also, belonging to opulent individuals, who devote their leisure to the study of botany and the cultivation of curious plants, must be ranked under this class, though in some respects far excelling the most extensive gardens. Such is the Count de Vande's garden at Bayswater, on the Uxbridge road, remarkable for a very rich collection of plants; and Mr Kent's at Clapton, near Hackney, where aquatics, both hardy and tender, are grown in great perfection. The tender aquatics are kept in a stove during winter; but, in the summer season, the vessels containing them are placed on slight hot-beds under glass frames, where linings of horse-litter can be added at pleasure; it being found, that in this way they flower more freely. Mr Vere, at his villa at Knightsbridge, possesses a very ample collection of rare exotics.

*Cottage Gardens.*

35. Under the title of cottage gardens, must be included all gardens of an inferior sort, such as those common about villages and towns. Cottage-gardens, properly so called, are in some places numerous and well-kept, affording not only an agreeable relaxation to the occupiers, but contributing very much to the comforts of their family. In South Britain, however, they are neither so useful, nor so well managed, as in some parts of Scotland. While in the former the vine may sometimes be seen extending its shoots over the cottage-roof, indicating a mild climate and a fertile soil, the really useful produce of the ground seems much neglected. In Scotland, on the contrary, too little attention is doubtless paid to ornament; but the healthy kale and cabbage plants, and other useful pot-herbs, with well-earthed rows of early potatoes, shew that the inhabitants understand the management of their little spots, and how to draw from them the most effectual assistance to their families.

*Public Nurseries.*

36. The *public nurseries*, especially near London, are of the first order. These, besides being remarkable for general collections of plants, are usually distinguished for excelling in some particular department. Thus at Lee and Kennedy's at Hammersmith, there is not only a most extensive general collection, but more particularly a complete assortment of heaths and other Cape of Good Hope plants. Loddige's at Hackney is distinguished for stove plants; Whitley, Brames and Milne, at Fulham, have a general collection; as have also Malcolm at Kensington, and Jenkins and Gwyther near Paddington. At Thomson's at Mile-End, besides a rich collection of young plants, are many fine old American trees of the rarer kinds, and a very large gingko tree of Japan, (*Salisburia adiantifolia*): at Colville's, on the King's Road, there is a great extent of glass for the growing of snowy plants for the London market; Davy's, in that neighbourhood, is famed for a fine collection of tulips, certainly the first in Britain: Milliken at Walworth excels in auriculas, ranunculuses and anemones; and Chandler, near Vauxhall, in camellias; Gray and Wear at Brompton Park (formerly the nursery grounds of London and Wise) have a great collection of fruit-trees. Mr Joseph Kirke, also at Brompton, has but a small nursery, but it is rich in the newly introduced fruits, particularly those raised by Mr Knight, and those recommended by the Horticultural Society of London. Ronalds at Brentford, and Wilmot and Lewisham at Deptford, may also be mentioned as excelling in the culture and training of young fruit-trees. At what is called the Botanic Garden at Sloane Street, kept by Mr William Salisbury, the partner and successor of Curtis, there is a considerable collection of curious shrubs and plants in general. Several of the nurserymen pay much attention to the production of seeds for the market, either of culinary plants, or of ornamental flowers. Of the principal kinds of the former, such as cabbages, turnips, and peas, they annually raise a small quantity of the different varieties, in their own nursery grounds, and under their eye, taking care however that each variety be as far separated as possible from any similar crop; they examine the plants when in flower, and reject such as are spurious. The whole seed thus procured is kept till next season; it is then sent to some seed-farmer in their employment, perhaps in a remote part of the country, and grown by him. In this way there is yearly procured a large stock for sale, and which in general is not only better saved, but more genuine than what can easily be got in a private garden.

Throughout the kingdom there are public nurseries near all the principal towns. At Edinburgh there are several, which it may confidently be affirmed are kept in a state of greater order and neatness than any in the south; they are particularly distinguished for the excellence of their seedling forest-trees. The number and the flourishing state of the public nurseries may be adduced as a strong proof of the general attention paid to horticultural improvements throughout the country. Towards this they afford great facilities, furnishing, when wanted, every possible variety of plants, at prices comparatively low. In one important article we believe all of them are deficient,—fruit trees. These, indeed, they contain in sufficient numbers; but their quality is often doubtful. This is particularly the case with apples and pears. The grafts for these are often collected from the nursery lines, instead of being taken, as they ought to be, from *bearing branches of fruitful trees.* Sometimes, no doubt, they are selected from fruit-bearing trees in gentlemen's gardens in different parts of the country; but it is frequently impossible for nurserymen to procure grafts of the desired kinds in this way. If any judicious nurseryman, therefore, would form a collection of fruit-trees of his own, to be maintained in a fruit-bearing state, he would thus not only be certain as to the kind which he propagated, but have at his command yearly a moderate quantity of proper grafts from the fruitful boughs of bearing trees. He would thus, no doubt, be limited in the number of his grafts, and might find it necessary to ask a higher price for his plants; but this would most cheerfully be given by judicious purchasers. A nursery orchard of this kind could only, with propriety, be formed on ground the property of the nurseryman, or of which he held a very long lease. Till some such establishment take place, gentlemen who wish to avoid disappointment, must, in general, be content to graft their own fruit-trees.

*Market Gardens.*

37 The *market gardens* near the metropolis are wonderful in extent, and managed in general in the best style. High rents are paid for the ground, so that as many crops as possible must be taken, and those must be of the most productive sorts. At the same time, such is the competition in Covent Garden market, that unless the produce be excellent of its kind, it will be rejected. The accumulated heaps of kitchen vegetables to be seen very early in a summer morning in this place, are quite surprising, and would confound many who have frequently passed through the market in the day time, after vast quantities have been sold, and carried off by retailers, and other quantities have been placed out of sight. If from an inspection of Covent Garden green-stalls, one may judge of the general state of horticulture in Britain, it may be said to approach perfection. It cannot however be denied, that although the kitchen vegetables exhibited for sale in this market excel in size, they are inferior in flavour, and perhaps in wholesomeness, to those raised at a distance from London. Much of the land here occupied as market-gardens has been heavily cropped every year for perhaps a century past, and the soil has been annually replenished with manure from the city. It thus acquires a grossness calculated to give size, certainly at the expense of delicacy of taste. The vegetables of the London markets, however, ought not to be judged of from specimens to be met with in taverns: these are often kept steeping in water for a day, or perhaps two or three days, as if it were intended to extract all flavour, or otherwise sweating in a heaped basket in the cellar, the alliaceous and strong-smelling plants tainting the others. Every one possessed of a garden is well aware of the superiority of potherbs when recently gathered; but those sent to the London market are gathered and packed on one day; they are carried, by the indefatigably industrious gardeners, during night, either in waggons, or by boats on the Thames, so as to reach the market very early the next morning. Even in this way, a complete day and night must elapse before the inhabitant of London can set on his table the freshest vegetables to be procured in the markets. But as the gardeners come to town only three times a-week, on Tuesdays, Thursdays and Saturdays, pot-herbs must very frequently be two or three days kept before they be used. They must therefore unavoidably suffer some deterioration; and the wonder is, to see an enormously overgrown city so amply and regularly supplied, and with articles so excellent in their kind.

38. Fuller, in his "Worthies," fixes the date of the establishment of a market for pot-herbs at London, to be 1590; but Lyson properly remarks, that entries occur in dinner bills of fare, detailed in the account of Queen Elizabeth's progresses, which shew, that "parsley, sorrel, and strong herbs, with peason," were to be *purchased* at least twenty years before that period. *Rathripe*, or early peas, were then accounted a dainty for a queen; and they still continue to be a dainty, selling, when they first come in, at a crown or even half a guinea a pottle (less than a quart.) Other articles, when produced early, give prices high in proportion, asparagus, 6s. or 7s. a hundred; and early potatoes, 3s. 6d. a pound. These and several other culinary plants are therefore extensively *forced* by the London market-gardeners; that is, they are forwarded by the artificial heat either of a hot-bed or of a flued pit. Some idea may be formed of the encouragement given to horticulture by the demand of the metropolis, from considering the extent of ground occupied in the production of kitchen vegetables and fruit within 12 miles of London. Mr Lyson, above named, author of the "Account of the Environs of London," and who, in the course of his minute investigations and inquiries, had a good opportunity of forming an accurate calculation, estimates that at least 5000 acres are employed, within that circuit, in raising kitchen roots and pot-herbs, exclusive altogether of late potatoes, and of vegetables raised for cow-feeders. He states that 800 acres are cropped with fruit, including apples, pears, gooseberries, currants, raspberries, and strawberries. Not fewer than 1700 acres are planted with potatoes for the market; and 1200 with cabbages, turnips, and parsnips, for the feeding of milch cows. The raisers of these articles are properly *farming gardeners:* they manure very highly, and raise garden crops, and then refresh their land by sowing with corn. They abound near Camberwell and Deptford. The production of medicinal herbs employs about 300 acres; and from 400 to 500 are in the hands of nurserymen. In this way, the employment of about 9500 acres of the richest and most highly manured lands in the vicinity of London is accounted for. At Hoxton is a very extensive and well conducted market garden, Mr Grange's; and this may be considered as a fair example of all the others. But the garden ground is chiefly situated near the Thames, both above and below the city, for the conveniency of water carriage in conveying the produce to market, and the not less important advantage of bringing back stable dung, for the construction of hot-beds and the manuring of the ground.

The districts of Brentford and Twickenham are famous for strawberries; and in the last alone, there are about 400 acres in fruit-trees, the produce of which is chiefly sent to London. Fruit arrives from every part of the surrounding country at the same emporium, and yet it is believed the demand is seldom satisfied. It may here be remarked, that the production of fruit, and the supplying of the market with it, should by every possible means be encouraged. It is a just observation of an eminent horticulturist, (Mr Knight,) that the palate which relishes fruit is seldom pleased with strong fermented liquors, and that as feeble causes, continually acting, ultimately produce extensive effects, the supplying the public with fruits at a cheap rate would have a tendency to operate favourably both on the physical and moral health of the people. Isleworth parish is remarkable for producing great quantities of raspberries, which are sent partly to Covent Garden market, but chiefly sold to distillers, or makers of sweets.

In Fulham parish, there are nearly 1000 acres under crops of esculent vegetables, intended either for market or for cow-feeders. In Mortlake parish, there are generally about 80 acres under asparagus; one asparagus grower here, Mr Biggs, has sometimes had forty acres under this crop at one time. Near Deptford also, much asparagus is raised; and one grower here, Mr Edmonds, has, we are informed, at this time, no fewer than eighty acres covered with asparagus beds,—a thing which must appear almost incredible to those who have not witnessed the loads of this article daily heaped on the green-stalls of the metropolis, for the space nearly of three months. About twenty acres in the neighbourhood of Deptford are employed in the raising of onion-*seed*, this article of Deptford produce having acquired reputation all over the country. What are called the *physic gardens* are chiefly near Mitcham, nine or ten miles from Westminster Bridge: in these are raised chamomile, lavender, liquorice, rhubarb, wormwood, and above all peppermint, not only for supplying the essential oil to apothecaries, but for the manufacturing of a favourite cordial.

We have now explained, perhaps, at too great length, the classification of gardens above given: but without going into some little detail, no idea could have been conveyed of the general state of the country in regard to horticulture. We now hasten to make some remarks on the subjects which naturally present themselves as important, when a new garden is projected. Most of them are applicable to several classes of gardens; but when not otherwise stated, a garden of the first character is to be understood as in view.

*Situation, &c. of a Garden.*

39. The consideration of the position of the garden with respect to the mansion-house properly belongs to the subject of LANDSCAPE *Gardening*. It may only here be remarked, that of late it has become fashionable to place the fruit and kitchen garden at perhaps half a mile's distance, or more, from the house. In many cases this has been found inconvenient; and it can seldom happen that the garden walls may not be effectually concealed, by means of shrubs and low growing trees, so as not to be seen, at least from the windows of the public rooms, and the garden yet be situated much nearer to the house. It is scarcely necessary to observe, that an access for carts and wheel-barrows, without touching the principal approach, is indispensable. Some of the circumstances which are considered as constituting the best kind of situation may here be mentioned, and these, it may be remarked, ought never to be altogether sacrificed to effect.

*Shelter* is, in our climate, a primary consideration. This may in part be derived from the natural shape and situation of the ground. Gentle declivities at the bases of the south or south-west sides of hills, or the sloping banks of winding rivers with a similar exposure, are therefore very desirable. If plantations exist in the neighbourhood of the house, or of the site intended for the house, the planner of a garden naturally looks to them for his principal shelter; taking care, however, to keep at a reasonable distance from them, so as to guard against the evil of being shaded. If the plantations be young, and contain beech, elm, oak, and other tall-growing trees, allowance is, of course, made for the future progress of the trees in height. It is a rule, that there should be no tall trees on the south side of a garden, to a very considerable distance; for during winter and early spring, they fling their lengthened shadow into the garden, at a time when every sun-beam is valuable. On the east also they must be sufficiently removed to admit the early morning rays. The advantage of this is conspicuous in the spring months, when hoar-frost often rests on the tender buds and flowers: if this be gradually dissolved, no harm ensues; but if the blossom be all at once exposed to the powerful rays of the advancing sun when he overtops the trees, the sudden transition from cold to heat often proves destructive. On the west, and particularly on the north, trees may approach nearer, perhaps within less than a hundred feet, and be more crowded, as from these directions the most violent and the coldest winds assail us. If forest trees do not previously exist on the territory, screen plantations must be reared as fast as possible. The sycamore (or plane-tree of Scotland,) is of the most rapid growth, making about six feet in a season; next to it may be ranked the larch, which gains about four feet; and then follow the spruce and balm-of-Gilead firs, which grow between three and four feet in the year. Excellent instructions for the formation of screen-plantations, as well as for the regulation of forest trees in general, may be found in "The Planter's Calendar," already mentioned, § 21. Walls and quick hedges are subordinate means of shelter, to be spoken of by and by. The best general *exposure* for a garden, must evidently be towards the south; and a gentle declivity in that direction, equal perhaps to a fall of one foot in thirty, is deemed very desirable; effectual draining being in this case easily accomplished.

*Water* is not to be forgotten. If a streamlet can be brought to flow through the garden, it may be rendered conducive both to convenience and amenity: where this cannot be accomplished, the situation should be such that water may be conveyed by pipes from some neighbouring stream; soft or river water being greatly preferable, for the purposes of the horticulturist, to that of springs or wells. Where running water cannot be commanded, recourse is had to a lake or pond, it being known that water freely exposed to the air and sunshine for some time, becomes comparatively soft, and fit for the nourishment of plants.

In selecting ground for a garden, the plants growing naturally on the surface should be noted, as from these a pretty correct opinion may be formed of the qualities of the *soil*. The *subsoil* should also be examined. If this be radically bad, such as an iron-till mixed with gravel, no draining, trenching, or manuring, will ever prove an effectual remedy; if, on the contrary, the subsoil be tolerably good, the surface may be greatly meliorated by these means. In every garden, two varieties of soil are wanted, a strong and a light one, or, in other words, a clayey loam and a sandy loam, different plants requiring these respective kinds. For the general soil, a loam of middling quality, but partaking rather of the sandy than the clayey, is accounted the best.

*Enclosure Walls.*

40. When the situation is fixed on, the next consideration is the enclosing with walls. Supposing a garden to be about an acre in extent, and the ground sloping gently to the south, the rule is, that the north wall may be 14 feet high; the south wall, 10; and the other walls, about 12. In a larger garden, containing perhaps four acres, the north wall is sometimes raised 18 feet high; the side walls, or those on the east and west, 15; and the south wall, not more than 12. On a dead level the north wall is generally made 16 feet high; the east and west walls 13½; and the south wall 11. It may be observed, that walls higher than 12, or at most 14 feet, are necessary only for pear-trees; peach, nectarines, apricot and plum-trees seldom requiring more than 12 feet. It may also be right to notice, that the terms north and south wall, are here used to denote the north and south sides of a square or parallelogram; but that, in speaking of wall fruit, if it be said that peach or fig trees require a south wall, this must be understood to mean

a wall with a south aspect, or what is in reality the north wall of the garden. There are two motives therefore for raising this wall some feet higher than the others; first, sheltering the garden from the northern blast; and, in the next place, the procuring of ample space for training the finer kinds of fruit-trees on the south side of the wall, or best aspect of the garden. Under the denomination of finer kinds of fruit-trees are to be understood not only peaches, nectarines, apricots and plums, but some of the French pears, such as the chaumontel, colmart, and crassane. Many gardeners are of opinion, that the best aspect for a fruit wall in this country is about one point to the eastward of south; such walls enjoying the benefit of the morning sun, and being turned a little from the violent west and south west winds. South-east is, for the same reasons, accounted by many, a better aspect than south-west. The south-west and west walls are assigned to fruits which do not require so much heat to ripen them as is necessary to those above mentioned; such are cherries, many kinds of pears, and apples. The north walls are appropriated to apples and pears for baking, plums and morella cherries for preserving; and a few may-duke cherry, white currant and gooseberry trees, are trained against these walls, with the view of their affording a late crop.

Bricks, it is generally allowed, are the best material of which to construct the walls. The foundation and basement are often made of common building sandstone, while the superstructure is brick; and sometimes the back part of the wall is of sandstone, and the front only of brick. Sandstone which rises in flags is the best substitute for bricks. Both kinds of materials admit of the branches of the trees being nailed in regularly, and without difficulty. Where the walls are of common rubble building, a trellis of spars is sometimes placed against them, and to this trellis the branches are tied with osier-twigs or rope-yarn. This is regarded as a very good plan; but the expence is considerable, as, to prevent the lodging of insects, the trellis must be smooth and painted. The trees thus enjoy the shelter and reflected heat of the wall, without being injured by its dampness in rainy weather; and as the wall is not injured by the driving and drawing of nails, there are fewer lurking-places for the wood-louse and the snail. The rails of the trellis are made closer or wider, according to the nature of the tree to be trained against it. In a few instances in Scotland, walls have been built of different kinds of *whinstone*, chiefly greenstone and basalt. These minerals, on account of their almost black colour, are calculated to absorb and retain more heat than stones of a light hue: but it is to be considered, that it is not the heat retained by the wall which benefits the tree, so much as the heat reflected from the wall. The proposal of painting walls black is, on the same principle, not admissible. It may here be of some importance to remark, particularly as applicable to Scotland, that in building brick walls, *bricklayers* only should be employed; stone-masons working as awkwardly and clumsily with bricks, as bricklayers would do with masses of whinstone.

As the walls of a garden form one of the principal sources of expence, it is proper, before proceeding to build, to ascertain correctly the average level of the borders, if the ground be unequal, so as to suit the depth of the foundation to it. If the inequalities be considerable, both walls and borders are made to sink and rise, so as to humour them. Declivities in a garden are not unpleasing; and when they happen to slope to the south or east, they afford the earliest crop of different legumes, such as peas or beans. Some improvers have constructed a series of low flat arches as the basement of the wall, these arches having their tops on a level with the surface of the borders; the piers left are from two to four feet broad, according as the foundation is firm or otherwise. The advantage consists not merely in saving much building, but in permitting the roots of the wall-trees, which are planted opposite to the arches, to extend themselves in every direction, and draw nourishment from the soil on both sides of the wall. In some places projecting stone buttresses are set at intervals in the walls, in order to strengthen them, and to break the force of the winds when sweeping along. But to this latter purpose they contribute little: temporary screens of reed, projecting at right angles from the wall, and removed after the blossoming season, when the chief danger is over, are thought better: and if any sort of strengthening columns or piers be necessary, they can be built so as to project only on the outside of the wall. In this country, walls are generally made of the thickness only of three bricks laid side by side, or somewhat more than a foot; and to such walls, in exposed situations, buttresses may be very proper. When the walls are intended to be high, indeed, they are commonly made sixteen inches thick for a few feet above the basement, and then gradually reduced to twelve or thirteen. The basement, whether of brick or stone, is always about six inches thicker than the lower part of the wall.

Walls have sometimes been built with curves; and in perfectly calm weather, the trees in these curves must receive more heat than on a straight wall; but it is found that in windy weather they suffer much more; and that even when there is only a slight air of wind, a draught is produced around the trees, rendering their situation colder than if they were at a distance from the wall. Curved or semicircular walls are therefore no longer constructed. The inclining of walls to the horizon, in order to their receiving the sun's rays more directly, is excellent in theory, but not adapted to practice. Trellises may be so inclined, or close wooden palings: such indeed have been successfully employed in some gardens, as at Brechin Castle, the seat of Mr Maule of Panmure; where curved walls may also be seen. A stone or brick wall, however, could not be sufficiently inclined without the support of a bank of earth, and this would inevitably keep the wall continually damp and cold. A coping is necessary to preserve the wall, not only by preventing the rain from sinking into it at top, but to throw it off from the sides, where its trickling down would do much damage. The best coping is formed of long pieces of freestone, neatly hewn from four inches thick in the centre to two at the plinth; the edges being made to project beyond the wall about two or three inches, and a groove being run underneath the plinth, to collect and throw off the drops.

What is commonly called the *kitchen-garden* has, in modern times, become almost the only walled enclosure. It is likewise the *fruit-garden*, the walls being chiefly intended for the protecting and training of fruit-trees. These, it is to be understood, are planted on both sides of the wall; the exterior fruit-border being defended generally by a sunk fence and an evergreen hedge, with a wire fence for the exclusion of hares. If, after all, the enclosing walls afford too little room for training, a cross wall is built in the middle of the garden; or where the establishment is large, and where fruit is much in demand, two cross walls are reared. These cross walls are not placed nearer to each other than a hundred feet; if they be two hundred feet separate, it is perhaps better. They can scarcely be said to disfigure the garden; on the contrary, they might be defended, as tending rather to enliven its effect, by presenting new scenes, as the successive central doors are opened. They seldom need to be high; being generally destined for peaches, nectarines, or plums, nine or ten feet are sufficient.

*Hot Walls.*

41. It may be proper in this place to say a few words of flued walls, as by much the best time for their construction is at the original enclosing of the garden. Hot walls are of two kinds; such as are intended to have sloping glass-frames attached to them, thus to a certain extent forcing the fruit; and such as are not calculated for having this appendage, but merely to have screens over the blossoms in the spring. Both are generally built about ten or twelve feet high.

In the first kind of hot wall, a ground plate or low parapet, a foot high, and at the distance of perhaps five feet from the wall, is, in some places, formed for the glass frames to rest upon, these being heavy and strong; the trees are trained on a trellis within a few inches of the wall; and along the border in front of the trees, early crops of peas, kidney-beans, or strawberries, are raised. In other places, the frames are of very slight construction, and easily manageable: they are about two feet shorter than the height of the wall; and this deficiency is supplied by a bordered parapet, on which rest the rafters for supporting the sashes: the space between the bottom of these and the wall, seldom exceeds three feet. One furnace is reckoned sufficient for 45 or 50 feet of such frame-work. When the new wood of the tree is sufficiently ripened, the whole is taken down and carried under cover. When there is a considerable extent of hot wall, adapted for the reception of glass frames, perhaps 250 or 300 feet, particular trees may be forced or omitted, and an opportunity is thus afforded of restoring trees, by allowing them a year's rest. For these hot walls, fire heat is required only for about four months, from the end of February to the end of May, and again for two or three weeks, when the new wood is ripening.

Flued walls, with an apparatus for temporary coverings of canvas, oiled paper, or woollen nets, are necessary for the perfect production of the finer sorts of peaches and nectarines in all parts of Britain north of Yorkshire. Without the aid of artificial heat, the young wood of these trees is seldom sufficiently ripened, in ordinary seasons, to ensure a supply of good flower-buds for the following year; and unless the buds be strong and plump, the chance of a crop the ensuing season is proportionally lessened; and frequently, after a sufficient quantity of fruit has been brought to full size, unless heat be supp ied artificially, in autumn, maturation is not effected. In the northern parts of the island, therefore, it is always proper to construct a portion of the garden walls with flues: the additional expense of forming the flues, particularly where the inside facing only is of brick, is but trifling; and little consideration should be attached to the expence of the small quantity of fuel that may be necessary for promoting the *setting* of the fruit, and for ripening off the young wood in autumn, the time when it is chiefly wanted.

The flues are commonly eighteen or twenty inches deep, and nine inches wide, inside measure, and they make as many turns as the height of the wall will permit. Formerly they made only three turns; but it has been found, that the oftener the flues are returned, provided they draw well, the less heat escapes by the chimney, and consequently the more is evolved from the surface of the wall. The sole of the flue to the length of the first turn, is generally a foot above the level of the border. The front wall of the flue is 4½ inches thick, or a brick on bed, without any inside plastering. In some places a wooden trellis covers the wall; but in general, the trellis does not extend higher than the first range of the flue, the heat above this not injuring the trees: where neatness is much studied, the trellis rods are sunk into a small recess purposely left in the wall, thus preventing the appearance of bulging, which is otherwise unavoidable.

*Soils.*

42. The improvement of the soil naturally becomes an object of great importance at the first formation of a garden; and its subsequent management, or "keeping in heart," as gardeners term it, is a matter of equal interest.

The various soils distinguished by gardeners and horticulturists consist of the simple earths (as they used to be called) of the chemists, particularly argil, silex and lime, mixed in different proportions. It is well known, that some of the principal offices of the soil are merely mechanical; such are, the giving proper support to the vegetable by means of its roots, and the supplying these with water in a slow and convenient manner, the superfluous moisture draining off. A mixture of clay and sand is called *loam*; and according as the one or other of these earths predominates, the soil is denominated a clayey or a sandy loam. In the same way, in some counties of England chalky loams are common; and in other districts, gravelly loams are not unfrequent. When oxide of iron prevails, and renders the clay hard and of a dark brown or red colour, the soil is called ferruginous loam, or more commonly *till*. Boggy or heathy soil consists of ligneous particles, or the decayed roots, stems, and leaves of various carices, heaths and sphagna, and the coaly matter derived from these, generally with a slight mixture of argillaceous earth and sand. While the nomenclature of soils remains so imperfect and unsettled as it now is, there seems no propriety in enlarging further on the different varieties. Some judicious remarks on these, and on the principles on which they should be distinguished and named, may be found in the Agricultural Report of Ross and Cromarty, drawn up by Sir George Mackenzie, Bart.

Carbonaceous matter, and certain salts, in small proportion, are likewise ingredients in a good soil, plants deriving not only support from the soil, and nourishment from the water, and from the decomposition of the water, supplied by the soil to their roots, but also other peculiar sorts of food from the carbon and salts alluded to.

43. Any substance added to a soil, either to supply a deficiency, or to rectify what is amiss, is called a *manure*. The use of manures is, of course, very various. They may be destined to render soil less retentive of moisture, or to make it more retentive; or they may be calculated to communicate carbonaceous matters or salts. With the former view, clay or argillaceous marl form a suitable manure for a sandy soil, and sand or lime for one that is clayey; while dungs and composts of every kind yield the other requisite materials to the soil. For opening clayey soils in gardens, marls are excellent, particularly gravelly marl. Where marls cannot be had, shelly sand, coal-ashes, or wood-ashes mixed with chips of wood, may be resorted to. For binding sandy soils, argillaceous marls or calcareous loams are proper; and the scourings of ditches are often, for this purpose, valuable.

The improvement of cold or sour clay is sometimes effected by scorifying it, or *burning* it, as it is commonly termed. The sward, with two or three inches of the clay adhering to it, is collected in heaps, and brought into a state of red heat, by means of furze, peat, or coals, taking care to add clay on the exterior, so as to confine the fire. Acids and vegetable matters of noxious tendency seem thus to be driven off, and a soil fit for garden culture produced. This is an old practice, which has been lately revived. In Hitt's Treatise on Fruit-trees, published in 1758, there is a chapter "Of the burning of clay for the improvement of land."

44. The soil of a garden should never be less than two feet and a half deep; the best gardeners prefer having it fully three feet. The natural soil, therefore, however good, is seldom of sufficient depth. If it be not two feet, a quantity of earth from the fields is carried in. The cleanings of roads and grass-turf of any kind form valuable additions to garden soil. In the course of trenching, a portion of the subsoil is brought to the surface, and gradually meliorated; but to bring up much of it at once, is very injurious. Soil of the usual depth may be trenched two spit (spadeful) deep; and if this be done every third year, it is evident that the surface which has produced three crops will rest for the next three years; thus giving a much better chance of constantly producing healthy and luxuriant crops, and with one half the manure that would otherwise be requisite. Nicol insists for the deeper soil, and recommends that, after taking three crops, the ground should be trenched *three* spit, by which the bottom and top are reversed; three crops are again to be taken, and the ground trenched *two* spit, by which the soil which formed the top goes to the middle, and that which lay in the middle goes to the surface. After other three crops, the trenching is to be again three spit deep. By thus alternately trenching two spit and three, after intervals of three years, the surface soil is regularly changed, resting six years and producing three; and an approach is thus made to the desirable object of having always a *new* soil.

It is agreed on all hands, that nothing contributes more to the preserving of the soil of a garden in good condition, than exposing it as often as possible to the action of the sun and air. It is a rule, therefore, that garden ground, when not in crop, should regularly be dug *rough*, or if possible *ridged up*, and left in that state to the influence of the atmosphere. If it be allowed both a winter and a summer fallow, the oftener a new surface is exposed the better; after it has lain ridged up during winter, therefore, repeated diggings are given in the spring and summer months. Whether some noxious matter be exhaled, or some fertilizing substance be imbibed, or what may be the precise nature of the operation that goes on, we do not here inquire. The fact is certain, that *aëration*, as it is sometimes called, is of the greatest advantage to garden soils.

45. It has been already remarked, that it is desirable to have soils of different quality in the garden. One of the most generally desired is what is called *mould*, by which is meant a soil in which vegetable earth predominates. Such as is of a bright chesnut colour is preferred: it is usually styled by gardeners, hazelly mould, or hazelly loam, from being of the colour of the hazel nut. The characters of the best mould, according to Miller, is, that "it cuts like butter, does not stick obstinately, but is short, tolerably light, breaking into small clods, is sweet, well tempered, without crusting or chapping in dry weather, or turning to mortar in wet." It should be so open, as not to stick to the spade or the fingers after a shower of rain. Dark grey and russet-coloured moulds are likewise considered good; ash-coloured are commonly bad; yellowish red still worse. Good moulds, after being broke up by the spade, or after rain, if the surface have been recently dug or hoed, emit rather a pleasant smell. What are called brick moulds, or loams, are much esteemed, both by the gardener and the florist, as auxiliaries to mix with other soils.

For some purposes a sandy soil is wanted. In this case, either the *surface* sand, from a sandy pasture, is alone used, as it contains a considerable portion of vegetable matter, or, if pure sea or river sand be employed, light rich mould, nearly in the proportion of one-half, is mixed along with it. For a very great number of plants, particularly in the flower garden, an excellent soil is to be found in the turf of old pastures, and the earth which adheres to the turf to the depth of six or eight inches, mixed with a portion of cow and horse dung in a rotten state, laid together in a heap for at least a year, and frequently turned over. This is a *compost*, and naturally leads us to speak more particularly on the subject of manures.

### *Manures.*

46. Many authors have treated of manures, and given theories of their beneficial action; Fordyce, Hunter, Cullen, Ingenhousz, Senebier, and others. The learned Kirwan wrote a separate essay on this subject. In this work of Mr Kirwan, and in the more recent publication of Sir Humphry Davy, may be found all the information on the matter that is to be obtained by reading. To enter fully on an account of manures, or the theory of their action, would here be out of place. Besides, manures in general have already been treated of in a former part of this work, (See vol. i. art. AGRICULTURE); and the remarks here made, shall be confined to manures considered as particularly applicable to gardens.

47. It is now an established fact in practical gardening, that for the greater number of culinary plants, and for all fruit trees and flowers, composts or compound manures are far preferable to simple dungs, and that till the latter be completely rotted, they should not in any case be suffered to touch the roots of the plants. Even composts should not be too rich. Trees especially are very apt to be injured by the injudicious and excessive use of manure. A very rich compost will stimulate them for a few years to preternatural exertion; but, as remarked by Mr Knight, will in all probability become the source of disease and of early decay. A very good practical gardener, Mr David Weighton, recommends, for cold clayey land, a compost made up in the following proportions: three parts light mould; one part rotten stable dung; one part sharp sand; one part coal ashes; half a part lime; with a small proportion, perhaps an eighth, of pigeon's or sheep's dung. For a light sandy soil, the following are the ingredients and proportions: to two parts of the natural soil, three parts of pond earth, or the scourings of ditches, and three of strong loamy earth; one part of clay, or rather clay-marl, if it can be got; and two parts of stable or cow-house dung.

In the opinion of some gardeners, the best mode of applying compost manures is, to trench deep, and put compost in the bottom, to the thickness perhaps of eight inches; then to lay on the old garden soil, and to cover the whole with compost to the depth of some inches. In this way, the old or worn out soil is placed in the middle, and is exposed to the effluvia which may arise from the lower stratum, and at the same time is incorporated, by digging, with the upper.

48. In the neighbourhood of the coast, sea-weed is often used; and if dug in soon after being collected, its fertilizing powers are considerable; for artichokes, asparagus, sea-cale, and cabbage, indeed, there cannot be a better manure. The careful gardener pays great attention to the preservation of the dung of the stable and cow-house. The essence of these kinds of dung is often in some measure lost, by the drainings being allowed to

escape. These should be collected in cisterns, and poured occasionally over the dunghill or the compost-heap. Indeed, it appears evident, that every large garden, and every well-regulated farm, should be furnished with a close shed as a dung-store; for *dungs*, properly so called, should be as little exposed to the influences of the weather as possible. It is two centuries since this was pointed out by Sir Hugh Platt, who recommends the building of a brick receptacle, and covering it over, so as to prevent the access of rain, and exclude air to a certain degree.

49. Mr Knight has proved, that vegetable matter in its recent and organised state may be employed as a manure, with more advantage than when it has been decomposed. It is evident, that no inconsiderable proportion of its component parts must be dissipated and lost during the progress of the putrefactive fermentation; and it is no less evident, that if this process be made to go on beneath the surface of the soil, the exhaled particles must first be applied to the roots of the plants, before they can escape.

*Fruit-tree Borders.*

50. The proper forming and managing of borders for fruit-trees is a matter of great consequence, especially when peaches and nectarines, vines, and the best sorts of plums and pears, are cultivated. In many old gardens the borders are only five or six feet broad, and are crowded with perennial flowering plants. Such borders are too narrow, and such plants must greatly rob the trees of their nourishment. The border, according to a gardener's common rule, should not be less in breadth than the wall is in height; but the general breadth is only from 8 to 12 feet. If care be taken to make the soil good below the walk, such a border may prove sufficient. If the bottom be not dry, it is made so by means of drains. Many are of opinion, that it should at the same time be rendered impervious to the roots of the trees, by means of lime-rubbish, or clay and gravel rolled hard, or by complete paving: this precaution is particularly necessary where the subsoil is a cold wet till.

The monastic cultivators of fruit-trees in the 13th and 14th centuries were well aware of the importance of this matter, and seem to have been unsparing either of labour or expence. When Mr Ferguson of Pitfour was laying out a new orchard in Aberdeenshire, he found, in clearing out the remains of the garden of the ancient Abbey of Deer, which is included within the precincts of the orchard, a border which had been prepared for fruit-trees in the following laborious and expensive manner: "First, rich soil above three feet deep; secondly, a well-paved causeway; thirdly, a bed of pure sand, a foot deep; fourthly, another causeway; and beneath the whole, a considerable depth of rich earth."

Gardeners always wish the soil of their borders to be more than two feet deep; for pear-trees it should be three feet at least. In many cases, no part of the natural soil is retained; but the entire border is formed, partly of good loam brought from the neighbouring fields, or prepared by rotting some old pasture turf, and partly of such compost moulds as have been already described. When the natural soil is to some extent retained, if it be a strong clay, it is opened by adding sea sand, or coal-ashes that have been kept dry. Sometimes, in place of these, a small proportion of quicklime is used; but this is seldom advisable. If, on the other hand, the natural soil be loose and sandy, the clayey matter to be found in ditches and open drains in ploughed land is resorted to, and laid about six inches thick at the bottom of the border. Many cultivators are particular in adapting the quality of the soil or compost to the nature of the trees to be planted. For apricot and apple trees, the compost usually preferred, consists of three-fourths light earth, and one-fourth strong loam, well mixed and incorporated with some thoroughly rotten cow dung. For peach, plum, and pear trees, a stronger soil is prepared, and the proportions are reversed, the loam constituting three-fourths, and the light soil one-fourth. Cherry-trees, too, like rather a cool bottom; and equal parts of light earth and of loam form for them a suitable soil.

In forming a new garden, it is very advantageous to have the borders prepared a whole season before planting the trees, and that, equally, whether these consist mainly of travelled soil, or of the natural soil enriched by some composts. If the ground be repeatedly turned and ridged up, it is found ultimately to be in a much better condition for receiving the plants.

The soil of the borders is at first made higher by some inches above the walks, than that of the quarters in the interior of the garden: the reason is, that the quarters annually receive a large accession of manure, whereas the fruit-tree borders are afterwards to receive comparatively little that can add to their depth. Some judicious gardeners contend, that such borders are to be manured only with composts, rendered as homogeneous as possible by frequent turning and intermixing. Others do not hesitate to use well-rotted dung: this is dug in with a three-pronged fork, so as to avoid injuring the roots of the trees; and it is generally applied in the month of November, after the winter dressing of the trees.

51. The borders, particularly those next to south walls, are in most places cropped with early peas, or turnips, or some other plant which does not extend its roots deep into the earth; avoiding, therefore, cauliflowers and beans. But many gardeners disapprove of this, especially in the case of peach and nectarine borders; and certainly if a crop be taken, it should be of the lightest kind, such as salad herbs, and perhaps a few scattered patches of ornamental annuals next the walk. In order to avoid using the fruit-tree borders, therefore, it is a custom, in some well ordered gardens, to have low reed hedges or palings run across some of the quarters; to these the earliest peas or beans are closely attached, as they advance in growth, so as to enable them to escape the frosts of March and April more effectually, even than in front of a south wall. It need scarcely be remarked, that fruit-tree borders are kept carefully clear of weeds, and that frequent stirrings with the hoe, or the three-pronged fork, and frequent rakings are practised, the maintaining of the surface in a fresh and porous state being found of singular advantage. When the season proves very dry, they are watered perhaps three times in the week, after sunset.

52. In many situations and circumstances, it is found impossible to form a soil for fruit-trees, with the care, and at the unavoidable expence, which have here been supposed. In these cases it is necessary to adapt the kind of trees to the soil. On soils naturally very light, gravelly, and sandy, peach and nectarine trees do little good: it is better to plant apricots, figs, or vines, which agree with such soils, and, when trained against a wall having a good aspect, will, in the southern parts of the island, afford excellent crops of fruit. On such soils, even espalier and dwarf-standard apple trees are short-lived, subject to blight, and produce only stunted fruit. Next to renewing the soil, the best remedy is to engraft and re-engraft frequently, on the best wood of the trees, giving the preference to grafts of those kinds which experience has

shewn to be most productive and healthy in that particular place. In shallow soils some have been in the practice of making troughs or hollows, and filling them with rich earth, for the reception of the trees: but this is not to be approved of; the roots of the tree will probably be confined to the trough, and it is possible that water may be retained in it. In thin soils, therefore, it is more proper to raise the surface into little hillocks than to dig hollows. If a tree be planted on the general surface, and have earth heaped around it, it will spread its roots in every direction, and to a great distance, in the shallow soil; and some subsoils, such as decomposed trap-rock, or chalk, are themselves calculated to afford much nourishment.

*Division of the Garden, &c.*

53. It is, of course, understood, that the wall-tree borders extend all around the margin of the garden. It naturally follows that a gravel walk should run parallel with them. On the other side of this walk, in very many gardens, there is a row of espalier-trees, (or, to speak more correctly, counter-espalier trees), fixed to trellis-rails. If the enclosure be tolerably extensive, the centre is traversed by a broad walk. If it be of the largest dimensions, and possess a cross wall, or cross walls, the arrangement of the walks falls to be altered accordingly; a main walk proceeding directly to the doors in the centre of the cross walls. The rest of the garden is divided into compartments, and most of these compartments, in some of our best gardens, are laid out in beds four feet wide, with narrow alleys. So many alleys, no doubt, occupy a good deal of room; but the advantages of conveniency and neatness, in enabling the workmen to clean and gather the crop without trampling the ground, seem to compensate the sacrifice of space. For currant, gooseberry, and raspberry bushes, the quarters are of course, reserved undivided; and narrow beds are unnecessary in the case of large perennial plants, such as artichokes or rhubarb. Border-edgings are not in use, excepting for the walks next the walls, and the cross walks in very large gardens; for these, dwarf box is almost universally employed. In the interior quarters, however, parsley may sometimes be observed forming an edging; and thyme, winter savory, or hyssop, are occasionally employed in the same way, and harmonize very well with the culinary crops around.

54. Hitherto nothing has been said of the situation of the range of hot-houses. In many gardens, these occupy a very considerable part of the south wall, that is, the wall on the north side of the garden. In the area behind them, are sheds for tanners bark, rich mould, and other requisites; while there is a cart access to the doors of the furnaces, and these, with all the rubbish necessarily attending the operations of forcing, are completely hid from view. In some places all the forcing-houses form a continuous range; but generally the pine stove and succession pit, being of different dimensions, are placed separately In some elegant gardens, as at Raith-House and Wemyss-Castle in Fife, the hot-houses have a flower-garden in front of them, while every thing offensive is excluded from view, as in the former case. In other places the hot-houses are disposed in a different manner: the several kinds of houses stand detached from one another, each being set down as it were in a separate grass lawn; the back part, where the furnaces are situated, is concealed by shrubs, so that the houses seem to stand in little thickets, and thus form an agreeable variety with clumps and patches of trees in the park. Donibristle, the seat of the Earl of Moray in Fife, may be mentioned as an example of this sort of arrangement.

55. In many instances, the flower garden is separated from the fruit and kitchen garden merely by a wall, perhaps by a quick hedge. But in modern *places*, (as gardeners speak) this garden is removed from the other by a considerable distance. To it belongs the green-house and the orangery; there is often connected with it a conservatory; and sometimes, where the owner has a taste for the culture of rare plants, a stove merely for the keeping of tender exotics.

Where the interior of the walled garden does not afford space enough for raising a sufficient supply of culinary vegetables for the family, a piece of ground is fenced off on the outside of the walls, on one or more sides, and is called the *slip*. If the melon and cucumber ground be not situated at the back of the principal suite of hot-houses, it may very conveniently be placed in the slip.

*Hedges.*

56. For tall hedges, to afford additional shelter to particular quarters, or to screen objects from view, various evergreen plants are employed. Holly answers admirably, for height, strength, and thickness; but it is of very slow growth, and flourishes only in clayey ground. Yew is also excellent, and much used. Several deciduous trees are likewise employed, such as lime, beech, and horn-beam. English elm is occasionally used; and in wet places alder is justly preferred. In very large gardens a hedge of holly or beach, running from north to south, is of incalculable advantage, especially if the garden be in the form of a parallelogram, and much exposed to high winds. Small ornamental divisions in gardens are formed of many different kinds of plants, according to the taste of the owner, and the size of the hedge wished for. Laurel, laurustinus, phillyrea, and evergreen oak, are suited to this purpose; as well as pyracantha, sea-purslane, rosemary, and French tamarisk; the last two, however, will not form hedges unless in our southern counties, where the myrtle can withstand the cold of ordinary winters. But of all shrubs used for such division hedges, evergreen privet seems the best; and it is the plant now most frequently employed for that purpose. Some persons are fond of flowering hedges: they are composed of different kinds of rose-bushes, sweet-briars, and honeysuckles; the lately introduced Rosa Indica, making here a conspicuous appearance, being equally covered with flowers early and late in the year. Garden hedges of any kind are now much less frequently planted than they used to be. In our climate the fruit-garden must be surrounded with brick or stone walls: these serve not merely for protecting the trees fixed against them, but supersede the necessity of tall hedges for the purpose of shelter. The flower-garden, however, is still chiefly sheltered by evergreen hedges, with rows of tall deciduous shrubs, or low-growing trees, behind. In some places these are situated on the declivity or talus of a bank, forming a highly ornamented screen, analogous to the *brise-vent* of the French. From the interior of this garden, however, hedges have been nearly banished, by the change of taste, and dislike of every thing formal.

In this country, as formerly remarked, the Fruit-garden and the Kitchen-garden are locally blended together, both being inclosed by the same walls: the objects of each, however, are quite distinct, and may conveniently be treated of separately. The general disposition of the departments of the garden has been already spoken of, and likewise the forming of fruit-tree borders. Other matters particularly connected with the *fruit-garden* shall now be considered.

## FRUIT-GARDEN.

57. The kinds of fruits usually cultivated within the walled garden, but in the open air, are eighteen in number; and of these ten are considered as indigenous to the country, and eight are exotics. The native fruits are, the apple and pear (*Pyrus*); plum and cherry (*Prunus*); the medlar (*Mespilus*); the red and the black currant, and the gooseberry (*Ribes*); the raspberry (*Rubus*); and the strawberry (*Fragaria*). The exotic fruits are, the peach, nectarine, and almond (*Amygdalus*); the apricot (*Prunus*); the grape (*Vitis*); the fig (*Ficus*); the quince (*Pyrus*); and the mulberry (*Morus*). The apples and pears, plums and cherries, found native in our woods, however, differ so completely in appearance and taste from those of our gardens, that none but a botanist could easily be persuaded to consider them as of the same original species. The chestnut (*Fagus*); hazel-nut (*Corylus*); sorb (*Sorbus*); elderberry (*Sambucus*); and berberry (*Berberis*), are likewise natives: these are also cultivated, but generally in the pleasure-grounds exterior to the walled garden. The walnut (*Juglans*) is a foreign tree, planted chiefly in lawns, or on the outside of the orchard. The pine-apple (*Bromelia*), and the melon (*Cucumis*), constantly require artificial heat. Oranges, lemons, and shaddocks (*Citrus*) must at least spend the winter under glass. The pomegranate (*Punica*) is sufficiently hardy to live in the open air in our climate; but it does not generally produce its fruit. This, with some other fruits occasionally cultivated, shall be noticed, after speaking of the more common.

Before treating of each of the fruits in detail, it will be proper to explain the operations of grafting and budding, training and transplanting, all of which must afterwards be frequently referred to.

### *Stocks for Grafting.*

58. When a cion, or part of a cion, is taken from a fruit-tree, and inserted either on a young stem, or on the bough of a full grown tree, it is called *grafting*. But in the former case a new or additional tree is procured; and in this way, chiefly, apples and pears are propagated; and sometimes plums and cherries. A good cion may generally be cut into two or three pieces, which are called *grafts*; the stems on which they are placed being named *stocks*. The raising of stocks, and the propagation of fruit-trees, will properly fall under the article Nurseries: a few explanatory observations in this place may therefore suffice. The subject is not without interest; for every one, who wishes to keep his garden and orchard well supplied with fruit-trees, should establish a small private nursery, in which, upon stocks of different kinds, according to the end in view, he may graft or bud the kinds of fruit which experience shews to be best suited to the soil and climate of the place, and which best meet his own views.

59. It is necessary that the stock should be a member of the same genus or natural family with the graft or bud to be inserted on it. The principal kinds of stocks employed are the following:

For *apples*,
- Common apple, from the kernels, for full standards.
- Crab apple, from the kernels, for half standards.
- Codlin, from layers or cuttings,
- Paradise, from layers,
- Creeper, from layers, all for dwarf trees.

For *pears*,
- Common pear, or wilding, from the kernels, for full standards.
- Quince, from the kernels, or by layers, for dwarf and espalier trees.

For *plums*, *apricots*, *peaches*, *nectarines*, and *almonds*,
- Red-wheat plum, either from stones, or layers, or suckers.
- Black muscle plum, the same.
- Greengage plum, the same.
- Bullace-plum, a common native species, which has received its trival name, *P. insititia*, from being used for stocks.

For *cherries*,
- Small black cherry of the woods *Prunus cerasus*; and,
- Wild red cherry of the woods, *P. avium*.

60. It may here be remarked, that seedling stocks, which have a natural tendency to attain the full height of the species to be grafted on them, are by horticulturists universally denominated *free-stocks*. If the seeds of different varieties of apples and pears be sown, free-stocks, suited for the grafting of apples and pears, are, generally speaking, produced. When very great numbers of such stocks are wanted, the seeds are procured from the manufactures of cider and perry; but where a private gentleman wishes only to have a few hundreds of stocks, it seems much better to employ only select seeds, that is, the kernels from good specimens of hardy and healthy kinds of choice fruits, when in a ripe state. Crab stocks are very much used: the seeds are to be procured in quantity only where verjuice is made from the fruit. The paradise apple is of no estimation as a fruit; but the tree being naturally dwarf, grafting on it tends to dwarf the engrafted tree. The creeper apple has got its name, from its tendency to throw up suckers, which are easily detached with roots: it is sometimes called the Dutch paradise. Pear-trees, as already said, are grafted either on free-stocks from the seeds, or on quince stocks from layers or suckers. The latter are employed chiefly for dwarfing the trees, and throwing them more early into bearing; but with the view also (whether well or ill-founded is not the question) of imparting some degree of hardness and sharpness to the melting sugary pears; the hard and breaking pears, on the other hand, being placed on free-stocks. For all practical gardeners, it may be observed, concur in stating, that the nature of the fruit is, to a certain extent, affected by the nature of the stock. Miller says, decidedly, that crab stocks cause apples to be firmer, to keep longer, and to have a sharper flavour; and he is equally confident that, if the breaking pears be grafted on quince stocks, the fruit is rendered gritty or stony, while the melting pears are much improved by such stocks. This is scarcely to be considered as inconsistent with Lord Bacon's doctrine, that "the cion overruleth the graft quite, the stock being passive only;" which, as a general proposition, remains true; it being evident, that the graft or the bud is endowed with the power of drawing from the stock that peculiar kind of nourishment which is adapted to its nature, and that the specific characters of the engrafted plant remain unchanged, although its qualities may be partially affected. Quince stocks, it may be added, are also proper, where the soil of the garden is naturally moist, the quince agreeing with such a soil. Peaches and nectarines are, in this country (as noticed in the tabular view) generally budded on plum stocks, particularly the black muscle: but the more tender sorts are placed on seedling stocks of their own kind, raised from peach-stones, or perhaps on apricot stocks. In France, almond stocks are much used; and

for this reason the French peach-trees seldom last good more than twenty years, while the English endure twice that period. Apricots also are chiefly budded on plum stocks, the red wheat plum being preferred for them.

61. In the second volume of the London Horticultural Transactions, Mr Knight has given a few remarks on the effects of different kinds of stocks in grafting,—well deserving of attention, as being the result of more than thirty years experience. He is of opinion, that a stock of a species or genus different from that of the fruit to be grafted upon it can rarely be used with advantage, unless where the object of the planter is to restrain or debilitate. If, therefore, extensive growth and durability be required, the peach, nectarine, or apricot, should not be grafted on the plum; but if it is intended to diminish the vigour and growth of the tree, and if durability be not thought an important quality, the plum stock is proper. The same remark is applicable to the grafting of pears on quince stocks. The finer sorts of peaches and nectarines are often budded on apricot stocks. Of this Mr Knight approves; but he adds, that, if lasting and vigorous trees be wished for, the bud cannot be placed too near the ground.

62. The seeds for stocks are commonly sown in March, in four-feet beds. The germination of some kinds is promoted by placing them in moist sand, in a greenhouse or cellar, for some time previously. Next season, the seedlings are transplanted into nursery rows. Here they remain till they reach the size wished for, in order to the forming of wall or espalier dwarfs, or dwarf standards, half standards, or full standards,—the characters of which will be immediately explained. For the first three kinds, they are generally ready after two seasons: for the last, not sooner than after three or four. The finer kinds of plums are budded or grafted on plum stocks, raised from the stones. The common kinds of plums, and the almond, are propagated chiefly by suckers; figs, mulberries, and quinces, principally by layers; gooseberries and currants, by cuttings. Several varieties of apple, as the original or burknot, the brown apple of Burntisland, and some others, grow by cuttings; and many kinds, indeed all those sorts of fruit trees that have small buds, may be propagated by laying down branches, having a ligature of leather or wire passed firmly around them, either above or below a bud, in the part buried in the earth. At the place of binding, the circulation of the sap being interrupted, a swelling ensues, and roots break forth. The layer is separated the following year, and planted where it is intended to remain. This mode of propagating fruit trees is well known and often practised on the continent, though little attended to in this country; by it, in the course of three years, bearing trees are produced, without the trouble of grafting. Stocks for cherry trees, raised either from the native black cherry or guigne, or the wild red cherry, are considered as less apt to prove gummy or diseased than those raised from the stones of garden cherries, and they are at the same time accounted more durable.

### *Nursery Training.*

63. Fruit trees are trained as *standards*, of different kinds; as *wall trees*, or as *espalier trees*. For these, stocks of different ages or sizes are requisite. Standards are subdivided into three kinds, full standards, half standards, and dwarf standards.

*Full standards* are less used in Scotland than in England, where stems six or seven feet in height, before the branches are set out, are indispensable in orchards to which cattle are frequently admitted. Apples and pears are very commonly trained as full standards, and also cherries and plums.

*Half standards* have shorter stems, perhaps from three to five feet. These are particularly well calculated for standards in small gardens.

*Dwarf standards* have low stems, from one foot to two feet high; they are grafted on the most dwarfing stocks of their respective kinds, (apples on paradise stocks, and pears on quinces,) to make them produce low heads, suited to small compartments or borders; they come soon into bearing, produce large fruit, and in considerable abundance; while so humble is the tree, that the fruit may often be reached by the hand. Apples, pears, plums, cherries, and filberds, are very often trained as dwarf standards; and sometimes apricots, peaches, and figs. The French frequently train them to a cylindrical or somewhat pyramidal shape (*en quenouille*): in this way their appearance is improved, and the ground is less shaded; but, in general, the giving this shape must prove detrimental to the fruitfulness of the tree. In this country, they are usually trained like bushes (*en buisson*); from which, it is presumed, Mr Nicol denominates them *buzelars*.

For dwarf *wall trees*, stems five or six inches in length are sufficient; these, it will be observed, are the trees which are ultimately destined to cover the garden wall, being named *dwarfs* only from the humble stocks on which they grow.

*Riders* are wall trees grafted or budded on tall stocks, and are generally meant for the temporary purpose of filling the wall till the dwarfs get forward. The term *riders* is of Scottish origin, English gardeners having no appropriate name for wall trees trained in this manner, but merely calling them standards.

*Espalier trees* are intended for being trained against low treillages or latticed work, or rails which consist of simple upright posts; stems or stocks, six or eight inches in height, are therefore sufficient. To those who may look into French horticultural books, it may be useful to observe, that *en espalier* is their term for what we call wall training, and that our espalier training is by them denominated *en contre-espalier*.

The management of these different kinds of trees, from the time of their being grafted till they be fit for transplanting, belongs, equally as the raising of stocks, to the nursery department. The operations of grafting and budding, however, being of general importance, and among the nicest operations in horticulture, must here be described.

### *Grafting.*

64. *Grafting* may be performed in several different ways. The most important points are, to apply the inner bark of the stock and of the graft precisely to each other, and to bind them firmly in that situation. M. Thouin of Paris, in his laboured but excellent papers in the *Memoires du Museum d'Histoire Naturelle*, has made many minute distinctions, enumerating and describing no fewer than forty modes of grafting, independent altogether of several modes of grafting by approach, and of budding. We shall content ourselves, however, with explaining only the principal kinds practised by our own gardeners. These, as well as several other sorts of grafting, are very distinctly described, and illustrated by figures, by the late Mr Curtis, in his "Lectures," vol. iii.

65. The mode of grafting most commonly adopted in forming young fruit trees is called *tongue grafting*. Here it is desirable that the top of the stock, and the extremity of the graft, should be nearly of equal diameter. Both

are cut off obliquely, at corresponding angles, as nearly as the eye can guess; and the tip of the stock is cut off horizontally. A slip (or very narrow angular opening made by cutting out a thin piece) is then made in the centre of the stock downwards, and a similar slip in the graft upwards. (Plate CCCIX. Fig. 1.) A very sharp and narrow-bladed knife is necessary. The thin point of the upper half of the sloping end of the graft is then inserted into the slip in the stock; this is sometimes called *lipping*. The barks of stock and graft are brought closely to unite, at least on the right hand side, so as not to be displaced in tying, which is always done from left to right, or in the course of the sun. Strands of fresh bass-matting, steeped for a little time in water to render them more pliant, and to prevent the knot from slipping, are generally used for ties. A quantity of clay is worked fine, and mixed with some hay chopped small, or horse droppings, and sometimes with a little salt. It is found better to have it prepared a day or two beforehand, and to beat it up with a little water as needed. The tying is then covered with this clay, in the form of a collar, or ball tapering at both ends, the upper end being applied closely to the graft, and the under to the stock. These balls are not removed till after midsummer. A neat substitute for clay is mentioned by Abercrombie: a composition of turpentine, bees wax, and rosin, at first melted together, and afterwards heated as wanted; care being taken not to apply it too hot. A coatling, laid on with a brush, to the depth of a quarter of an inch, is said to be less liable to crack than clay; and, it is added, that when the full heat of summer arrives, the composition melts away of its own accord. It may be remarked, that the *whip grafting* mentioned in old horticultural books, is merely the kind now described, wanting the important improvement of the tongues or lips.

66. When the stocks to be grafted upon are strong, or perhaps branches of large trees, *cleft grafting* is often resorted to. The head of the stock or branch, (which we may suppose to be two or three inches in diameter,) is first cut off obliquely, and then the sloped part is cut over horizontally near the middle of the slope; a cleft, nearly two inches long, is made with a stout knife or thin chisel in the crown downwards, at right angles to the sloped part, taking care not to divide the pith. This cleft is kept open with the knife. (Plate CCCIX. Fig. 2. *a.*) The graft has its extremity for about an inch and a half cut into the form of a wedge, (Fig. 2. *b.*); it is left about the eighth of an inch thick on the outer or bark side, and is brought to a fine edge on the inside. It is then inserted into the opening prepared for it; and the knife being withdrawn, the stock closes firmly upon it. A circular incision is now made in the bark of the stock at the base of the wedge, to the extent of three parts of the circumference of the stock; by this means a shoulder can be formed on each side of the cleft.

67. Old stocks are sometimes grafted in another way, called *grafting in the bark* or *rind*, or *crown grafting*. The head of the stock or thick branch is cut off horizontally; a perpendicular slit is made as in budding, (to be presently described); a narrow ivory folder, or a silver fruit-knife, is thrust down between the wood and the bark, at the places where the grafts are to be inserted. The graft is cut, at the distance of an inch and a half from its extremity, circularly through the bark, not deeper than the bark on one side, but fully half way through, or beyond the pith, on the other. The cut portion is then sliced away; the end of the graft is pointed, being sloped a little to the point on the outside, but left straight on the inside. A shoulder is likewise left, to rest on the bark of the stock. The grafts are then inserted into the openings made by the ivory folder; and either three or four grafts are inserted on a crown, according to its size. This mode cannot be practised till the sap be in full motion, perhaps in the end of March, as till then the bark cannot easily be raised from the wood. When the grafts are placed on old trunks, they are apt to be drawn from their places by violent winds; it is proper, therefore, to bind them to stakes for the space of perhaps two years, when they will have acquired a sufficient hold of the stock.

68. *Saddle grafting* consists in cutting the top of the stock into a wedge-like form, and in making a corresponding angular notch in the bottom of the graft, to fit the wedge like a saddle. It is a mode sometimes adopted in the grafting of orange trees.

69. *Side grafting* is merely tongue grafting, performed in the side of a branch, or in the body of a stock, without heading down. The bark, and a little of the wood, are sloped off for the space of an inch and a half, or two inches; a slit is then made downwards, and the graft is cut to fit the part, with a tongue for the slit, (Plate CCCIX. Fig. 3.); the parts, being properly joined, are tied close, and clayed over. This mode is sometimes employed for supplying vacancies on the lower parts of full grown fruit trees. It cannot properly be performed till the sap is in action, or till about the middle of March.

70. *Grafting by approach*, *inarching*, or *ablactation*, as the older horticulturists termed it, is practised on some kinds of fruit trees, chiefly tender, such as oranges, lemons, pomegranates, and mulberries, and on several ornamental trees which do not readily succeed by the ordinary means, such as myrtles, jasmines, andrachnes, and some rare species of oaks, firs, and pines. Walnut trees are sometimes also increased in this way. The principle is, that the graft shall continue to have a degree of attachment to the parent plant sufficient to keep it alive, until such time as its bark shall have become united to the bark of the stock which is approached to it. The stock is often planted in a pot (Plate CCCIX. Fig. 4. *a.*) at least a year before, and is brought close to the tree or shrub to be grafted on it, (Fig. 4. *b.*); if too low, it is raised on a slight stage to the required height. Where the tree is strong, the pot is sometimes fixed upon one of the branches of the tree. The operation of inarching is seldom performed before the middle of April, or the beginning of May. When it can be accomplished, tongue grafting is even in this way advisable. In four or five months the inarched graft is generally found to be fairly united to the stock; the head of the stock is then cut off; but the graft is not separated from the parent plant till nearly a year has elapsed. Sometimes, for sake of curiosity, branches of contiguous trees are joined by approach-grafting. To make this experiment succeed, it is necessary to fix the branches to poles, to prevent wind-waving; and indeed this caution is in general necessary in all kinds of inarching practised in the open air.

71. Recourse is sometimes had to *root-grafting*, either for curiosity, or on account of seedling stocks being scarce. A piece of the root of a tree of the same genus, well furnished with fibres, is selected, and a graft placed on it, tied and clayed in the ordinary way. Thus united, they are set with care in a trench in the ground, the joining being covered, but the top of the graft being left two inches above ground. Some gardeners have thought that in this way the plant must preserve a nearer resemblance to the parent tree; but Abercrombie remarks, that though it is an expeditious way of obtaining a new plant, such a graft cannot be materially different from a cutting or layer.

72. What is called *shoulder* or *cheek grafting*, was formerly much more frequently employed than it is now. The head of the stock being first cut off horizontally, one side

of it is then sloped. The graft is sloped in the same manner, and a shoulder left at the point where the sloping begins. This shoulder is applied to the horizontal head of the stock, and the bark is brought to join at each edge, if possible. Another old method of grafting was called *terebration*, or *peg-grafting*: the head of the stock was cut off horizontally, and a hole was bored in the centre of it; the graft was selected of equal bole with the stock; within an inch and a half of the lower end of the graft, a circular incision was made, and the bark and a great part of the wood were removed, leaving only a peg to fit the hole bored in the stock.

*Cions for Grafts.*

73. The *cions* are gathered a good many weeks before the season for grafting arrives: the reason is, that experience has shewn, that grafting may most successfully be performed, by allowing the stock to have some advantage over the graft in forwardness of vegetation. It is desirable that the sap of the stock should be in brisk motion at the time of grafting; but by this time, the buds of the cion, if left on the parent tree, would be equally advanced; whereas the cions, being gathered early, the buds are kept back, and ready only to swell out when the graft is placed on the stock. Cions of pears, plums, and cherries, are collected in the end of January or beginning of February. They are kept at full length, sunk in dry earth, and out of the reach of frost, till wanted, which is some time from the middle of February to the middle of March. Cions of apples are collected any time in February, and put on from the middle to the end of March. The selecting of proper cions is a matter of the greatest importance, if we wish to enjoy the full advantage which may be derived from grafting. They should be taken from a healthy tree in full bearing, and from the outer side of the horizontal branches of such a tree, where the wood has freely enjoyed the benefit of sun and air. It is however the observation of a judicious practical gardener, Mr James Smith, at Hopetoun House, that particular notice should be taken, whether the tree to be grafted from be in a luxuriant or in a debilitated state. If the former be its condition, the grafts are very properly taken from the extremities of bearing branches; but if it be in the latter predicament, the most healthy shoots in the centre of the tree should be resorted to; and if no proper shoots exist, the amputation of some central branches will quickly tend to produce them. The least reflection must convince every one, how extremely improper it must be to take cions from young trees in the nursery lines, as is too often done. It may be remarked, that the middle of the cion generally affords the best graft.

*Budding.*

74. Budding, or inoculating, as it is sometimes, though not very correctly, called, depends on the same principle as grafting, the only difference between a bud and a graft being, that a bud is a shoot in embryo. On this account, grafted trees usually produce fruit two seasons earlier than budded trees: but those kinds of trees that are apt to throw out gum are not grafted without difficulty, while they are readily propagated by budding; such are, the peach and nectarine, the apricot, the cherry, and the plum; the cherry, however, being occasionally grafted, and the plum not unfrequently. In the case of both these sorts of fruit trees, there is another reason for preferring budding, —that gum is apt to exude at the places necessarily cut in performing the process of grafting. Budding is performed any time from the beginning of July to the middle of August, at which period the buds for next year are completely formed in the axilla of the leaf of the present year, and they are known to be ready by their easily parting from the wood. The buds preferred are the shortest observed on the middle of a young shoot, on the outside of a healthy and fruitful tree; on no account should an immature tree, or a bad bearer, be resorted to for buds. For gathering the shoots containing the buds, a cloudy day, or an early or late hour, are chosen, it being thought that shoots gathered in full sunshine perspire so much as to drain the moisture from the buds. The buds should be used as soon after being gathered as possible, and the whole operation should be quickly performed.

In taking off the bud, the knife is inserted about half an inch above it, and a thin slice of the bark and wood along with it taken off, bringing out the knife about an inch and a half below the bud. (Plate CCCIX. Fig. 5. *a*.) This lower part is afterwards shortened and dressed; and the leaf is cut off, the stalk being left about half an inch long. (Fig. 5. *b*.) Perhaps it is better to insert the knife three quarters of an inch *below* the bud, and to cut upwards; at least this mode is practised in the Scottish nurseries. The portion of wood is then taken out, by raising it from the bark, and pulling it downwards or upwards, according as the cut has been made from above or below. If the extraction of the wood occasion a hole at the bud, that bud is spoilt, and another must be prepared in its stead; as gardeners speak, the *root* of the bud has gone with the wood, instead of remaining with the bark. It is to be noticed, that the bud, and the portion of bark above and below it, receive together from gardeners, simply the name of a *bud*.

On a smooth part of the bark of the stock, a transverse section is now made, through the bark down to the wood: from this is made a longitudinal cut downward, about an inch and a half long, so that the incision may somewhat resemble a Roman T; by means of the flat ivory haft of the budding-knife, the bark is raised a little on each side of the longitudinal incision, so as to receive the bud. (Plate CCCIX. Fig. 5. *c*.) The prepared bud is placed in the upper part of the incision so made, and drawn downwards: the upper part is then cut off transversely, and the bud pushed upwards, till the bark of the bud and of the stock join together. (Fig. 5. *d*.) It is retained in this situation by means of tying with strands of moistened bass-matting.

In about a month after the operation, the tying is slackened: buds that have *taken* appear swelled, and the footstalk of the old leaf falls off on being slightly touched. All shoots that spring below the budded part are carefully cut off. The head of the stalk is not removed till the following March; after this, the bud grows vigorously, and in the course of the summer makes a considerable shoot. Against the next spring, the shoot is headed down, in the manner of young grafted trees.

*Production of New Varieties of Fruits.*

75. From the well-known facts, that some of the favourite cider apples of the 17th century have become extinct, and that others are fast verging to decay, the conclusion has been drawn, that our varieties of fruit are but of limited duration. Each variety springs from an individual at first; and this individual has been extended by means of grafting and budding. Dr Darwin, indeed, in his *Phytologia*, has contended, that each bud is a separate plant, the viviparous offspring of a bud of the preceding year, and deriving nourishment from the soil by means of a set of lengthened radicles peculiar to itself. This opinion cannot be support-

ed. Mr Knight's view is more rational, and more consistent with observation. All the extensions, by means of grafts and buds, must naturally partake of the qualities of the original; where the original is old, there must be inherent in the derivatives, the tendency to decay incident to old age. Some popular writers, such as Southey, have represented this doctrine as on a par with that of the hamadryads, or as equivalent to saying that a graft could not survive the trunk from which it was taken: but these authors are more lively than accurate; for such an absurdity was never taught by any horticulturist. It may be assumed as a fact, that a *variety* or *kind* of fruit, such as the golden pippin or the ribston, is equivalent only to an *individual*. By careful management, the health and life of this individual may be prolonged; and grafts placed on vigorous stocks, and nursed in favourable situations, may long survive the parent plant, or original ungrafted tree. Still there is a progress to extinction; and the only renewal of an individual, the only true reproduction, is by seed. This doctrine seems to be true, at least, as to fruit trees, and more particularly as to varieties of these, produced by cultivation: whether it can safely be extended to plants in general may admit of some doubt.

76. As the production of new varieties of fruit from the seed is a subject which now very much occupies the attention of horticulturists, it may be proper here to state the precautions adopted by Mr Knight and others in conducting their trials. It is, in the first place, a rule to take the seeds of the finest kinds of fruit, and from the ripest, largest, and best flavoured specimens of that fruit. When Mr Knight wished to procure some of the old apples in a healthy and renovated state, he adopted the following method: he prepared stocks of the best kinds of apple that could be propagated by cuttings, and planted them against a south wall in very rich soil; these were next year grafted with the stire, golden pippin, or some other fine old kind. In the course of the following winter, the young trees were dug up, and the roots being retrenched, they were replanted in the same place. By this mode of treatment they were thrown into bearing at two years old. Only one or two apples were allowed to remain on each tree; these consequently attained a large size, and more perfect maturity. The seeds from these fruits Mr Knight then sowed, in the hopes of procuring seedlings possessed of good or of promising qualities; and these hopes have not been disappointed.

It may here be mentioned, that in order to produce a hybrid variety, possessing perhaps a union of the good properties of two known kinds, Mr Knight had recourse to the nice operation of dusting the pollen of one variety upon the pistils of another: He opened the unexpanded blossom, and cut away, with a pair of fine-pointed scissors, all the stamina, taking great care to leave the styles and stigmata uninjured. The fruits which resulted from this artificial impregnation were the most promising of any; and the seeds of these he did not fail to sow. Mr Knight has generally observed in the progeny a strong prevalence of the constitution and habits of the female parent: in preparing seed for raising new pears, therefore, he would employ the pollen only of such delicate pears as the chaumontel, crassane, and St Germain, upon the flowers (deprived of stamina) of the swan-egg, longueville, muirfowl-egg, auchan, or green yair, which are hardy.

Every seed, though taken from the same individual fruit, furnishes a distinct variety: these varieties, as might be anticipated, prove of very various merit; but to form a general opinion of their value, it is not necessary to wait till they produce fruit: an estimate may be formed even during the first summer, by the resemblance the leaves bear to those of the highly cultivated or approved trees, or to those of the wild kinds; the more they approach to the former, the better is the prospect: the leaves of good kinds improve in character, becoming thicker, rounder, and more downy, every season. The plants whose buds in the annual wood are full and prominent, are usually more productive than those whose buds are small, and shrunk into the bark. But their future character, as remarked by Mr Knight, must depend very much on the power the blossoms possess of bearing cold, and this power is observed to vary in the different varieties, and can only be ascertained by experience. Those which produce their leaves and blossoms early are preferable; because, although more exposed to injury from frosts, they are less liable to the attacks of caterpillars. It is also to be observed, that even after a seedling tree has begun to produce fruit, the quality of this has a tendency to improve, as the tree itself becomes stronger and approaches maturity; so that if a fruit possess any promising qualities at first, great improvement may be expected in succeeding years.

Mr Knight has of late brought into public notice several new varieties of apples, pears, and cherries. Some of these seem likely to maintain a high character of excellence: they will be noticed in their proper places. He has, at his seat at Downton in Herefordshire, many hundreds of promising seedlings coming on, some of them annually improving in character.

77. From this digression we return to the young grafted or budded fruit trees. When they have been trained one year, they are called *maiden plants;* and these, especially in the apple and pear, are considered as forming the best plants. But trees of two, three, or four years growth, or even more, succeed very well, provided due care be taken in transplanting.

### *Transplanting.*

78. Here it may be enough to observe, in general, that in raising young fruit trees from the nursery lines, or in transplanting them from one part of the garden to another, much more care should be bestowed than is often given, particularly in public nurseries. The surface earth should be removed, and the horizontal roots carefully traced, and raised at full length, if possible: should this be inconvenient, or thought unnecessary, the roots should be cut with a sharp knife, not hacked with a blunt spade. A tap root, or one which penetrates straight down, should not be left more than a foot long at most. If the trees are only to be carried a short way, the roots should be as little cut as possible. When they are to be carried to a distance, it is thought best to prune off the small and soft fibres, which are apt to rot and injure the whole root. If the tree be several years old, and have a large head, it is proper to dig a trench all round, and to scoop out the earth from under the root. In this way a ball of earth rises with the tree, and its success is ensured. A bass-matting is sometimes introduced as far as possible beneath the tree on one side; and when it comes to be turned over on the other side, the root and ball of earth are completely included in the matting; but this is seldom necessary. As it unavoidably happens that some roots are destroyed at the time of transplanting, and the means of drawing nourishment are thus lessened, many consider it proper to prune the tops of the trees to a certain extent, that the demand on the roots may be diminished. This however must be done cautiously, and by an experienced gardener; to lay down rules for it is impossible.

It may here be observed, that when the plants are of considerable size, they are prepared for transplanting, by cutting the roots a year beforehand, or in some sorts even two years before lifting. In this way the remaining short roots are induced to set out many radicles or fibres, and the entire roots of the tree are contained within a small compass. If the trees be young, this abridgment of the roots may be effected by a downright cut with a sharp spade all around, at a short distance from the stem; passing the spade entirely under the plant on one side, if it be wished to cut off the tap root.

It may scarcely be necessary to remark, that an essential preliminary to transplanting, is the preparing of the ground to receive the trees, by digging it over. The distances should likewise be fixed, and even the holes dug. Some gardeners make a point of digging the holes for the trees perhaps a fortnight before planting: in this way the soil into which the fibres are likely soon to penetrate, is softened and meliorated by the action of the air; but this practice is more applicable to orchard planting. In putting in wall trees, it is not uncommon, not only to have the border well prepared generally, but to have a quantity of very good friable mould for each tree in particular, into which it may strike young fibres freely: this mould however should not be screened or made fine, but should be of the ordinary degree of roughness natural to garden soil. When the trees have been brought from a very great distance, so as to have been several days on their journey, Miller recommends the placing the roots in water for eight or ten hours before planting.

It may be considered as a safe general rule, to plant shallow, more especially for dwarf standards and half standards, the soil for which is not particularly prepared. Whether the general soil be cold and moist, or thin and gravelly, it is found better to place the roots of the young trees almost on the surface, and rather to heap earth over them in the form of a hillock than to sink them into the soil. Suppose the subsoil be a mouldering rock, and a hole be dug in it, it is evident that the tree will be placed in a sort of well, which will at once retain water, and hinder the spread of the roots. If the tree be placed on the surface, it will insinuate its roots into and draw nourishment from many invisible crevices. Since shallow planting has been recommended, it follows as a necessary consequence, that stakes are indispensable for dwarf standard and half standard trees.

From about the end of October, or after the shedding of the leaf, till the end of November, is considered as the best time for the planting of fruit-trees in this country, particularly in light soils. The weather is then mild, and the earth has time to settle about the roots during winter, before the first approaches of genial spring. But trees may be transplanted, in open weather, any time from the end of October till the beginning of March; and for heavy or wet land, planting in this latter month is accounted preferable. Young wall trees are planted about six or eight inches from the wall, and the part that has been cut at the time of grafting is placed next to the wall. The tree is planted at the same depth at which it formerly stood; but the roots are not the better for being deeply covered; if they be saved from the frost, they can scarcely be too near the surface. At the time of planting, the mould should be moderately dry, so as readily to crumble down. If, however, very dry weather occur, the ground is *mulched* at some distance around the roots, so as to prevent the bad effects of drought. *Mulching*, it may here be explained, consists in rendering a portion of the ground thoroughly moist by adding water, and working it like mortar. To increase the retentiveness of moisture, some short stable dung, or other litter, is added. When the roots are covered, the tree is gently raised and shaken, so as to cause the earth to apply closely to the roots. The soil is at the same time slightly pressed down. Wall-trees are not nailed up till the following spring. In this way they settle or subside along with the loose earth of the border. Were they nailed to the wall, they would run the risk of being suspended.

*Garden Training.*

79. Towards the end of March, young trees that have been planted out since October of the former year are headed down, or have their shoots shortened back to three, five, or six buds, according to their strength, and the purpose for which they are intended. When the trees have stood two, three, or more years in the nursery, after grafting or budding, the heading down is of course confined to the last year's shoots, and its extent, as well as the thinning out of superfluous shoots, must be left to the judgment of the experienced gardener, it being impossible to lay down rules where the circumstances must be perpetually varying.

80. The two principal methods of training wall-trees which are followed in this country, are called the *fan* and the *horizontal* modes. In the former, the branches are arranged like the spokes of a fan, or like the hand opened and the fingers spread. In the other way, a principal stem is carried upright, and branches are led from it horizontally on either side. The Dutch style consists in taking a young tree with two branches, and leading these horizontally to the right and left, to the extent perhaps of twelve feet each way, and in then training the shoots from these perfectly upright to the top of the wall. This is now seldom practised here, excepting perhaps with fig-trees, or white currants. In some places a few of the wall-trees are trained in a stellate form, the stem being led upright for about six feet, and then some branches trained downwards, others laterally, and others upwards. When walls exceed seven feet in height, the best gardeners seem to concur in giving the preference to the fan training, variously modified: in this way they find that a tree can much sooner be brought to fill its allotted space, and the loss of a branch can much more easily be supplied at any time. For lower walls, the horizontal method is preferred; and the same plan is adopted almost universally on espalier rails. Mr Hitt strongly recommends this mode for most sorts of wall-trees; and for pears he adopts what is called the *screw* stem, or training the stem in a serpentine manner, the branches going off horizontally, as in the ordinary straight stem.

In the first volume of the transactions of the London Horticultural Society, Mr Knight has made some ingenious and excellent remarks on the training and pruning of fruit-trees. His year-old plants are headed down, as usual, early in the spring, and two shoots only are trained from each stem, in opposite directions, and in an elevation of about 5°. (Plate CCCIX. Fig. 6) To procure the shoots to be of equal lengths, the stronger is depressed, or the weaker elevated. All lateral shoots are destroyed. Thus far it may be remarked, Mr Knight's method agrees very much with Hitt's, described in his Treatise on Fruit-trees. This shape, Mr Knight observes, ought to be given to young trees in the nursery, and is perhaps the only one that can be given to them without the risk of subsequent injury. Next season, as many branches are suffered to spring from each plant as can be conveniently trained, without shading each other; and by selecting the strongest and earliest buds towards the points of the year-old branches, to be trained lowest, and the weakest and latest near their bases, to be trained inclining upwards, each annual shoot will be nearly equal in vigour. (Fig. 7.) In the following winter, the shoots are alternately shortened, and left at full length. In the course of the third year, (Fig. 8.) if the tree be a peach, the central part consists of bearing wood: And, upon the whole, the size and general health of the trees trained in this way, afford evidence of a more regular distribution of the sap than Mr Knight has witnessed in any other mode.

The distance at which the branches are laid in, in all the different modes, varies from eight to ten inches, according to the nature of the tree, or the size of its foliage or fruit. While fan-trained trees are still in progress, a few more shoots are preserved at the summer pruning, than are likely to be ultimately laid in: this is for fear of accidents. Trees that have filled the spaces allotted to them, are disbudded of most of the woodbuds that appear. Woodbuds on old spurs are always displaced. Trees which are in training for the horizontal method require different management. The leading stem is constantly to be attended to; all the buds that appear on it are carefully preserved, till enough be procured to lay right and left, and form the tree. All wood-buds on the horizontal branches, excepting the leading one, are displaced. The fan-training is considered as best for apricots, cherries, and plums, placed against walls, even though the walls be low. None of these kinds of fruit answer well for espaliers; cherries or plums succeed better as half standards or dwarf standards.

81. The wall-trees which have now been spoken of are called *dwarfs* by the gardeners. It is a very common practice to train high standards on the intermediate spaces between the dwarf trees; such trees are in Scotland termed *riders*, (§ 63.) Plants four or five years old are preferred, because they are but temporary, and the object is to get fruit as soon as possible. Some good judges have condemned this plan of temporary trees as hurtful; being calculated to deprive the permanent trees of a proportion of the nourishment which they would otherwise draw from the border: but if the border be tolerably rich, and be only slightly cropped with herbaceous plants, it does not seem likely that the temporary trees can do much injury.

82. In popular language, the term *Espalier* is somewhat equivocal: it means either rows of fruit-trees planted like hedges, or the individual trees composing the rows; or, lastly, it means the stakes or rails to which the branches of the trees are tied. By using the terms espalier-*tree* and espalier-*rail*, ambiguity may always be avoided. Of late years, some have proposed to banish espalier-trees altogether, alleging that they injure the kitchen-garden quarters, by depriving them of sun and air. But in point of fact, they exist in the greater number of kitchen-gardens, and are not likely soon to be laid aside. If they are sometimes injurious by depriving the plants of air, they are at other times very useful, acting as a hedge in protecting the young crops from the violence of strong winds. Espalier trees generally produce excellent fruit, the sun and air having access to both sides of the tree; they commonly afford abundant crops, and the fruit is not apt to be shaken by high winds. Further, they tend to hide the crops of culinary vegetables from the eye, and to render the walk of the kitchen garden as pleasant as an avenue in the shrubbery.

Apples and pears are the fruits best suited for espaliers. The apples are generally grafted on crab stocks, to keep them of moderate size; or, if the tree be wished still smaller, on Dutch paradise stocks. The distance allowed between the former is from 30 to 40 feet; between the latter, 25 is found sufficient. These may seem large spaces at first; and, to take away the naked appearance, a small cherry-tree, or white currant bush, is sometimes planted in each interval. It is to be studied that, in the same line of rail, trees of similar growth be planted, so that the whole may be nearly equally filled. The trees, when planted, should be of one year's growth, or at most of two years. If the rail be not previously erected, so that the branches can be tied to it, a stake is necessary, to prevent wind-waving. Very often, the permanent rails are not put up till the trees have been two or three years trained on temporary stakes. Simple ash-poles firmly stuck in the ground, and either charred or smeared with tar at the bottom, to retard rotting, form a very efficient substitute for a rail; for it is to be observed, that during summer, when the leaves are expanded, they equally hide the roughest poles, or the most finished rail. Mr Nicol, however, recommends sinking hewn stones in the earth, and fixing a wooden rail in them: and a writer, in the Scottish Horticultural Memoirs, vol. i. has described a kind of cast iron espalier-rail, which of course must be highly durable, and, what is remarkable, is cheaper at the first than a wooden one. Some gardeners shorten the head of the tree in the usual way; others preserve the original branches at full length, never cutting a branch unless where there is a real deficiency of wood for filling the rail. The pruning is chiefly done by disbudding in the summer season. The distance at which the branches are laid in depends on the size of the fruit and leaves; when these are large, seven or eight inches are required; when small, four or five may be sufficient.

83. Dwarf trees were formerly much in vogue; and, strange as it may appear, the prospect of fruit was generally sacrificed to a fine shape. It was thought necessary that the lower branches should spread horizontally near the ground, and should decrease in width upwards, so that the tree should have a conical form. Now, it is well known that the fruit-buds of pears and apples in general, and of many sorts of plums and cherries, are produced at the end of the former year's shoots, which therefore should remain at full length; yet these were necessarily shortened, in order to preserve the desired shape, and it may easily be conceived that trees so dressed could not prove fruitful. For these reasons, the training to espalier-rails has generally been preferred. A few dwarf trees, however, prove ornamental, and they sometimes afford a great deal of fruit. The kinds of dwarf fruit-trees now in request are chiefly pears and apples. The pears must be of the summer and autumn sorts, the later fruits requiring a wall in our climate. Dwarf pears are chiefly budded on quince stocks. The trees are planted out, at two or three years old, where they are to remain, and they are placed from 20 to 25 feet asunder. A few stakes are driven into the ground, and, by means of tying down, the lower branches may soon be made to acquire a horizontal direction. No branches must cross each other, and no central upright shoots are permitted. The only other particular to be attended to is, when the trees are to be trained in a concave form, that, in shortening the shoots, the uppermost eye or bud is to be left *outwards*, as in this way the hollowness in the middle of the tree is better preserved. Sometimes the branches are trained round a hoop, which is supported by three or four small poles. Dwarf-standard apple trees on paradise stocks may be planted very closely, as they occupy but little room: they do not require more than 10 or 15 feet; on crab stocks they need at least 25. Plums are now seldom planted as dwarf-standards; cherries more frequently; apricots scarcely ever.

*Preserving of Blossom.*

84. In this country, particularly on the east coast and in the northern division of the island, it is an important part of the gardener's duty, to preserve the blossoms of apricots, nectarines, peaches, and the finer sorts of plums, from being destroyed by spring frosts, and especially frosty winds. One of the means first employed is still occasionally resorted to; namely, shading the trees slightly with branches of spruce fir, yew, or beech; but the branches ought to be so firmly fixed as not easily to be displaced by the winds, or to shake much: if this precaution be neglected, they will be ready to beat off the blossom which they are intended to defend. Strong fronds of the common brake (*Pteris aquilina*) have been used with advantage in this way; being the remains of the former year's growth, they are light and dry, and much less apt to injure the blossom than branches of trees.

The most effectual protection, however, is afforded by canvas-screens, in moveable frames; the fabric of the canvas being made thin enough to admit light, and yet affording sufficient shelter. The stuff called *buntine*, of which ships' flags are sometimes formed, is recommended by Nicol; and he adds, that it may be rendered more transparent, and more durable, by being oiled. The stuff called *osnaburg*, manufactured in the towns of Dundee, Arbroath, and Montrose, answers equally well, especially if made on purpose, of a wider texture, so as to resemble gauze. These screens are kept clear of the tree, a foot at top, and 18 inches at bottom. If, when not in use, they may be stowed in a dry loft, they last for many years. Sometimes the canvas is used in the form of sheets to hoist up and down; and in some places (as at Dalmeny Park garden, one of the finest in Britain) the contrivance is such, that the covering can be drawn up or let down the entire stretch of the wall, by two men, in the course of a minute. These screens are employed only at night, or in bad weather; and chiefly from the end of March to the beginning of May. Blossom thus partially protected is perhaps more tender than if no protection whatever had been given. The screens must therefore be continued till all risk of danger be over; perhaps till the leaves of the tree be pretty fully expanded, the blossom of several of our fruit-trees preceding the unfolding of these.

Frames covered with oiled paper have been successfully employed at Grangemuir garden in Fifeshire. The frames are of wood, inch and half square, with cross bars mortised into the sides. To give support to the paper, strong packthread is passed over the interstices of the frames, forming meshes about nine inches square. Common printing paper is then pasted on; and when this is quite dry, a coating of boiled linseed oil is laid on both sides of the paper with a painter's brush. These frames are placed in front of the trees, and made moveable, by contrivances which must vary according to circumstances. If the slope from the wall be considerable, a few triangular side frames may be made to fit the spaces. At Grangemuir, the frames are not put up till the blossoms be pretty well expanded; till which time they are not very apt to suffer from spring frosts or hail showers. In this way, it may be remarked, there is much less danger of rendering the blossom delicate by the covering, than if it were applied at an earlier period. The paper frames, if carefully preserved when not in use, will endure for a good many years, with very slight repairs.

At Dalkeith garden, in order to break the force of the winds, screens made of reeds are projected, at right angles with the wall, perhaps to the distance of ten feet, and at intervals of thirty or forty feet from each other; and at the same time nets wrought with straw are placed in front of the trees. These straw nets are very well deserving the attention of gardeners who may find their walls too much exposed to the east winds during the spring months. Old fishing-nets, kept at the distance of fifteen or eighteen inches from the tree by means of hooked sticks, are sometimes employed; these may be doubled over, in order to render the interstices closer. But nets made of coarse woollen yarn or carpet-worsted, are preferable to these. At Haddington, in East Lothian, woollen nets for this purpose are manufactured in the loom, and can thus be afforded at much less expence. They are woven very thick, the meshes not being larger than to admit the point of the finger, even when stretched out. The advantage of woollen yarn over flax for this purpose is evident; every small mesh being in effect rendered still smaller, by the bristliness of the material, and its constant tendency to contract; and from its aptitude to attract and concentrate moisture, such as cold dews and hoar-frost, the blossom derives additional security. These nets, and indeed nets of any kind, remain on night and day, till the season be sufficiently advanced.

To guard against the effects of hoar-frosts falling perpendicularly, some make a temporary coping of boards, to project a foot or eighteen inches over the tree at the top of the wall. Hitt recommends, that, in what are called *black frosts*, the borders opposite to the trees should be watered every night, affirming that he perceived advantage from this. So it might be; but he is, no doubt, wide from the true *rationale*, when he ascribes the good effects to some thinning of the glutinous juices, &c. Perhaps the latent caloric evolved in the freezing of the newly moistened surface, may preserve a higher temperature immediately around the plant.

85. We now proceed to the consideration of the different species of fruits cultivated within the walled garden, and the principal varieties of each. The order in which these are treated of, seems to be of little moment: the following arrangement is adopted, partly on account of the importance of the fruits, and partly because of natural alliances:

| | |
|---|---|
| Peach, and<br>Nectarine;<br>Almond, | *Amygdalus.* |
| Apricot,<br>Plum,<br>Cherry, | *Prunus.* |
| Apple,<br>Pear,<br>Quince, | *Pyrus.* |
| Vine,—*Vitis.* | |
| Fig,—*Ficus.* | |
| Mulberry,—*Morus.* | |
| Medlar,—*Mespilus.* | |
| Red Currant,<br>Black Currant,<br>Gooseberry, | *Ribes.* |
| Raspberry,—*Rubus.* | |
| Strawberry, six species,—*Fragaria.* | |

Some other hardy fruits and nuts, which are planted exterior to the garden, will afterwards be noticed; as also the pine-apple and the melon, which require a constant high temperature, and the orange, lemon, and shaddock, which are rather inhabitants of the green-house.

All the common fruit trees and fruit-bearing plants are extremely well known, both here and on the continent; any botanical description of them seems therefore unnecessary. The generic and trivial names given by Linnæus shall merely be mentioned, and at the same time the class and order in his system, and the family in the Natural Method of Jussieu, to which the plant belongs. Occasionally, when it may appear useful, some of the foreign names of the trees or the fruits shall be given.

### Garden Fruits.

#### *Peach.*

86. The *Peach tree* is the *Amygdalus Persica* of Linnæus, belonging to the class and order Icosandria Monogynia; and natural order Rosaceæ of Jussieu. This species is by Linnæus divided into two varieties; 1. With downy fruit, the *peach*; 2. With smooth fruit, the *nectarine*. Peaches and nectarines have sometimes occurred on the same tree; in a few cases, on the same branch; and one instance is on record, of an individual fruit partaking of the nature of both. Yet they are generally considered as distinct kinds of fruit, and they shall here be spoken of separately.

A good peach possesses these qualities: the flesh is firm; the skin is thin, of a deep or bright red colour next the sun, and of a yellowish green next the wall; the pulp is of a yellowish colour, full of high flavoured juice; the fleshy part thick, and the stone small. Those varieties, the flesh of which separates readily both from the skin and the stone, are the proper *pêches* of the French, and are by our gardeners termed *free-stones*. Those with a firm flesh, to which both the skin and the stone adhere, are the *pavies* of the French, by our gardeners named *cling-stones*. The latter require more shelter and better seasons to bring them to perfection than the former. In countries possessing sufficient climate, as in France and the warmer states of North America, the pavies are preferred: in this country, the preference is generally given to the free-stones, pavies being chiefly planted in forcing-houses, where the climate can be made.

87. Parkinson, in his *Paradisus*, enumerates twenty-one kinds of peaches, several of which, particularly the Old Newington, are still cultivated. Miller gives a list of thirty-one, with their characters; but as these are taken only from the fruit, without any notice of the bud, blossom, or leaf, they sometimes prove unsatisfactory. The following are the names:

| | |
|---|---|
| 1. White Nutmeg, | Boudine, |
| Red Nutmeg, | Rossana, |
| Early or small Mignone, | Admirable, |
| Yellow Alberge, | 20. Old Newington, |
| 5. White Magdalen, | Rambouillet, |
| Early Purple, | Bellis (Belle de Vitry.) |
| Large Mignone, | Portugal, |
| Belle Chevreuse, | Teton de Venus, |
| Red Magdalen, | 25. Late Purple, |
| 10. Early Newington, | Nivette, |
| Montauban, | Royal George, |
| Malta, | Persique, |
| Noblesse, | Monstrous Pavie, |
| Chancellor, | 30. Catherine, |
| 15. Bellegarde or Galande, | Bloody Peach. |
| Lisle, | |

88. The characters of such of these as are chiefly cultivated, and chiefly deserving of attention in this country, may be mentioned.

The *White Magdalen*, or Early Magdalen, is a round fruit, of a middling size, with a deep furrow; of a pale colour, and the flesh white to the stone; melting, juicy, with considerable flavour; ripening in August; the tree sometimes succeeds on the open wall, even in North Britain.

The *Red Magdalen*, however, is altogether a superior fruit; it is large, round, and of a fine red next the sun; the juice very sugary, and of exquisite flavour; ripening in the end of August: the tree is a free grower and great bearer: the blossoms are small. Nicol recommends the red magdalen as the "best peach we have, either for the open air or the hot-house." In doing so he is justified by the experience of Scottish gardeners; for the peach commonly known in Scotland by the name of red magdalen ripens well, in ordinary years, even in the northern districts of the country. This we believe to be the same which goes by that name in the south; but we have reason to think that the same name is applied, in some parts of England, to another peach; for English horticulturists sometimes complain that the red magdalen does not succeed well.

The *Large Mignone* is somewhat oblong in shape, and generally swells out on one side; the juice is very sugary, and of high flavour: this, though a free-stone, being rather a tender sort, is generally budded on a peach or apricot stock.

The *Early Newington*, or Smith's Newington (supposed to be the *pavie blanc* of Duhamel) is a fruit of middling size, of a fine red next the sun; flesh firm, with a sugary well-flavoured juice; ripening the beginning of September: a cling-stone: the tree a good bearer.

The *Noblesse* is a large fruit, red or marbled next the sun; flesh greenish white and melting, very juicy, and, against a good wall and in a favourable season, the juice becomes rich and well-flavoured; ripens in the beginning of September; and should be eaten *sharp ripe*, as the gardeners term it, the fruit being apt to become mealy if not taken just when it ripens.

The *Boudine*, sometimes called the bourdine, is a large round fruit, of a fine red next the sun; the flesh white, melting, juice vinous and rich; ripens from the beginning to the middle of September: the tree a plentiful bearer, especially when old. In favourable situations in the south of England it has sometimes produced fruit on standards.

The *Old Newington*, already mentioned, is a large round fruit, of a beautiful red next the sun; the flesh white and melting; when ripe, the juice very rich and vinous; a clingstone, and not ready before the beginning of October.

The *Rambouillet*, often called rumbullion, is a fruit of middling size, deeply divided by a furrow; the flesh melting, of a bright yellow colour; juice rich, and of a vinous flavour: ripens about the middle of September: the tree a good bearer.

The *Téton de Venus* is a fruit of middling size and longish shape, of a pale red next the sun; flesh melting, white; juice sugary, and not without flavour; ripens the end of September: the tree is a free bearer, on a warm light soil; but the fruit comes to perfection only in fine seasons.

The *Royal George* is an excellent peach; and in a very good soil and aspect the fruit becomes large, dark red next the sun, juicy, and high-flavoured. If the soil and aspect be not favourable, the tree proves a shy bearer.

The *Catherine* is a large round fruit, of a dark red next the sun; the flesh white, melting, full of a rich juic ; a clingstone; ripens from the beginning to the middle of October, against a good wall, and in a favourable season;

the fruit, however, is improved by lying two or three days before being used: it is sometimes called the October Peach.

89. To the ample list of Miller, a few others might be added. The *Ann Peach*, sometimes called the Early Ann, is a small round fruit, of a yellowish white colour, faintly tinged with red on the sunny side; ripening about the middle of August. This is said to be of English origin. The *Royal Kensington* is described by Forsyth, and the tree is said to grow freely, and not to be liable to blight. The *Orange Peach* is mentioned by Nicol as the most elegant he was acquainted with, and the best-flavoured of the clingstones; rather large than otherwise, round, dark red or purple next the sun, and bright orange on the other side; the flesh of a deep orange colour, but purple at the stone; the tree a very great bearer. It is possible this may be the Yellow Alberge, the fourth in the tabular list above given. The *Double-flowering Peach* is sometimes cultivated for curiosity, on standards, being very ornamental while in bloom; the flowers being only semi-double, fruit is generally produced, and in fine seasons abundantly; in most cases, however, it is fit only for preserves.

90. That indefatigable and excellent horticulturist, Mr Knight, has produced several new peaches of the most promising qualities, at his seat of Downton in Herefordshire. After due precautions to bring his trees (small ones planted in large pots) to the highest state of health and vigour, he impregnated the pistil of one with the pollen of another: only three peaches were suffered to remain on each tree: from sowing the stones of these, he obtained his new varieties. The situation of Downton being rather high and late, it may reasonably be presumed that fruits produced there will succeed in all places not less favourably situated as to climate. Two of these new peaches deserve particular notice; 1. The *Acton Scott Peach*; the fruit ripens early, and uniformly attains perfection; it is juicy and sweet, with a rich flavour; where secluded from the sun's rays, the skin is very white: the tree is an abundant bearer, and not subject to mildew: and Mr Knight considers it as calculated to succeed in many cold and unfavourable situations, where the more delicate varieties would certainly fail. 2. The *Spring Grove Peach* has a firm flesh, but not hard; the exterior colours are bright yellow and dark red; it melts in the mouth, resembling a nectarine in consistence as well as taste, having a remarkably rich, brisk, and vinous flavour; the stone parts readily from the flesh, which is of a greenish cast: it never becomes over-ripe or mealy, but is apt to shrivel a little, and is then most perfect: the tree grows slowly, but the wood is healthy, and acquires maturity early in the season: It succeeds better on an apricot than a plum stock.*

By persevering in the track pointed out by Mr Knight, we may hope, in time, to obtain peach-trees sufficiently hardy to produce their fruit in almost every situation in Britain, perhaps even as standards. In Maryland and Virginia, peach-trees are propagated from the stones, without budding. Every peach orchard contains, of course, numerous varieties. Among these a few are always of superior quality; with the fruit of the rest, pigs are fed. One of these American seedlings, possessed of good properties, is now growing in the garden of Mr Braddick at Thames Ditton: it has produced fruit, which is figured in the second volume of the London Horticultural Transactions, under the title of Braddick's American Peach.

In arranging the different varieties of peach-trees in a new garden, the late kinds, especially the pavies, must have the full south aspect; the others may be a point or two to the east. The kinds which ripen nearly at the same time should, as far as possible, be placed together, as this afterwards saves much trouble in collecting for the dessert, especially in a large garden.

91. The fan mode of training is considered as best suited to peach-trees, and is the plan generally adopted. These trees may, to a certain extent, be considered as constantly in a state of training. In pruning them, the great object is, to keep every part of the tree equally furnished with bearing wood, that is, with a succession of new shoots, laid in to the wall every year. This is to be attended to in April, and especially in May: for the wood and young shoots laid in afterwards, seldom ripen sufficiently to stand the winter. Besides, at that early season, the superfluous shoots can be pinched or rubbed off, without the use of the knife. The blossom-buds, it may be remarked, rise immediately from the eyes of the shoots; they are round, short, and prominent; while the leaf and shoot buds are oblong, narrow and flattish. The winter pruning is performed any time from the end of October till the end of February; but the early part of winter is generally thought best. Where the trees are well managed, there is not a great deal of winter pruning required. In shortening branches, it is a rule to cut behind a wood-bud, which may become a leader, to attract nourishment towards the shoot; for a shoot possessing flower-buds, but having no wood-bud to act as a leader, may blossom, but will produce no perfect fruit. Branches which are considered as too weak to ripen fruit, are commonly cut, as they must tend to rob the other parts of the tree. When the trees have completely filled the spaces allotted to them, the principal shoots are not shortened, unless with the view of filling vacancies, or when the extremities of the shoots have remained unripe, and been checked by the frost.

Mr Knight has explained the nature of what are called *luxuriant shoots*, and also the right mode of managing them. Most gardeners have directed the shortening of these in summer, or the cutting of them out in the following spring: But Mr Knight has experienced great advantages from leaving them wholly unshortened, but trained with a considerable inclination to the horizon; for, in this way, they have uniformly produced the finest possible bearing wood for the succeeding year; and so far is this practice from tending to render naked the lower or internal parts of the tree, whence these branches spring, that the strongest shoots they afford invariably issue from the buds near their bases. The laterals from luxuriant shoots, if stopped at the first leaf, often afford very strong blossoms, and fine fruit in the succeeding season.

92. In the milder parts of England, the blossom of the peach-tree scarcely requires protection: in less favoured places, it is protected by some of the means already specified. Dr Noehden, in the second volume of the London Horticultural Transactions, has mentioned rather a singular mode of preventing the bad effects of frost on the blossom or young fruit of the peach-tree. It is this: after a frosty night, the first business of the morning is to sprinkle cold water over the trees by means of the garden engine, taking care that the blossom or young fruit receive their share, and that the operation be performed some time before the rays of the sun strike the trees. Whether the water is useful, merely by promoting a gradual thawing, has not been ascertained.

When the fruit has attained the size of large peas, or of

* These two varieties were sent by Mr Knight in the spring of 1816, to the garden of Sir George Mackenzie at Coul, in Ross-shire, where they are planted against a south wall. If they succeed well in that latitude, they will prove a great acquisition to Scotland.

small hazel-nuts, it is thinned, to the distance of five or six inches between each fruit. In this way it acquires a larger size, and the tree is not exhausted. The picking off of leaves which overshadow the fruit, as recommended by Nicol and others, is not a good practice; at least it must not be pushed to any considerable extent; for the flower-bud for the succeeding year, being lodged in the axilla of the leaf-stalk, must greatly depend on the leaf for its nourishment.

In dry seasons, and especially in soils naturally dry, a hollow basin, about six feet in diameter, is sometimes formed around the root of the tree; this is covered with *mulch* (small dung moistened, mixed with a little loam, and worked together like mortar,) and water is occasionally added, according to the state of the weather. This is practised only while the fruit is growing, and the intention is, to keep it always in a state of progress.

Mr Knight seems to think, that in the milder parts of England, plentiful crops of fruit might be procured from the hardier sorts of peach-trees, trained as espaliers: he suggests that they should be planted in rows in the direction of north and south; that they should not exceed five feet in height; and that while the blossom is exposed to danger from frost, mats should be thrown over them, so secured as to descend on each side nearly in the angle of an ordinary roof of a house.

On account of the usual mode of training and pruning peach-trees in this country, they do not occupy much space on the wall. Some of the old horticultural writers speak of twelve or fourteen feet as enough: but the trees are now permitted to spread wider, from fifteen to twenty feet being allotted to each tree. Near Paris, a single peach-tree may sometimes be seen covering sixty feet of wall. It is at Montreuil that peaches are cultivated in perfection, peach-gardens being here established for the supply of the capital. Making due allowance for the difference of climate, advantages might probably be derived from copying some of the practices of these French cultivators, whose whole attention is devoted to the management of peach-trees. In 1814, Mr John Mozard, who was bred under the famous gardener, Pepin, and is himself one of the principal proprietors of peach-gardens at Montreuil, published a little piece, entitled "*Principes pratiques sur l'éducation, la culture, la taille, et l'ébourgeonnement des arbres, fruitiers, et principalement du pêcher*," which is well deserving the attention of horticulturalists in this country.

*Nectarine.*

93. The *Nectarine*, as already observed, is merely a variety of the peach. The English name may be supposed to be derived from the nectareous flavour of the fruit. The skin is smooth, not downy as in the peach; and the flesh is rather more plump than in that fruit. Nectarines, like peaches, are either free-stones or cling-stones; the former are called by the French *Pêches lisses*, smooth peaches; the latter, *Brugnons*. Miller enumerates ten varieties:

| | |
|---|---|
| Fairchild's Early. | Red Roman. |
| Elruge. | Murrey. |
| Newington. | Golden. |
| Scarlet. | Temple's. |
| 5. Brugnon or Italian. | 10. Peterborough. |

Of these the following are in most esteem:

The *Elruge*, a middle-sized fruit; when ripe, of a dark red or purple next the sun, pale towards the wall; ready in the middle of August: the tree grows freely, and is a sure bearer; indeed it is perhaps the best nectarine for the open air, especially in the less favoured counties.

The *Newington* nectarine is rather a large fruit; of a beautiful red next the sun, and on the other side of a bright yellow; flesh melting; juice very rich, racy and high flavoured; a cling-stone, not ripening before September: the tree a good bearer, when in a favourable situation.

The *Red Roman* nectarine is a large fruit; deep red or purple next the sun, and yellowish on the other side; flesh firm and of excellent flavour; when quite ripe, it shrivels; a clingstone, not ready before the middle of September.

The *Murrey* (*i. e.* murrey-coloured) is a middle-sized fruit, of a dirty red colour next the sun; the pulp pretty well flavoured; ripens from the beginning to the middle of September.

*Temple's* nectarine is a middle-sized fruit, of a light red next the sun, and yellowish-green on the other side; pulp melting, with a fine poignant flavour; the skin shrivelling when the fruit is perfectly ripe, which seldom happens before the end of September: the tree grows freely, and is generally productive.

To these may be added the *Early Violet* nectarine, of middle size, violet purple next the sun, pale yellow on the other side; flesh sugary, juice with a vinous flavour; a clingstone, ripening in the beginning of September: the blossom is very small, but the tree very productive; it requires a good situation, and succeeds only in warm seasons.

The production of a new and early nectarine, suited to the climate of Britain, may be considered as one of the desiderata in our horticulture. It may here be mentioned, that a new variety of white nectarine is described by recent French writers as being remarkably early and of excellent flavour; the foliage of the tree is of a pale or whitish green; it was raised by Mr Noisette, a nurseryman at Brunoy.

The management of the nectarine-tree is in every respect the same as that of the peach. In this country nectarines require the best exposure in the garden; and to the northward of Yorkshire, they seldom acquire maturity without the aid of a fluid wall and artificial heat.

*Almond.*

94. The *Almond-tree*, (*Amygdalus communis*, L.) can scarcely be ranked as an effective fruit-tree in this country. In clumps of shrubs on the lawn, it makes a fine appearance in early spring, when covered with its beautiful blossoms. In good seasons, such standards produce some ripe fruit: but ornament is its principal recommendation; and if the fruit be no object, the double-flowered variety is preferable. Trained against a wall, the almond-tree perfects its fruit in our ordinary seasons, when the outer cover opens naturally to give out the stone containing the kernel. They are very sweet and fit for the table when green, and they are sometimes kept in sand till winter.

In France, the almond tree is much cultivated. Bastien enumerates nine varieties; among which is an *amandier pêcher*, or peach-almond tree, supposed to have been derived from an impregnation of the almond by the pollen of the peach. On the same tree, he tells us, two sorts of fruit occur; the one round, fleshy, and divided by a furrow like the peach; the other oblong, not fleshy, and resembling the common almond.

The kinds of almond chiefly cultivated for their fruit are,

The common sweet almond;
Tender shelled;
Hard shelled;

Sweet Jordan; and
Bitter almond.

These different varieties are propagated by budding on plum or peach stocks, or on almond stocks raised from the stones; plum stocks being preferred for strong and moist soils, and peach or almond stocks for such as are light and dry. In this country it often happens that the varieties are little attended to. Almond trees are raised from the stones, and of course are liable to *sport*, as gardeners speak. It may be remarked, that even when they are raised from the stones, budding or working of one new variety upon another, is extremely useful in hastening the production of fruit.

The general management in regard to pruning, &c. is similar to that of the peach tree, only that the bearing twigs are often left six inches long without being nailed to the wall.

### *Apricot.*

95. The *Apricot tree* (*Prunus Armeniaca*, L.; *Icosandria Monogynia; Armeniaceæ*, Juss.) is said to be a native of the whole of the Caucasus, the mountains almost to the top being covered with it. It is supposed to have been introduced into this country in the reign of Henry VIII.

96. In 1629, Parkinson describes six varieties. At least ten varieties are now commonly cultivated. Several of these have been known since the days of Parkinson, particularly the Masculine; and others are mentioned by Rea in 1702, such as the Roman and the Orange.

| | | | |
|---|---|---|---|
| | Masculine. | | Transparent. |
| | Moorpark apricot. | | Peach apricot. |
| | Orange apricot. | | Breda. |
| | Royal orange. | | Brussels. |
| 5. | Roman. | 10. | Turkey apricot. |

The *Masculine* is generally first ripe. It is a small roundish fruit, red next the sun, and, when ripe, of a greenish yellow on the other side. It has a quick high flavour, but in general is rather tartish. The tree is a good bearer.

The *Breda* is a large roundish fruit, becoming of a deep yellow when ripe; the flesh soft and full of juice, and of an orange colour within. It is considered as among the best of the apricots, and the tree is a liberal bearer.

The *Moorpark* is a large fruit, flat shaped, of a deep yellow colour, and very high flavoured. Nicol declares, that one Moorpark is worth three of any other kind of apricot; and it is esteemed by many the richest of the stone-fruit kind. The tree requires a good soil and situation, but deserves them. It is regarded as of English origin, and it receives various names in different parts of the country, such as Lord Dunmore's apricot, the Anson apricot, and the peach apricot. It takes its name from Moorpark in Hertfordshire, a place celebrated by Sir William Temple in his account of English gardens at the close of the 17th century. (Miscellaneuus Works, vol. ii.)

97. The stocks commonly preferred for apricots are those of the muscle plum; but Mr Knight has observed, that they succeed better, and are more durable, on stocks of their own kind, that is, on apricot stocks: this he found to be the case, in particular, with the Moorpark apricot. The apricot being an early tree, the budding is performed any time from the end of June to the end of July; the bud is inserted about six or eight inches from the ground. The apricot is sometimes twice budded; that is, one variety is budded on another. The tree is said in this way to be kept more dwarf. When apricot trees are wanted as *riders*, or temporary trees, to fill the wall, they are of course budded on stocks four or five feet high. The best plants for dwarfs are such as have two strong branches, expanding as widely as possible from each other, and inclined at an angle of about 30°. But it very frequently happens, that there is only one main shoot, and this is headed down to six or eight inches, to obtain a supply of lateral wood. October is the best time for planting, and the end of February for heading down. The young shoots are laid in horizontally, or nearly so, and are not shortened till November following.

The fruit being produced partly on spurs, but chiefly on young wood of the former year, during summer care is taken to pick wood-buds from these spurs, and to lay in and protect a sufficiency of new wood for next season. In June, the superfluous and fore-right shoots can be displaced with the finger and thumb; late in the season a knife must be used. The young shoots cut off, it may be mentioned, may be used for dyeing a fine cinnamon colour. Some good fruit, it must be observed, however, is produced from the curzons or spurs upon two-year-old shoots. The shape of the buds indicates those likely to be fruitful, and which of course are to be preserved. The winter pruning is done any time from October to March. Not only all decayed and very old wood is as much as possible removed, but some of the most naked parts of the bearers of the two last years are cut out, so as to make room for a supply of new wood. The retained shoots are commonly shortened a little, and are always cut next a wood-bud, which is to act as a leader. The full grown apricot tree is managed much in the same way as the peach; but its late or autumn shoots do not agree with being shortened; when wanted as bearers, therefore, they are laid in at full length to the wall. The small and subordinate, or late shoots of the apricot, are more apt to be destroyed by frost than those of the peach tree. On this account, the pruning is often delayed till the end of January, when it can be seen which shoots are alive, and which have perished.

98. When the fruit is over-crowded, it is thinned, but cautiously, in the early part of summer. In the beginning of July it is finally thinned, and the best of the thinnings may then be used for tarts. Some gardeners recommend thinning the Moorpark to a fruit to every foot square, and the smaller kinds of apricots to a fruit to every eight inches; but, in general, the thinning is not carried so far. As the fruit approaches maturity, it is nailed close in to the wall, in order to its gaining as much reflected heat as possible. In this country, apricots begin to ripen in the end of July, and they continue till peaches be ready. Before the introduction of the new style, they were sometimes ready early in July, and hence received the name of Mala *præcocia*, to which epithet our English name may be traced.

Apricot trees are generally placed against an east or a west wall; the heat of a full south wall being apt to render them mealy before they become ripe. In the northern parts of the island, however, a south-east or south-west aspect answers best. In some of the warmer districts of England, several varieties of the apricot, particularly the Moorpark, transparent, Breda, and Brussels, are frequently planted as espalier trees, the horizontal branches being tied to the rail, but the bearers left loose. Occasionally some of these, especially the Breda and Brussels, are tried in the form of dwarf standards; and in fine seasons, they yield the highest flavoured fruit.

When an apricot tree has been greatly mismanaged, it may be cut down very much, as it sets out stronger branches than a peach tree, and these may soon be trained so as to fill the former space. The strong branches of this tree are very apt to throw out gum at places where any accidental hurt has been received: the usual remedy is to cut out the diseased part, filling up the space with pitch and rosin melted together, or merely with a little tar, or any sort of mild paint.

Apricots are seldom forced, as they do not in general answer expectation in this way. The Moorpark, however, is sometimes seen on the flued wall along with peach trees; and dwarf or espalier plants of the early masculine and Brussels, are occasionally introduced into the border of the cherry-house or the peach-house, with success.

*Plum.*

99. The *Plum tree*, (*Prunus domestica*, L.) is completely naturalized in this country, but can scarcely be said to be indigenous to Britain: it is however admitted into our Flora by Sir J. E. Smith, and is figured in English Botany, plate 1783. There are many varieties, of which some of the oldest and best marked are *P. præcox*, the primordian; *damascena*, the damask or damson; *juliana*, the St Julian; *pertigona*, the perdrigon; and *cerea*, the magnum bonum. Parkinson enumerates no fewer than sixty sorts. Miller describes only about thirty.

100. The following are the kinds chiefly cultivated at present:

| | |
|---|---|
| White primordian. | Apricot plum. |
| Early damask. | Mirabelle. |
| Black damask. | Drap d'or. |
| Precoce de Tours. | White imperial, or magnum bonum. |
| Maître Claud. | Red imperial. |
| Monsieur's plum. | St Catherine. |
| Imperatrice. | Orleans. |
| White Perdrigon. | Fotheringham. |
| Blue or Violet Perdrigon. | Wine-sour. |
| Red Perdrigon. | La Royale. |
| Queen Claudia, or true green-gage. | La Roche-corbon. |
| White gage. | Coe's golden drop. |
| Blue gage. | |

The *White primordian*, which is also called St Barnaby's plum, and sometimes Jaune-Hâtive, is the earliest plum we have, commonly ripening in the end of July. The fruit is small, of a longish shape, sugary, but without much flavour. One tree on a wall is reckoned enough, the tree being a free bearer.

The *Early Damask*, or Morocco, immediately succeeds the white primordian. The *Precoce de Tours* and *Maître Claud* are well flavoured plums, and the trees grow freely, and bear well as standards.

*Monsieur's Plum*, or the Wentworth, is a large fruit, somewhat resembling the white magnum: the tree is a copious bearer, and answers very well as a standard: the fruit is much used for tarts and in sweetmeats. The *Imperatrice* is remarkably late, seldom ripening on standards till the end of October.

The *Perdrigons* are melting, sugary, and perfumed fruits; the trees are not very free bearers, but are in many places planted as espalier and dwarf standards.

The *Queen Claudia* of Rouen, or Verte bonne, seems to be the proper *Green-gage*; "the best (says Mr Nicol,) the most generally known, and most highly esteemed of the plum kind." A few trees of this sort are generally trained to a south-east or south-west wall; but in a sheltered situation, and where the soil is a rich deep loam, with a dry bottom, the fruit acquires a higher flavour when produced on standards. The *white* or yellow gage, and the *blue* or red gage, though inferior to the green, are much cultivated.

Tho *Drap-d'or*, golden drop, or cloth of gold plum, is a good fruit; but it requires a wall, and the tree is not in general a plentiful bearer.

The *White Imperial*, or white magnum bonum, has also several other names, as yellow magnum, Holland magnum, Mogul plum, and egg plum. It is a very common fruit; of a large size; sweet, but with no great flavour; excellent for tarts and sweetmeats: the tree grows freely, and seldom fails to bear, either on a wall, or as a standard.

The *Red Imperial* is likewise called red magnum bonum; it is also a large fruit, and of fine appearance; but it is principally used for baking and preserving: the tree is a free bearer as a standard. The *St Catherine* has a rich sweet juice, and is fit either for the dessert, or for being used in confectionary.

The *Orleans* is a middling good plum, of which there are several varieties, as the old or red, the new, and white. The tree is a vigorous grower, and great bearer: it succeeds perfectly as a standard, but is sometimes placed against a wall: it is well suited for a market fruit-garden.

The *Fotheringham*, or sheen plum, is a beautiful large red fruit, of considerable flavour; "there is hardly any plum that excels it," says Forsyth: the tree answers equally well for a wall, or as an espalier or standard.

The *Wine-sour* is a plum said to be of Yorkshire extraction; it is not much cultivated, but seems deserving of attention; it it very late, and chiefly used for preserves.

*La Royale* is an excellent plum, of a red colour; the tree, however is generally a dull bearer. The *Roche-corbon*, or red diaper plum, is large and of high flavour.

*Coe's Golden Drop* is a late ripening plum, the merits of which have within these few years been attended to, in consequence of a recommendation by Mr Knight in the first volume of the Horticultural Transactions of London. This gentleman considers it as a new variety, while others allege that it has been known for many years. The tree is distinguished by the great size of its foliage, the leaves being often five inches long and three broad. The flesh of the fruit is of a golden colour when ripe; on the side next the sun, the skin is dotted with violet and crimson. It is beautifully figured in Hooker's *Pomona*, t. 14; and is there announced as superior to any late plum at present in the British gardens. It keeps many weeks: Mr Knight mentions, that he suspended some of the fruit by their stalks in a dry room in October, and that they remained perfectly sound till the middle of December, and were then not inferior, either in richness or flavour, to the green gage, or the drap d'or. This variety requires a wall, but succeeds extremely well on a west aspect.

The *Bullace-plum* is the fruit of a distinct species of Prunus, *P. insititia*, which grows naturally in hedges in England. It is often planted in shrubberies or lawns; it is a great bearer, and the fruit is excellent for baking or preserving. There is a variety with wax-coloured fruit, called the White bullace. The *Myrobalans*, or cherry-plum, is by some considered as only a variety of the common plum; but others rank it as a distinct species: Willdenow describes it under the title of *P. cerasifera*.

101. If the wall be high, or above ten feet, a plum tree is allowed about twenty-four feet in length; if it be low, perhaps thirty feet, horizontal training being in this case adopted. An east, south-east, or south-west aspect is found to be better than a full south exposure, in which last the fruit is apt to shrivel and become mealy. Several kinds bear

well as espalier trees; and many as standards. Even in some parts of the Highlands of Scotland, the yellow magnum and the green-gage trees may be seen thriving luxuriantly, and bearing excellent crops of fruit. The late Mr Hunter of Blackness, a zealous Scottish horticulturist, describing the garden of Macdonald of Glenco, says, "The magnums were large, well shaped, free from gum, and of a rich yellow colour all over; the gages of the true brownish and green colour, and completely ripened; and these were growing on standards, in the heart of Lochaber, where the snow on the tops of the hills was visible to us from the garden, on the 23d of September." (*Scot Hort. Mem.* i. 179.) It is to be observed, however, that in such situations, the blossom had probably not expanded till late in the spring, when the danger of frost was over. In the lower and milder parts of the country, plum blossom frequently requires protection as much as that of the apricot or the peach; indeed, the calyx drops sooner, and the blossom is in this respect more tender. In favourable seasons, it may be added, plums are plentiful much farther north; a degree at least.

Plums produce their fruit, partly on the former year's wood, but chiefly on small spurs, rising along the sides, and at the end of the branches, when of two years growth or upwards. These spurs continue long in a fruitful state. There is no necessity, therefore, for securing a supply of new shoots annually, as in peach and nectarine trees. During the summer, fore-right shoots are displaced with the fingers, and side shoots are laid in horizontally, or in a sloping direction, where there is room for them. Useless wood-buds proceeding from spurs are at the same time removed. In this way little winter pruning is required; only some extended spurs, and a few supernumerary shoots, are to be cleared away. The cuts must always be clean, and the knife sharp; plum-trees, like other stone fruits, being very apt to throw out gum and to canker. In regulating mismanaged trees, the lopping off of large branches is, however, sometimes practised; if the air be excluded by some mild paint or other plaster, the wound frequently closes, and new branches set out, which bear fruit in two or three years. For wall plum trees, many gardeners prefer the fan mode of training; but some train in the horizontal manner, being of opinion that this is the best way to check luxuriance of growth, and throw the trees into bearing. When the fruit come in close bunches, some are thinned out, in the beginning of July, when the stoning is over, to allow the rest to acquire full size; and care is taken to lay in the young shoots close to the wall, so that the sun and air may not be intercepted, but may have access to ripen and give flavour to the fruit.

The finer varieties of plums are budded or grafted on plum stocks raised from the stones. Young trees bear transplanting very well, four or even six years after they have been budded or grafted; so that they are often ready to bear the year after being planted. Great pains, however, should be taken, to raise the roots at full length, and to replace them in their new situation without bruising or other injury, and without much exposure to the air.

### *Cherry.*

102. The *Cherry tree* is the *Prunus cerasus*, L.; *Cerisier* of the French, who make three subdivisions, *Griottier Bigarreautier*, and *Guignier*.—It has been generally said that cherries were introduced into England by the fruiterer of Henry VIII.; but Professor Martyn has shown that they were known much earlier. Lydgate, in his account of the London cries in the middle of the 15th century, mentions that

> "Hyt (supposed white) pescods one began to cry,
> "Straberys ripe, and cherries in the ryse."

*Ryse* is a word not yet obsolete in Scotland, signifying spray or twigs; and on the stalls of the Edinburgh fruit market, cherries may sometimes be seen "in the ryse," or at least stuck on the thorns of hawthorn sprigs, in order to catch the fancy of children. The white pescod is a kind of plum.

103. Parkinson's list in 1629 contains about thirty varieties of cultivated cherries, several of which are still known, and in esteem, as the mayduke, heart, amber, and morello, but others have entirely disappeared. Miller enumerates only twenty-one; and of these it is not necessary to notice more than one half, being those commonly cultivated.

| | |
|---|---|
| May-duke. | Carnation cherry. |
| Archduke. | Morello |
| Harrison's heart. | Lundie guigne. |
| Hertfordshire heart. | Black coroun. |
| White heart. | Tartarian cherry. |
| Black heart. | Kentish. |

Of the *May-duke*, Nicol observes that we have no cherry equal to it, and that the tree thrives in all situations. It does very well as a standard; but against a good wall, and with a southern aspect, the fruit becomes considerably larger, and, contrary to what happens in other fruits, it seems to acquire a higher flavour. It ripens early in June; and before the change of the style, it was often gathered in May: this was particularly the case with a small variety called the Early May.

The *Archduke* is also called the Late duke: it is a good cherry when ripened on a wall; but the tree does not answer well as a standard.

*Harrison's heart* is a large cherry, of good qualities, and the tree bears freely. The *Hertfordshire* has a firm flesh and excellent flavour: it is a late cherry, not ripening till August. The *Carnation cherry* has received its name from the fruit, being variegated red and white: it is a late cherry, and requires a good wall.

Though the taste of the *Morello* cherry, approaching that of the mulberry, is not agreeable to many, yet when ripened on a wall in the full sun, it acquires a size and richness of flavour superior to any other: The tree grows freely, and bears well.

The *Lundie guigne* is of a dark colour, and nearly as large as maydukes which grow on standard trees: it receives its name from Lundie in Fife, the seat of Sir James Erskine, where the original trees still remain. The *black coroun* resembles the black heart; it is an excellent fruit, and the tree is a healthy grower and great bearer. The *black* and the *white Tartarian* cherries are much cultivated at Petersburgh, and were introduced from Russia about 1797: the fruit is of good flavour, and ripens early; and the trees produce plentifully. The *Kentish* cherry is chiefly planted in cherry orchards, and in market gardens: the flowers being late in expanding, they generally escape the spring frosts, and afford a plentiful crop: the fruit, however, is fit only for tarts.

104 That indefatigable and truly meritorious horticulturist, Mr Knight, has lately added to our list three new cherries raised from seed; they have been called the Elton, the Black Eagle, and the Waterloo.

The *Elton* is the offspring of a blossom of the graffion, or ambrée of Duhamel, fecundated by the pollen of the white heart; it is distinguished by a very deep tinge of crimson in the petals, and by the extraordinary length of its fruit-stalks. The pulp is very juicy, and of delicate flavour. The tree grows vigorously, and is a free bearer.

The *Black Eagle* was from the graffion, with the pollen of the mayduke, and the tree and its fruit resemble the mayduke in a considerable degree.

The *Waterloo* was of the same origin. "It sprang (says Mr. Knight) from the largest and finest ambrée cherry that I ever saw; and I imagine it was the best fed; for it stood alone upon a tree, which was well capable of bearing at least half a dozen pounds of cherries." The Waterloo is somewhat later than the black eagle. It is nearly as hardy as the mayduke; and it has been observed to acquire tolerable perfection even in cloudy and rainy weather. On approaching maturity, one side presents a dark livid colour; but in ripening, it acquires a rich and deep red colour, nearly black. It is larger than the black eagle, and more conic towards its point.

All of these three varieties possess valuable qualities, and deserve the attention of cultivators in every part of the country. The only plants of these yet brought to Scotland, as far as we know, are in the garden of Sir George Mackenzie, Bart. at Coul in Ross-shire, where, as it is situate far to the northward, their qualities in regard to climate will be put to the proof. They who possess opportunities should also attempt the production of new kinds. The cherry, it is believed, *sports* more extensively in variety when raised from seed than almost any other fruit; and Mr Knight justly remarks, that it is probably capable of acquiring a higher state of perfection than it has yet attained.

105. The finer kinds of cherries are trained against the wall, chiefly in the fan manner: they are placed about twenty-four feet distant from each other, and, at the first planting, a temporary tree is usually put in between each. When favoured with a south aspect, they not only produce early, but large and excellent fruit, highly worthy of a place in the dessert. To prolong the cherry season, some of the duke and heart varieties are generally placed against a west wall. The morello, being chiefly wanted for preserves, has frequently a north aspect assigned to it. This variety in so far differs in habit from the others, that it is produced rather on the young wood of the former year than on spurs; it is necessary, therefore, at the time of pruning, to have a supply of young wood in view. Cherry-trees are sometimes trained on espalier rails; and in this case, as in wall-trees, it is a great object to keep up a stock of young wood, or at least a quantity of young spurs, or curzons. The branches are generally tied to the rails by means of willow-twigs, or strands of bass-matting. All stone-fruit trees being liable to become gummy at places where they are galled, attention is necessary that the tyings do not injure the bark. Cherries, it may be added, succeed much better as half-standards or dwarf standards than as espalier-trees.

It is a general rule to bud or graft cherries at the height where the head is intended to begin. Some prefer having only two main branches for a wall cherry-tree; but three branches are, in general, found more commodious. Miller suggests, that budding heart cherries on stocks of the birdcherry (*Prunus padus*), might have a similar effect as grafting apples on paradise stocks; that not only might the tree be thus kept in less compass, but rendered more fruitful.

In prunning cherry-trees, the shoots are not shortened, for they produce many fruit-buds at the extremities. It is a common remark of practical gardeners, that cherry-trees dislike the knife. The branches therefore are trained at full length, superfluous fore-right shoots being displaced by the hand in the early part of summer. Much fruit is produced on small side-spurs proceeding from wood two or three years old; these side-spurs are therefore carefully preserved.

When the fruit begins to colour, it is assailed by blackbirds, jays, and other birds. The most effectual remedy is found in hanging a net in front of the tree, or over it, if it be an espalier or dwarf-standard. In gathering the fruit, care should be taken not to break the fruit-spurs, which are very brittle: to avoid the risk of this, some gardeners are at the pains to cut the fruit-stalks with a pair of small scissars.

### *Apple.*

106. The *Apple-tree* (*Pyrus Malus, var. sativa*, L) belongs to the class Icosandria, order Pentagynia, and natural order Rosaceæ of Jussieu. The crab-tree, *P. malus*, is a native of various parts of Britain, and is figured in English Botany, t. 179. Like the wild pear, it is armed with thorns. Many of the cultivated kinds have been imported from the continent at different times; and many others have been raised from the seed in this country. Ray, in the close of the 17th century, described seventy-eight sorts, then accounted good: several of these still retain their character, but many more have either lost it, or have entirely disappeared. The costard-apple, which was then so commonly sold in London that dealers in apples were styled costard-mongers, is not now known. At this time among the favourite cider apples were the redstreak, the golden-pippin, the gennet-moil, the white and red masts or musts, the fox-whelp, and the stire; all of which, as remarked by Mr Knight, are now fast hastening to decay and extinction. Several new apples, however, possessed of excellent qualities, have of late years been brought into notice; and so many amateurs of gardening are now engaged in raising new varieties from seed, that there seems little reason to apprehend a deficiency. This is as it should be; the apple being doubtless the most useful of the fruits freely produced in this country.

107. Forsyth, in his Treatise on Fruit-trees, describes no fewer than 196 varieties, exclusive of many, of which he gives the names only, without descriptions. In this place only a few of the finer apples can be noticed; such as are commonly cultivated in gardens, as wall or espalier trees, or as half and dwarf standards. The other standard apples used for baking, or in the manufacture of cider, will be treated of under the article ORCHARDS.

Golden pippin,
Balgone pippin,
Nonpareil,
Scarlet nonpareil,
Ribston pippin,
Oslin pippin,
Hawthorndean,
Margaret,
Jenneting,
Nonsuch,
Margil,
Quince apple,

Aromatic pippin,
Royal Russet,
Codlin; Royal, Kentish, Carlisle, and Keswick.

Newton pippin, and Spitsenberg.

Rennets, grey, golden, and Canadian.
Violet apple.

The *Golden pippin* is a well known excellent fruit, ripening late in autumn; when fully matured it keeps long, and forms, during winter, one of the choicest dessert apples; it is generally small, but beautiful, and the juice is sweet and high flavoured. The tree requires a light but good soil; if the subsoil be wet, it is extremely apt to canker. It is rather of low growth; against a wall, however, it grows freely, and produces abundance of fine fruit. The golden pippin is highly praised by French horticultural writers, under the name of Reinette d'Angleterre. Miller notices the general falling off of this fruit, and the subject has been enlarged upon by Knight: the fact cannot be denied: the former ascribes it to the practice of grafting on free-stocks instead of crab-stocks; the latter, we believe with more reason, to the natural decay of the variety through old age. The *Balgone pippin*, so named from the seat of Sir James Suttie in East Lothian, much resembles the golden pippin, and to all its excellencies adds the advantage of larger size. The tree grows luxuriantly against walls, and appears at present to be in health and vigour. It deserves the attention of the horticulturists of South Britain.

The *Nonpareil* is one of the best apples known, and the chief of the russet tribe: it is rather a flat-shaped fruit, with a sharp, pleasant, high-flavoured juice. It is scarcely ripe till the end of November; but if well ripened, it keeps till May, or later. The tree grows to a large size; and in a good soil, such as a hazelly loam, it bears pretty freely. It is very generally trained against a wall; and in the northern parts of the island, it requires not only a wall, but a good aspect. The *Scarlet nonpareil* ripens more freely than the former; and the fruit becomes larger, and more smooth and plump, being at the same time highly charged with the flavour peculiar to the nonpareil: it is in season in January and February.

The *Ribston pippin* is an excellent apple; when well ripened, it adds to the dessert; for kitchen use it is unrivalled. The tree grows freely in almost every situation, and is a good bearer. The fruit is of a greenish-yellow colour, with red or brown streaks on the side next the sun. It keeps very long, remaining quite firm till April or May. Mr Nicol is justly in raptures with it: "It may be called a universal apple for these kingdoms; it will thrive and even ripen at John-o-Groat's, and it deserves a place at Exeter or at Cork." It was long supposed to have been raised at Ribston Hall in Yorkshire; but it is now ascertained to be a Normandy pippin, introduced early in the 18th century.

The *Oslin pippin* is sometimes called the Original, and sometimes the Arbroath pippin; by Forsyth it is named Orzelon. This is a very good apple, excelled in flavour only by the nonpareil, over which it has the advantage of ripening in a worse climate. It does not keep: indeed it should be eaten from the tree, and it is known to be fit for use by its acquiring a fine yellow colour. It is particularly described by Dr Duncan, senior, in the first volume of the Scottish Horticultural Memoirs. The tree grows freely by cuttings, provided each cutting include a knot or bur. The Doctor mentions, that of fifty branches detached early in the spring, more than one half blossomed and produced ripe fruit the same year; they continued fruitful for the next two years, and promised to form permanent fruit-bearing trees. The Oslin has been for time immemorial cultivated at St Andrews and Arbroath, where there were formerly magnificent establishments for monks, by whom it was probably introduced from France.

The *Hawthorndean*, or White Apple of Hawthorndean, derives its name from the romantic seat, in Mid Lothian, of the poet and historian Drummond, at which he was visited by the celebrated Ben Jonson. It is a summer apple, but does not keep long; it is juicy and good, excellent for kitchen use. The tree is a free grower, and bears quickly and plentifully; it is however but short-lived, generally shewing symptoms of decay when twelve or fifteen years old: it is well calculated, therefore, for a temporary tree in any situation, and for this purpose it is much employed.

The *Margaret apple* is also called Magdalene apple; it is an early fruit, of good flavour, but does not keep long. The tree is of middling size; commonly productive.

*Jenneting*, or Geniton, as Dr Johnson has it, is generally supposed to be a corruption of June-eating. It is a small fruit, but very early ripe; certainly however not in June, nor earlier than August. It is perhaps inferior to the Oslin, Margaret, and one or two other early apples; but no one possessed of a healthy jenneting tree in full bearing would willingly part with it.

The *Nonsuch* is a well known pippin; the tree is rather subject to the canker, but it generally bears more or less every season.

The *Margil* is a very good late apple, fit for the dessert in January; the fruit is much improved when the tree is trained against a wall.

The *Quince apple* is a small fruit, shaped like the quince; the side next the sun of a russet colour, the other side yellowish; it is an excellent apple for about three weeks in September, but does not keep much longer. The tree is of low growth.

The *Aromatic pippin* receives its name from its fine flavour; the side next the sun is of a bright russet colour. It ripens in October, and is fit for use from December to February.

The *Royal russet*, or leathercoat russet, is so named from the deep russet colour of the skin; it is a large fruit, of an oblong figure, broad towards the base: it is an excellent kitchen fruit, and may also appear in the dessert; it keeps till April. The tree grows to a large size, and bears very freely.

The different varieties of *Codlins* are chiefly baking apples, although they may also occasionally be taken to the table: they are early; but none of them are good keeping apples. The trees are great bearers, and make commodious half and dwarf standards in gardens; the latter are frequently trained around hoops to support their branches. An account of the valuable properties of the Carlisle and Keswick codlins is given by the Right Hon. Sir John Sinclair, in the first volume of the Scottish Horticultural Memoirs. The codlins are frequently propagated by slips, suckers, or layers, trees thus procured yielding fruit much more quickly than grafted trees.

The *Newton pippin* and *Spitsenberg apple* are two American sorts, which have of late years become favourites in some parts of this country. The former was introduced from Long Island, New York: it is a beautiful and excellent apple; it ripens best on a wall, but in favourable seasons it succeeds on espalier rails, or even on dwarf standards. The Spitsenberg is also a very good fruit, with somewhat of the pine-apple flavour; the tree requires a sheltered situation and a good soil: it is observed to thrive better on a west than on a south wall.

The *Grey rennet*, Reinette grise, is a middle-sized fruit, of a deep grey next the sun, but on the other side intermixed with yellow; a juicy apple, of a quick flavour, yet sugary: it ripens in October, but does not keep long. The *Golden rennet*, Reinette dorée, is a very good apple, ripening in the end of September, fit either for the table or the kitchen, and keeping till February. The *Canadian rennet* is called by the French horticulturists Reinette de Trianon: it is a large fruit, of a yellow colour, with a tinge of red: it keeps till February.

The *Violet apple*, Pomme violette, is a middling large fruit, of a long shape; pale green on one side, but deep red next the sun; flesh delicate, juice sugary, with a slight flavour of the sweet or March violet. The tree grows vigorously, and the fruit ripens in the end of October.

The *Eve apple* is originally from Ireland, but now very generally cultivated in the west of Scotland. The tree is nearly as ample a bearer as the Keswick codling; and it is peculiarly well calculated for forming small standards, to be trained either hollow, or like a cylinder or a cone, the tree growing close and compact, and the fruit spurs being regularly distributed along every part of the branches. The apple is of a fine colour, and well tasted, fit either for table or kitchen use. It keeps nearly four months. The tree produces fruit the second year after being grafted; and, like the burknot, it may be propagated by cuttings or by layers.

Several excellent and well known garden apples are not included in the list above given, in order to avoid prolixity; such as the summer and the winter Thorle; different varieties of Pearmain; the Wine apple, or Queen; the red and the white Calville; Wheeler's Russet; Holland pippin; the Strawberry apple; the Devonshire Quarenden, the Crofton, and the Kerry pippin. It cannot be too often inculcated, that the choice of varieties of fruits, and especially of apples and pears, ultimately to be employed as standards and dwarf standards in gardens, ought to depend very much on *experience*,—on observing which kinds succeed best in the particular soil and situation in question.

108. As formerly mentioned, several new apples have of late been brought into notice. Of these, the following have deservedly acquired a good character: The Yellow Ingestrie pippin, the Downton pippin, and the Wormsley pippin.

The *Yellow Ingestrie pippin* was raised a few years ago by Mr Knight, from a flower of the orange pippin dusted with the pollen of the golden pippin. It is similar in form and colour to the latter, which it almost rivals also in richness and flavour: it ripens in October, but does not keep. The tree is very productive.

The *Downton pippin*, named from Mr Knight's seat, had the same origin; and also possesses very good qualities in certain upland situations; but in the low grounds about London it is not good.

The *Wormsley pippin* is another of Mr Knight's apples, a very large fruit, and, in the consistence and juiciness of its pulp, nearly resembling the Newton pippin; it ripens in the end of October, and keeps for some time.

The apple called *Hughes's new golden pippin* possesses the finest qualities; but we suspect it will be found to be, not a new fruit, but a French apple, cultivated in Normandy, and not unfrequently shipped for this country at Charante.

Some varieties are cultivated chiefly by way of curiosity; particularly the *Fig-apple*, which is remarkable for producing no seeds, and indeed for having no proper core; it is said also to shew stamens and pistils only, or to be destitute, or nearly so, of petals. The *Dwarf rennet* is also deserving of notice; when grafted on a paradise stock, the tree scarcely exceeds in size a large plant of gillyflower. It is therefore sometimes kept in pots, and forced, and placed in a growing state on the table. The fruit completely resembles the common French rennets. To these may be added, the *Pomme d'Api*, or Apius's apple, a very small fruit, of a yellowish colour, but bright red next the sun; and the *Pomme de deux ans*, or John apple, remarkable for having apples and blossoms on the tree at the same time.

109. Apple trees intended for full standards are grafted on free stocks, or crab stocks; those for espalier rails or walls, on paradise and codlin stocks. A young grafted apple tree should have three branches; and, if intended for a wall-tree or espalier, the centre branch only is cut down, perhaps to a foot in length, to encourage the setting out of a succession of branches. The fruit of the apple tree is produced on small side and terminal spurs, or short spurs or curzons, from an inch to more than two inches long, proceeding from branches two, three, or four years old, the same wood continuing fruitful for a number of years. The nonpareil, and some other varieties, indeed, yield a few fruit from shoots of the former year; but this is not usual. Espalier and wall trees are pruned twice in the season, in summer and in winter. In May and June, foreright and other superfluous shoots are taken out, a few being laid in, to supply wood where wanted. Any time between December and March, a selection of these is made; and unfruitful, decayed, or cankered branches being cut out, new branches are led along in their place. At the same time, old rugged spurs, and useless snags, are taken clean off close by the trunk, applying any mild ointment to the wound. On walls from nine to twelve feet high, the fan-training is preferred; but on walls under nine feet, the horizontal method is often adopted. About twenty-five feet are allowed to each tree. Standard apple trees receive, and indeed require, but little attention. The ground is dug over, lichens and mosses on the trunks or branches are destroyed, dead branches are cut out, and such as cross each other so as to rub together. When a standard or a dwarf standard is heavily loaded with fruit, several clefted or forked stakes are stuck into the ground, and made to support the drooping branches, which are otherwise apt to break down. Standards in gardens are placed generally thirty feet apart; espalier trees on dwarf stocks, fifteen feet apart; on free stocks, perhaps twenty-five feet.

110. The apple tree grows and thrives on very various soils. It equally dislikes a strong clayey and wet soil, as one that is open, dry, and gravelly; a deep rich cool soil answers best. To lay down more particular rules would be nugatory. It is a fact, that in each particular place, certain kinds of apples are observed to succeed better than other kinds. When therefore the cultivator has discovered the varieties most congenial to the soil and situation, it will be his wisest plan to encourage them, by multiplying grafts of them on his other and less productive trees, or by forming new additional trees of those successful sorts. Where the soil is shallow, and the subsoil bad, it is by following this plan only that large crops of apples can be regularly procured, the new wood of the grafts bearing for a few years, and then giving place to other grafts.

This may be illustrated, by instancing Dalkeith Park garden near Edinburgh, belonging to the Duke of Buccleuch. Formerly few or no apples were here produced, the soil being very shallow, and the subsoil pernicious. But his Grace's gardener, Mr James Macdonald, planted many new trees on this plan:—He formed a small hillock of earth about a foot high, and four or five feet in circumference; on this he placed the tree, carefully spreading the roots, and then covering these with six inches of good earth, and fixing the stem to a stake, to prevent wind-waving. The roots of the trees so planted do not appear ever to have penetrated to the bad subsoil. Still, however, finding that all his standard fruit trees, and particularly apples, would inevitably prove short-lived, Mr Macdonald had recourse to the other plan, of constantly putting on new grafts. He inserts regularly from 2000 to 3000 every year, sometimes placing five or six sorts on one tree. The grafts are of such kinds as experience has taught him to be most fruitful in Dalkeith garden. Apples are now produced in this garden in wonderful profusion, the young wood being often bent down with heavy clusters of fruit, which in many cases are to be seen resting on the ground.

### *Pears.*

111. The *Pear tree* (*Pyrus communis*, L.) is naturalized in some parts of England, and is figured in "English Botany," t. 1784, but can scarcely be accounted an original native. The date of the introduction of the earliest cultivated varieties is not known; for most of them we are indebted to France and the Netherlands. Parkinson enumerates sixty-four, many of which have disappeared. Knoop, in his *Pomologie*, describes and figures above a hundred. Miller has selected eighty, which he describes in his Dictionary, as the best then known in England. Not above one half of those contained in this list are now much esteemed or cultivated. Pears are distinguished, according to the season in which they are fit for use, into *summer*, *autumn*, and *winter pears*. Summer pears must be gathered as they ripen, and eaten from the tree, none of them keeping more than a few days; autumn pears do not keep much more than a fortnight; winter pears are gathered before being fully ripe, in dry weather, and kept, some for several weeks, and others for several months, before being used. They are also classed, according to their general qualities, as *dessert* or *kitchen* pears; and, according as their flesh is firm and breaks, or is soft and melts, into *breaking* and *melting* pears.

112. The following are the best kinds at present cultivated.

*Summer Pears.*

| | | | |
|---|---|---|---|
| | Jargonelle. | | Skinless. |
| | Cuisse madame. | | Prince's pear. |
| | Red muscadelle. | 10 | Summer bergamot. |
| | Green chisel. | | Musk blanquet. |
| 5 | August muscat. | | Longueville. |
| | Little muscat. | | Green Yair. |
| | Summer bonchretien. | | |

*Autumn Pears.*

| | | | |
|---|---|---|---|
| | Brown beurré. | 20 | Great Mouthwater. |
| 15 | Autumn bergamot. | | Red orange. |
| | Gansel's bergamot. | | Great russelet. |
| | Swiss bergamot. | | Red doyenné. |
| | Verte longue. | | Auchan. |
| | Green sugar. | 25 | Muirfowl egg. |

*Winter Pears.*

| | | | |
|---|---|---|---|
| | Chaumontel. | | Easter bergamot. |
| | Colmart. | 35 | Dry martin. |
| | Crassane. | | Louise bonne. |
| | St Germain. | | Marquise. |
| 30 | Echassery. | | Little lard pear. |
| | Winter bonchretien. | | Ambrette. |
| | Virgouleuse. | 40 | Poire d'Auch. |
| | Holland bergamot. | | Swan egg. |

113. The *Jargonelle* (meaning the cuisse madame of the French, whose jargonelle, *vice versâ*, is our cuisse madame) is a well-known fruit, the tree being universally cultivated, either against walls, or espalier rails, or as dwarf standards The flesh is breaking, sweet, and has a slightly musky flavour. It ripens in August, and does not keep; but if two or three trees be planted on an east aspect, the jargonelle season may be prolonged till the end of September.

The *Cuisse Madame* (*i. e.* the French jargonelle) is not nearly so good a fruit as the former; but the tree being a great bearer, the kind is liked for the London market.

The *Red Muscadelle*, or *La bellissime*, is a large beautiful fruit, of a yellow colour, with red stripes; the flesh melting, and of a rich flavour, when not too ripe.

The *Green Chisel*, or Hasting pear, is of a whitish-green when ripe, has a very thin skin, flesh melting and sugary, but when too ripe, mealy.

The *August Muscat*, Royal Muscat, Hanville, or Poire d'Averat, is a roundish flat pear, shaped like a bergamot, skin smooth, of a whitish-yellow colour; flesh breaking, juice richly sugared and perfumed; characterized by Miller, as "one of the best summer pears yet known." The fruit is produced in clusters, and the tree is a great bearer.

The *Little Muscat* is of a longish shape, of a yellow colour, except next the sun, where it is red. On a south or south-east wall it is ripe early in August.

The *Summer bonchretien* is a large oblong fruit, with a smooth and thin skin, of a whitish-green colour, but red next the sun; full of juice, and of a rich perfumed flavour. It succeeds very well on an east or west wall, but as a standard only in good situations, in the milder counties of England.

The *Skinless*, Early russelet, or Flower of Guigne, is a long-shaped reddish coloured fruit, with a very thin skin, the flesh melting, and full of a sugary juice.

*Prince's Pear* is a small roundish fruit, of a yellow colour, but red next the sun; flesh intermediate between breaking and melting; juice high flavoured. The tree is generally a great bearer, and the fruit will keep for a fortnight.

The *Summer Bergamot*, or Hamden's bergamot, is a round flattish pear, of a fine greenish-yellow colour; the flesh melting, and the juice highly perfumed: the tree is a strong and healthy grower, answering either as an espalier or standard.

The *Musk blanquet*, Little blanquet or Pearl pear, is of a yellow colour, full of juice and quite melting; the fruit is produced in clusters, and ripe on the wall in the end of August.

The *Longueville* is very generally spread over the northern part of Britain, where aged trees of it exist in the neighbourhood of ancient monasteries: it is not, however, contained in Miller's list; nor is it mentioned by the French writers. In quality it is surpassed by several of those already mentioned; but still it may be accounted a good summer or early autumn fruit. The longueville of Jedburgh, in Roxburghshire, it may be remarked, seems to be a variety, the fruit possessing the quality of keeping for many weeks: the trees at that place are very old, and evidently the remains of orchards or gardens belonging to the rich religious establishment which once flourished there.

The *Green Yair*, or green Pear of the Yair, is a small green fruit, sweet and juicy, but with little flavour; the tree is a copious bearer, either as a standard or espalier tree. It is supposed to be of Scottish origin, the Yair being an ancient seat on the Border.

114. The *Brown Beurré*, or Red Beurré, is a large and long fruit, of a brownish-red colour next the sun, melting, and full of sharp rich juice, slightly perfumed; indeed it is one of the best autumn pears we have; it must, however, have every advantage of soil and shelter, and a good aspect on the wall. The fruit varies considerably in colour, the

difference seeming to depend on accidental circumstances of soil and vigour.

The *Autumn Bergamot* often gets the name of English Bergamot: it is a smaller fruit than the summer bergamot, but resembles it; the flesh is melting, and the fruit richly perfumed: the tree is a free grower and great bearer.

*Gansel's Bergamot* is of English origin, having been raised from a seed of the autumn bergamot by the late General Gansel at Donneland Hall near Colchester. It is nearly allied to its parent. In good situations, the tree answers excellently as a standard; and if the fruit be gathered in the middle of October, it is in perfection about the middle of November, and continues a month on the wall: it sometimes attains a large size; we have seen one produced at Torry in Scotland, which measured in circumference 14 inches, and weighed, when taken from the tree, 1lb. 10oz.

The *Swiss bergamot* is a round fruit, with a tough skin, of a greenish colour striped with red: flesh melting, and full of juice, slightly perfumed: the tree a copious bearer.

The *Verte longue* (long green pear,) or *Muscat-fleuri*, is a handsome fruit, of good qualities: in a dry soil and warm situation, the tree produces great crops.

The *Green Sugar* pear, or Sucré vert, has a very smooth green skin; flesh melting, and the juice sugary, with an agreeable flavour: the tree is a free bearer.

The *Great Mouthwater*, or Grosse mouille-bouche, is a very good pear; and the tree answers equally well for the wall or the espalier rail.

The *Red Orange* pear is middle-sized, of a round shape, greenish colour, and purple next the sun; the flesh is melting, and the juice sugary, with a slight perfume.

The *Orange Rouge* was formerly the most common pear in France, but it is now much less cultivated.

The *Great Russelet*, or Gros rousselet, is a large oblong fruit, of a brownish colour, becoming dark red next the sun; the flesh tender and agreeably perfumed.

The *Red Doyenné* or Dean-pear is smaller than the common doyenné; it is usually a little turbinated or top-shaped, sometimes, when the fruit is clustered, almost globular, crowned with the persistent leaflets of the calyx; colour yellow; when ripe, red next the sun; ripens from the end of October to the end of November, and continues in perfection a fortnight or three weeks; the flesh is pale-coloured, melting, and, though not very juicy, agreeably perfumed. The tree is a great bearer, even in unfavourable seasons, answering perfectly well either as a standard or espalier. The Dean-pear has been long known in this country, but rather neglected, perhaps on account of Miller's characterizing it generally as "a very indifferent fruit." Mr R. A. Salisbury, however, having recommended the red doyenné in the Memoirs of the Horticultural Society of London, particularly for high and exposed situations, it has risen in estimation.

The *Auchan* sometimes receives the epithet of *grey* or *red:* it is an excellent pear, said to be of Scottish origin: in Scotland the tree is often placed against an east or west wall, but it answers better as an espalier or a standard. It probably deserves more of the attention of English gardeners than it has met with. The tree is a free grower and plentiful bearer, even in light soils. The fruit is sweetish, with a peculiar and rather agreeable flavour. When the name *Auchan* alone is used, this is the kind to be understood: What is called the Summer Auchan is a trifling green fruit, not worth cultivating; and the Black or Winter Auchan is a smaller and later variety.

The *Muirfowl egg* is another pear of good qualities, said to be originally Scottish. It ripens in September, and keeps for many weeks. It is often placed against walls in Scotland, but the fruit from standards is much higher flavoured, though not of so large a size.

115. The finer sorts of winter pears are of French origin; and in this country they require all the aid of a wall with a good aspect, and very considerable attention after they are taken from the tree, several kinds attaining maturity only in the fruit-room.

The *Chaumontel*, or winter beurré, was raised at Chaumontel near Chantilly, where, it is said, the original tree still exists. It is a large rich flavoured melting pear; the skin a little rough; often of a pale green colour, but becoming purplish next the sun; sometimes with a good deal of red. The tree may be considered as in general requiring a wall, and a pretty good aspect: in a few places it succeeds on espalier-rails in good seasons. The fruit is left on the tree till the close approach of winter; it is fit for eating in the end of November, and continues till January. The Chaumontel is produced in great perfection in Guernsey and Jersey, and considerable quantities are yearly commissioned from these islands by the London fruiterers.

The *Colmart*, or Manna pear, is large and excellent; the flesh very tender and melting, and the juice greatly sugared; both in shape and quality, it considerably resembles the autumn or English bergamot: it keeps throughout the winter, and till the end of February. The tree requires a large space of good wall, but deserves it.

The *Crassane* (said to derive its name from *crassus*, thick,) or Bergamot crassane, is a pear of a large size and round shape, with a long stalk; the skin is roughish, of a greenish-yellow when ripe, with a russety coating; the flesh is very tender and melting, and full of a rich sugary juice. It is fit for use from the middle to the end of November, and is one of the very best pears of the season. The tree requires a good wall.

The *St Germain* is a large long pear, of a yellowish colour when ripe; flesh melting, and very full of juice, with considerable flavour. If the tree be planted on a dry soil, in a warm situation, and trained against a good wall, it bears pretty freely: There are two varieties, a spurious, and the true; and it is believed the former is by much the more generally disseminated. The spurious fruit ripens in December, remaining green when ripe, and generally decays by the end of January; unless the soil and season be favourable, it is insipid and watery; it is shorter, and its form is subject to more variations than that of the true variety. The true St Germain keeps in perfection till the end of March, and, for sweetness and flavour, ranks among the very best of the winter pears. It is beautifully figured by Hooker, in the *Pomona Londinensis*, Plate 5.

The *Echassery* is a thick oval fruit, shaped like a citron; skin smooth, and yellow when ripe: flesh melting, juice sugared, with a delicate perfume. In season in December and January. The tree requires a good wall; the fruit is produced in clusters.

The *Bonchretien*, or winter bonchretien, requires even in France all the advantages of a south wall and well prepared border. But although Quintinye and Duhamel mention this as the very best late winter-pear, we would be inclined to consider it as greatly inferior to those already named, judging either from the specimens imported into this country, or from those produced in our gardens. With us it attains a large size, but seldom acquires sufficient maturity to bring forth the characters for which the French authors praise it. The French graft the tree on a quince-stock; but Miller gives it as his opinion, that if it were placed on a free stock, and the branches trained at full length on a good wall, the fruit might be much improved in this country. It is to be observed, that even in France the tree is late of coming into a bearing state, but that it becomes more fruitful as it advances in age. Delauny mentions that the French use the unripe fruit in soups, in place of turnips; and it must be confessed, that those generally produced in this country seem much fitter for that purpose than for appearing in a dessert.

The *Virgouleuse*, or ice-pear, is a large and long fruit, of a green colour, inclining to yellow as it ripens; flesh melting, and full of rich juice; for eating in December, and continues till February. The tree is often accounted a bad bearer; but it has been justly remarked by Miller, that this may frequently arise from gardeners not attending to its nature: it produces vigorous shoots, and the blossom comes principally at the ends of these shoots; if therefore the tree be pruned in the ordinary way, much of the blossom must be cut away; if, however, it be allowed ample space, and the branches be laid in at full length, the tree produces fair crops. In favourable situations, it succeeds on espalier-rails, but it is commonly trained against a wall.

The *Holland Bergamot* is a good pear, of a greenish-yellow colour; the flesh tender, and high flavoured: it must remain on the tree till the approach of frost: it keeps till May.

The *Easter Bergamot*, Bergamotte de Pâques, or winter bergamot, is a large roundish fruit, of a greyish-green colour, with a little red; the flesh between breaking and melting. In this country, the tree must stand on a free stock, and have a good wall, and well prepared border. The fruit is fit for the table in February, and keeps till April.

The *Dry martin* (martin-sec), or winter russelet, is an oblong pear, russety on one side, inclining to red on the other; flesh breaking, juice sugary, with a little perfume; ready in November, and keeps about three months. The tree is generally placed on a free stock; but it succeeds either against a wall or rail, and bears pretty freely.

The *Louise-bonne* resembles the St Germain, and is pretty good when produced against a wall, and from a dry soil; in season in December. The tree generally bears well.

The *Marquise*, or marchioness's pear, is a long pyramidal fruit, of a greenish-yellow colour, with a little brown; the flesh is melting, and the juice rich and sweet. In season in November and December. In this country the tree requires a good wall and favourable aspect.

The *Ambrette* is an oval middle-sized fruit, melting and sugary; when produced from a dry soil and against a south wall, the fruit acquires a flavour resembling the scent of the sweet-sultan or *ambrette* of the French.

The *Poire d'Auch* is described by Forsyth as resembling the colmart, but fuller towards the stalk, and "without exception the best of all the winter pears."

The *Swan-egg* is a very good late pear, for use in November and December. It is egg-shaped, of a green colour, thinly spotted with brown; flesh melting, and abounding with a pleasant juice. On standards or espaliers the fruit acquires a higher flavour than on wall-trees; indeed it is only trained against a wall in high and bleak situations.

116. With the exception of five, all the pears which have now been enumerated and described are of French origin. Of these five, two are considered as of English origin, the Gansel's bergamot and the Swann-egg; and three of Scottish origin, the Muirfowl-egg, Green Yair, and Auchan. Some other Scottish pears, which occur chiefly in country gardens, but are of good quality, may just be named. Such are *Pear-James*, the *Early Carnock*, *Late Carnock* or *Drummond*, *Golden Knap*, *Crawford* or *Lammas*, the *Grey Goodwife*, and the *John Monteith*.

Among English pears little known or attended to, may be mentioned the *Elton pear*, figured in the London Horticultural Transactions, vol. ii. It ripens on standards, for which it is best suited, from the middle to the end of September; but it must be gathered ten days before being ripe, else it is apt to get mealy. When in perfection, it is described as uniting much of the fine flavour of the bergamots with the melting softness of the beurrés. The fruit is without seeds, and indeed almost without internal cavity. The original tree stands on its own roots in an orchard of seedling pears at Elton in Herefordshire. It is about a hundred and fifty years old, but still healthy.

The *Aston-town pear* is regarded as a native of Cheshire, and said to have received its name from Aston-town in that county. The branches of the tree have a peculiar tendency to twist round in growing upwards. The young shoots are pendent, and the blossoms are produced chiefly at the extremities. The leaves are small and oval. The fruit somewhat resembles the swan-egg pear; is of a greenish colour, spotted with russet; when ripe, the flesh is melting, and high flavoured. It is in perfection early in October, but does not keep. The fruit seems to be improved when the tree is trained to a wall; but in order to have fruit in this way, the shoots should be trained downwards according to their natural inclination.

117. Of new pears of any kind, our list is very scanty. The *Wormsley bergamot* has of late years been raised by Mr Knight, from the blossom of the autumn bergamot, stripped of its stamina, and dusted with the pollen of the St Germain. It is a good melting pear, and the tree grows freely in any common soil where other pear-trees thrive; the blossom appears to possess the advantage of being very hardy; the fruit remains on the tree till the end of October, and is in perfection about three weeks afterwards. At this time, we have scarcely any winter keeping pears sufficiently hardy to grow on standards. Mr. Knight, however, confidently predicts, that winter pears will, in the course of another generation, be obtained in the utmost abundance from standard trees; that is, that new varieties, combining perhaps the hardiness of the swan-egg with the valuable qualities of the colmart or chaumontel, will be produced.

118. All the kinds of summer pears ripen, in ordinary seasons, on the different sorts of standards, or on espaliers; the autumn pears, on dwarf standards or espaliers. Espaliers, however, are in both cases preferable to dwarf standards, as the tree may in the former way stand on a free stock, and yet have ample space allowed it. The finer French winter pears in general require a wall, with an east, south-east, or south-west aspect; and in the northern parts of the island a full south aspect. Several of the kinds, however, answer on espalier-rails; and as the fruit ripens more slowly and equably when hanging in the open air, than when assisted by the shelter and reflected heat of a wall, it is found to keep longer. While the espalier-trees are in blossom, and till the fruit be fully set, they require some protection; such as screens of reed or straw, or woollen nets.

A pear-tree, especially on a free-stock, cannot do with less than forty feet of wall. In many varieties the fruit-buds are produced chiefly at the extremities of the new shoots: if the dimensions of the tree must be much circumscribed, therefore, it will often happen, in the ordinary way of training and pruning, that the fruit-buds will be cut away. One well-trained horizontal tree is, on this account, better than two or three upright or fan trees; and there is little danger of keeping the wall covered, however high it be. Miller mentions a summer bonchretien, which extended fifty feet in width, and filled a wall thirty-six feet high, and was at the same time extremely fruitful. The object of the French gardeners, such as Quintinye, was to keep their pear trees within narrow bounds: hence their prolix and confused descriptions of the mode of training and pruning, forming a perfect contrast with the concise and perspicuous directions of Hitt and Miller.

119. For wall pear-trees horizontal training is now very generally preferred to the fan mode; chiefly because, in this latter way, the nearly upright position of the branches encourages the throwing out of numerous strong shoots, in producing which the sap of the tree is exhausted; these shoots are destined to be cut out in the winter pruning, and the middle part of the tree comes in this way to be barren. In the horizontal mode, provision is made for having fruit-bearing wood near the stem, as well as at the extremities of the branches; and it is estimated that, on an average, wall pear trees so trained afford a third more of good fruit than such as are trained in the fan way, or suffered to ramble on the wall as chance may direct. It is a general rule, therefore, that the branches of pear-trees are not to be shortened, unless where wood is wanted to fill up a vacancy; the only effect of shortening being, that in place of small fruitful spurs, rambling and unfruitful shoots are produced. During the summer, foreright and superfluous shoots are displaced with the finger. In this way, no wood buds are left to form shoots next season; and if disbudding be carefully performed, there will be little to do at the winter pruning. It is a rule, that the fruit spurs, especially of the finer French pears, should at all times be kept as close as possible to the wall.

120. But the mode of managing wall pear-trees recommended by Mr Knight (in the London Horticultural Transactions, vol. ii) deserves here particular notice. It will be best understood by describing nearly in his own words, his mode of reclaiming an old St Germain pear-tree which had been trained in the fan form. The central branches, as usually happens in old trees thus trained, had long reached the top of the wall, and had become wholly unproductive. The other branches afforded very little fruit, and that little never acquired maturity. It was necessary therefore to change the variety, as well as to render the tree productive. To attain these purposes, every branch which did not want at least twenty degrees of being perpendicular, was taken out at its base; and the spurs upon every other branch intended to be retained, were taken off closely with the saw and chisel. Into these branches, at their subdivisions, grafts were inserted at different distances from the roots, and some so near the extremities of the branches, that the tree extended as widely in the autumn after it was grafted, as it did in the preceding year. The grafts were also so disposed, that every part of the space which the tree previously covered, was equally well supplied with young wood. As soon, in the succeeding summer, as the young shoots had attained sufficient length, they were trained *almost perpendicularly downwards, between the larger branches and the wall*, to which they were nailed. The most perpendicular remaining branch, upon each side, was grafted about four feet below the top of the wall; and the shoots thus procured were trained inwards, and bent down to occupy the space from which the old central branches had been removed; and therefore very little vacant space any where remained at the end of the first autumn. In the second year, and subsequently, the tree yielded abundant crops, the fruit being equally dispersed over every part. Grafts of no fewer than eight different kinds of pears had been inserted, and all afforded fruit, and nearly in equal plenty.

By this mode of training, Mr Knight remarks, the bearing branches being small and short, may be changed every three or four years, till the tree be a century old, without the loss of a single crop, and the central part, which is almost necessarily unproductive in the fan mode of training, and is apt to become so in the horizontal, is rendered in this way the most fruitful. Where it is not meant to change the kind of fruit, nothing more, of course, is necessary, than to take off entirely the spurs and supernumerary large branches, leaving all blossom buds which occur near the extremities of the remaining branches. In some varieties, particularly the crassane and colmart, the dependent bearing wood must be longer than in others.

The training the bearing shoots downwards, has also been found to throw young trees much sooner into a productive state. Fruit is in this way generally obtained the second year: even the colmart tree, which seldom produces sooner than six or seven years from the time of grafting, yields fruit by this mode in the third season. Mr Knight recommends giving to young trees nearly the form above described in the case of the old St Germain, only not permitting the existence of so great a number of large lateral branches. In both cases, the bearing wood should depend wholly beneath the large branches which feed it; for, in Mr Knight's opinion, it is the influence of gravitation upon the sap which occasions an early and plentiful produce of fruit.

121. To destroy old pear-trees, if they be tolerably healthy, is in any case very injudicious, because, by proper management, they may again be brought into a bearing state. If the soil be bad, it may be mended: if the tree be full of worn-out spurs, new horizontal branches, or new dependent shoots, as above exemplified, may be procured: if the sort of fruit be bad, grafts of more approved kinds may, as we have seen, be introduced. Mr James Smith, gardener to the Earl of Hopetoun, at Hopetoun House, has written a very sensible paper (published in the first volume of the Scottish Horticultural Memoirs) on the cultivation of French pears in Scotland. It contains some judicious remarks on the means of bringing into a bearing state such full grown trees as are nearly barren of fruit, although in a luxuriant state of growth. In the same volume there is a communication from Mr Thomas Thomson, an experienced gardener, on this subject. In order to check unprofitable luxuriance, he particularly recommends cutting some of the roots of the tree, at the distance of about four feet from the stem, especially such roots as incline downwards. He mentions his having brought a crassane tree into a bearing state by cutting it two-thirds through with a hand-saw, below the level of the earth, and above the forkings of the root. From being very luxuriant but barren, it was thus rendered less luxuriant but fruitful, yielding next season, "at one gathering, forty-seven dozen of handsome fruit." If horizontally trained trees have become full of old spurs and breastwood, the most effectual remedy (as described by another judicious Scottish gardener, Mr Alexander Stewart at Valleyfield, in *Hort. Mem.* i. 459) is found in cutting out every second branch on each side, within a few inches of the stem. New shoots are trained along, in place of the former branches; but in the mean time a number of side-shoots from the remaining branches are laid in; these, Mr Stewart remarks, form fine fruit spurs, equal to the young wood from the stem of the tree; and they also tend to lessen the production of breastwood: they are however removed, as the regular new horizontal branches advance. In making use of these side

shoots, it may be remarked, Mr Stewart had very nearly hit on the mode of management now adopted and recommended by Mr Knight.

In managing prepared borders, planted with the finer sorts of pear trees, it is important, that, during the summer, particularly if the soil be strong or inclined to clayey, they be occasionally forked over, or that the light crop supposed to be on this border be frequently hoed. If the season prove dry, and at the same time the soil be light, water is given to the trees. A hollow is formed around the stem, and two or three pailfuls of water poured into it once a-week, or oftener; some *mulch* being at the same time formed to prevent rapid evaporation. In this way the fruit, while in progress, is kept constantly and uniformly in a growing or advancing state. When ripening approaches, the water is withheld, lest the flavour should suffer.

### *Quince.*

122. The *Quince tree* is the *Pyrus Cydonia* of Linné, the *coignassier* of the French. This not being very much cultivated in Britain, it may be mentioned, that the tree is of low growth, much branched, and generally distorted; and that there are different varieties of the fruit,—globular, or apple-quince; oblong, or Portugal quince; and pear-shaped, or pear quince. The quince is a native of some parts of Germany. It was known in England in the time of Gerarde, and probably long before. The fruit has a peculiar, rather disagreeable smell, and an austere taste when raw; but when prepared, it is by many held in esteem. A small portion of it added to stewed or baked apples, is useful for giving quickness and flavour. Quince marmalade is commonly sold in the confectioners' shops. The Portugal quince is the best, but the fruit is produced sparingly. Like the others, it is of a yellow colour; but the pulp has the property of assuming a fine purple tint in the course of being prepared. The quince tree is propagated by layers, by suckers, or by cuttings. It thrives best in a moist soil, but the fruit is superior in a dry one. In this country, the fruit scarcely ripens unless the tree be trained to a wall; and, even then, it is not ready till November.

### *Grape Vine.*

123. The *vine*, or grape tree, (*Vitis vinifera*, L. *Pentandria Monogynia; Vites*, Juss.) it is perhaps superfluous to mention, has a twisted irregular stem, with very long flexible branches, supporting themselves by means of tendrils; the leaves large, lobed, alternate, on long footstalks; the flowers in a raceme, of a herbaceous colour, insignificant in appearance, but fragrant. The berry, or grape, is generally globular; in some varieties, oval; of various colours, green, yellowish, or amber, reddish brown, and black.

124. It has generally been said, that the vine was introduced into this country by the Romans; but from Tacitus we learn, that it was unknown in Britain when Julius Agricola had the command. It was probably first cultivated here in the time of the late Emperors, perhaps about the close of the 3d century.

At the date of the Conquest there seem to have been vineyards in the south and south-west of England. From that period downward to the Reformation, vineyards appear to have been attached to all the principal religious foundations in England; and it is somewhat curious, that from the time of the Reformation to the present day they have in a great measure disappeared. A few, however, have occasionally been formed. From the *Museum Rusticum* we learn, that one was established at Arundel Castle in Sussex about the middle of the last century; and that in 1763, there were in the Duke of Norfolk's cellars sixty pipes of English burgundy, its produce. Professor Martyn of Cambridge has, with his usual industry, drawn together the evidence concerning the culture of the grape vine in Britain in former times, and the practicability of resuming it; and he concludes, that in former times there were many real vineyards in England,—not merely orchards and plantations of currants, as the Hon. Daines Barrington and others have suspected; and gives it as his opinion, that vineyards might still be successful in the southern and western parts of England, in proper soils and situations, if conducted by persons skilled in their management. The earliest and hardiest grapes, or those best suited to the climate, are not, however, well calculated for the making of wine. The miller and small black cluster may do; but they are inferior to the large black cluster, which has an austere taste. Mr Vispré, in 1786, published a dissertation on the growth of vines in England. He proposed to train the shoots, like the runners of melons and cucumbers, near the ground; and he actually found, that the berries thus produced were larger than those of the same kinds trained against a south wall. In the north of France, it is well known, the vines are trained very low, not rising more than four or five feet from the ground.

125. Parkinson, in 1629, describes twenty-three kinds of grape vines, several of which are still cultivated, and in high esteem, such as the Muscadines, and the Frontignacs. The following are the principal kinds which are at this time cultivated in Britain; those which succeed in the open air being distinguished by an asterisk.

*White Grapes.*

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| * White Muscadine, | White Muscat of Alexandria, |
| * White Sweetwater, | White Constantia, |
| * White Frontignac, | White Hamburgh, |
| * Malmsey Muscadine, | Tokay, |
| * Royal Muscadine, | Greek Grape. |

*Red Grapes.*

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| * Brick Grape, | Red Hamburgh. |
| Red Frontignac, | |

*Black Grapes.*

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| * Miller Grape, | Black Frontignac, |
| * Early July, | * Black Hamburgh, |
| * Black Sweetwater, | Alicant, |
| * Small Black Cluster, | * St Peter's, |
| Large Black Cluster, | Claret, |
| Black Muscadine, | * Black Prince. |

The *White Muscadine* is very generally cultivated against open walls in the southern parts of England; and, being an early grape, it ripens well. The berries are roundish, thin skinned, and of an amber colour when ripe; at which time their juice becomes sweet, and of delicate flavour. The bunches are small, but many are produced. Forsyth says, that it is the best vine we have for a common wall, and a great bearer; and Speechly remarks, that it is often cut and eaten before it be fully ripe, but that when well matured, it is an exceedingly fine grape.

The *White Sweetwater* is likewise an excellent early grape, much cultivated in the open air. The berries are round, not of equal size, some being as large as cherries, while others remain nearly as small as mustard seeds; they are thin skinned, and full of juice, which is sugary, but not vinous. When nearly ripe, they become of an amber colour; when clouded with russet, they are in perfection. Nicol remarks, that this grape, like the former, is often cut before it be fully ripe, and that this has occasioned it to be less in repute than it deserves. The shoots are thick and strong, but not long; the leaves very large.

The *White Frontignac* vine is a copious bearer. The berries are round, and of a good size, closely clustered on a long bunch, somewhat *shouldered*. When ripe they are excellent, and remarkable for uniting the qualities of being fleshy, and having a sweet juice and perfumed flavour,—not so powerful, however, as that of the black and red varieties, the last of which has a very strong musky flavour. The ripe berries have a fine white bloom or farina on them, from whence the name is given. It has a place in the vinery, and is also trained against open walls.

The *Malmsey Muscadine* grape has a sweet juice, and high flavour, and the vine is a good bearer. It is commonly planted in the vinery, but succeeds also against the open wall.

The *Royal Muscadine*, or White Chasselas, the d'Arboyse of Speechly and Forsyth, is an excellent grape for the vinery or the hot-house; the bunches large and shouldered; berries round and amber-coloured when ripe; the juice rich and vinous. The vine generally grows remarkably gross and strong, both in wood and foliage.

The *White Muscat of Alexandria*, or Alexandrian frontignac, has large oval berries, which hang loose in the bunches, these being long, and not shouldered; when ripe the berries are amber-coloured; and the juice is then rich and racy; the skins are thick, and the pulp hard, but of a highly musky flavour. It is fit only for the grape-house or pine-stove.

The *White Constantia* berries are tolerably large, rather of an oval shape, of a sweet taste, with only a slight flavour. The bunch is of considerable size, and well formed. This is the kind which has acquired fame at the Cape of Good Hope. It is said to degenerate when transplanted. At Constantia farm it grows in a light sandy loam; the situation is low, but more elevated than other parts of the district. There is likewise a *red* Constantia; and a *black* Constantia appears in some catalogues: but this last has proved to be the same as the black frontignac.*

The *White Hamburgh*, or Portugal grape, grows in large long bunches; the berries are oval, pale white, with a thick skin, and firm pulpy flesh. The vine is a plentiful bearer, and grows very strong both in wood and leaves. It much resembles the Syrian.

The *Tokay*, when well managed, produces both large bunches and large berries, and becomes one of the finest grapes in the vinery. The berries are white, oval-shaped, skin thin, pulp delicate, and of agreeable flavour. The leaves on the under side are covered with a fine soft down like satin. It should be placed in the warmest end of the vinery, and is well suited for the pine-stove.

The *Greek grape* is a high-flavoured and delicate fruit. The berries are of moderate size, somewhat oval, bluish-white; growing close, in middling sized bunches. The leaves of the tree resemble those of the sweetwater, but stand on shorter footstalks; it is a plentiful bearer either in the vinery or hot-house.

The *Brick grape* gets its name from the berries being of a pale red or brick colour; they are thin skinned, with a sweet juice. The bunches are small, but two or three often proceed from the same shoot, so that the vine is, upon the whole, a plentiful bearer. It succeeds on walls and treillages, and is hardly deserving of a place in the vinery.

The *Red Frontignac* is an excellent musky flavoured grape, when fully ripe, of a brownish red colour. The juice of this, says Miller, has the most vinous flavour of all the sorts, and is greatly esteemed in France. It is well calculated for the vinery.

What is called the *Grizzly Frontignac* seems to be only the red in an unripe state, at which time the berries are greyish-coloured, with a few dark stripes.

The *Red Hamburgh*, or Gibraltar grape, grows in large bunches; the berries somewhat oval shaped, of considerable size, thin skinned, red when ripe, juicy, with a rich vinous flavour. It is suited only for the vinery and hot-house.

Of the Black Grapes, one of the most hardy kinds is called the *Miller*, or Dusty Miller, from a white powdery appearance on the surface of its leaves: It is nearly allied to the black cluster grape. It is much cultivated in gardens, and against the front and gable walls of houses in the south-west of England: the fruit ripens freely, and is very good, the skin and pulp being delicate, and the juice sweet and pleasant; the berries are oval, of a middling size, and closely placed to each other in the bunches.

The *Early July* has small black round berries, with large stones; they grow loose on the bunches, which are small but numerous; juice sugary, with but little flavour. It ripens early in September, without fire heat. There is also a White July grape, which is little cultivated.

The *Black Sweetwater* is a small roundish grape, growing close in the bunches; the skin is thin, and the juice very sweet. It ripens early, and is calculated either for the vinery or the wall.

The *Small Black Cluster* resembles the Miller grape, but the leaves are not quite so hoary, and are rather smaller. The fruit is sweet, and of delicate taste. This is extremely common on walls of houses near London.

In the *Large Black Cluster*, the berries are oval, and grow close in the bunch, which, notwithstanding the name, is not large. The juice has a harsh taste, and makes the palate feel rough, as in tasting Port wine; Mr Speechly indeed considers it as the sort used in the manufacture of that celebrated wine.

In the *Black Muscadine*, the bunches and berries are smaller than in the white; it is a very productive kind, and makes a fine appearance, the black berries having a bluish bloom. Fit for the vinery or the hot-house.

The bunches of the *Black Frontignac* are long, and the berries, which are round and of moderate size, are thinly or loosely hung on them. They are of good quality, the juice being vinous, and of exquisite flavour.

The *Black Hamburgh* is well known and generally liked. The berries are somewhat of an oval shape, the skin thick, and the pulp hard; but it is a well flavoured fruit, and the tree bears plentifully. The bunches are large, and handsomely shouldered. It answers very well in the vinery; but, in the open air, it comes to maturity only in very warm situations and in favourable seasons.

The *Alicant*, or Black Spanish grape, forms very long shouldered bunches, the berries being also large and of an oval shape; at first they are red or flame-coloured; but when ripe, they become of a dark brown or black colour; the skin is thick, and the stones large; the pulp soft and juicy, and of agreeable flavour. It is often called the Lombardy grape, and sometimes the Rhenish. It is excellent for the hot-house or the vinery. In autumn the leaves are finely variegated with red, green, and yellow.

* A small quantity of wine was sent some years ago from Portugal to a mercantile house in Leith as a present, which was made from the Constantia grape grown in Portugal. It was a white wine, extremely sweet, but the flavour not particularly good,—altogether quite different from the Cape Constantia wine.

*St Peter's grape* has the berry large, roundish, black; skin thin; the bunches large, handsomely formed, and making a fine appearance at table; the pulp delicate and juicy. The vine is a good bearer, but the grapes are late of ripening. They are apt to crack in the forcing house, or in the vinery. In fine seasons, this kind ripens on a south wall.

The *Claret grape* is distinguished by its harsh sourish taste, and dark claret colour; when the grapes are perfectly ripened in a hot-house, however, the taste is pleasant. The berries are small, and grow close, on small bunches. The leaves are large, and acquire a russet red or claret colour; on which account they have been recommended for making *vine-leaf* wine.

The *Black Prince* is an excellent grape, well deserving a place in the hot-house or the vinery, where it produces both large berries and large bunches. Even on the open wall, in the south of England, it succeeds in favourable seasons: Forsyth mentions, that in this way he has had bunches which weighed a pound and a half, and which ripened in October.

Besides the list already given, two or three others deserve notice.

The *Verdelho*, or Verdellio grape of Madeira, is the kind from which the celebrated Madeira wine is understood to be principally made. The vine grows with great vigour in our grape houses, and is remarkably productive of fruit, frequently yielding three bunches on a shoot. Here, however, the bunches are but small; the berries are also of diminutive size, of an oval shape, green colour, and with a thin skin. The fruit is very acid till it arrive at the last stage of maturity, when the berries become of a fine amber colour, and of a very rich saccharine taste, with considerable flavour. Mr Williams of Pitmaston, near Worcester, has given an account of this variety in the 2d volume of the London Horticultural Transactions; and he expresses his opinion, that in favourable situations in the south-west of England it would succeed on the open wall, especially where the soil is light, dry, and shallow, but that in a deep highly manured soil, it would run too much to wood and foliage. The leaf is dark green, and very thick; and would resist the autumnal frosts, and protect the fruit till a late period in October. The verdelho is much cultivated in the province of Languedoc in France; it is described by Delaunay under the name of *Verdal*, and is highly esteemed at Paris, its berries being accounted the most sugary and delicate in flavour of all the dessert sorts. In France the bunches become tolerably large, and very beautiful; and the berries also acquire considerable size.

The *Raisin de Carmes*, or, as it is sometimes called, *Raisin de Cabo*, is a grape of fine qualities. The fruit is produced in rather loose long bunches; the berries large and of an oval form. The skin is thickish, of a dusky purple colour, covered with a fine bloom; the pulp is firm and extremely rich, though containing a considerable portion of acid. The filaments and anthers frequently remain when the fruit is ripe. The vine needs a high temperature; in the stove it grows freely and bears well, but it requires particular attention at the time of flowering. The wood is rather slender, of a yellowish-brown colour; the leaves small, and pale green. It is figured by Hooker, in the *Pomona Londinensis*, t. 10.

The *Raisin grape* is of a brown or blackish colour; large, oval, fleshy and firm, but with a pleasant juice; forming handsome long bunches. It also is only suited to the hot-house.

The *Syrian grape*, is among the coarsest of the grape kind; but the vine is a good bearer under glass, and produces bunches of extraordinary size. The berries are large, oval, white, with a thick skin and firm pulp; they continue in good condition till January. In this country, Mr Speechly once produced a bunch which weighed 19½lb. and he describes another which was four feet and a half in circumference, and near two feet in length. This last bunch was sent to the distance of twenty miles as a present. Four men were employed, two by turns, carrying the bunch suspended on a pole or staff resting on their shoulders. No doubt one man *could* have carried the bunch, if the weight alone be considered; but it was a great object to transmit it without bruise or injury. This may tend to illustrate a passage in the Sacred Writings (Book of Numbers, ch. xiii.), where the description of this mode of carrying a bunch of grapes has sometimes very unnecessarily excited a sneer.

127. In warmer countries than this, vines that are suffered to grow without pruning attain a large size, their stems assuming the appearance of trunks of trees. Vines that are regularly pruned or dressed cannot be expected ever to arrive at such magnitude. Even in the ungenial climate of Britain, however, they sometimes have a surprising size and expansion. The Northallerton vine, about the year 1785, covered a space of 137 square yards, and the circumference of the trunk near the ground was almost four feet; it was then considerably more than a hundred years old. Lysons, in his Account of the Environs of London, describes a Black Hamburgh vine at Valentines in Essex, the branches of which extended 200 feet, the stem being 1 foot 13 inches in circumference. It sometimes yielded 4 cwt. of grapes in a season. Another Black Hamburgh vine, still more famous for the quantity of its produce, has already been mentioned § 26, as existing in a grape-house at Hampton Court Palace. This season (1816) it yielded about a ton of grapes.

128. New varieties of grapes are of course only to be procured by sowing the seeds. When this is intended, the grapes should be left on the vine till almost in a state of decay, taking care, however, if they be exposed to the open air, to cover them from the attacks of birds. The stones, in this very mature state, become of a dark brown colour; they are to be separated from the pulp, and laid in a dry airy place till spring. Mr Speechly, in his work first published in 1786, recommends the bringing together of flowering branches of two different kinds of grape, calculated to modify or improve each other: the frontignac and other high-flavoured grapes, he observes, may add flavour to other kinds; the white sweetwater may be coupled with the red frontignac, with the Black Hamburgh, or with the white muscat of Alexandria. He boldly augurs, that the best sorts of grapes hitherto known, will at some future day be esteemed only as secondary or inferior. The distinguished Mr Knight supports these views, and indeed has done much towards their accomplishment.

Under the name of *Variegated Chasselas*, Mr Knight has described a new variety which sprung from a flower of the white Chasselas, dusted with the pollen of the Aleppo grape, which last, he remarks, readily variegates the leaves and fruit of the offspring of any white grape. The berries are striped and very beautiful; with a thin skin, and juicy. The leaves become variegated with red and yellow in autumn. It has been found to be a very hardy and productive variety, bearing well in the open air. When gathered in October, and hung up in bunches in rather a damp room, it keeps till February or later.

This active horticulturist has described (*Trans. Hort. Soc. Lond.* vol. i.) still another variety of variegated grape, in which the bunches on the same plant are of different colours. This too he considers as fit for the open air, at least in the south of England: it is very productive, though both the bunches and berries are small. It contains much saccharine matter, more perhaps than any grape, except the *verdelho* of Madeira. Mr Knight therefore considers it as better calculated for the press, in a cool climate, than any we now possess, and observes, that if it were trained to low walls in the warmer parts of England, it would afford a wine of considerable strength.

Several others besides Mr Knight are now engaged in the raising of seedling vines; and in all probability some excellent and hardy kinds will soon be produced; so that another generation may once more see vineyards common in this country. The raising of new vines is by no means a very tedious process. The fruit of the seedling may in general be tasted in the fourth year; while a florist waits patiently for five or six years before his seedling tulips shew flower, and perhaps nurses his breeders as many years more before they *break* to his mind.

129. Vines are often propagated by layers, which, when rightly managed, form good enough plants. Strong healthy shoots from different sides of the stool are bent down, generally in February, and gently twisted or notched: this twisted part is introduced into a flower-pot, filled with fresh mould, and which is sunk an inch or two beneath the surface. In the course of the summer, plenty of roots are sent out at the doubling, and in autumn the offset is separated from the parent plant. In the nurseries near London this mode is much practised; and both parent plant and layers may often be seen bearing fruit, so that the kind can be positively ascertained. Abercrombie describes the mode of forming layers in the open ground; but the advantage of having the plants in flower-pots is evident, as a ball of earth can thus be preserved to the roots. Indeed, the roots of the vine are so liable to be injured in transplanting, that flower-pots should always be employed.

Vines are likewise extensively propagated by cuttings. These are taken off at the usual time of pruning in autumn or winter, and are kept till the following spring, merely by sinking them nearly to the top in dry earth. It was formerly considered of great advantage to have an inch or two of old wood to each cutting; the cutting was from a foot to fifteen inches long, and a single cutting only could in this way be made from a shoot. The Rev. Mr Michell, a philosophical as well as practical horticulturist, first introduced the use of short cuttings, about three inches and a half long, and all consisting of the new wood, if properly ripened, and having only one bud or eye. Plants raised in this way he found to be furnished with more abundant roots, to come sooner into bearing, generally in the second year, and to prove more fruitful, than long cuttings, with several eyes, and a portion of the old wood attached. These cuttings are often planted in a nursery bed in the spring; but they are much forwarded by placing them in pots, into the bark-bed of a stove. Mr. Michell usually planted his cuttings in the naked bark, four or five inches asunder; being short and throwing out tufty roots, they are easily potted when thought necessary. Shoots of strong growth, it may be remarked, are not good for cuttings, having too much pith. Many gardeners are of opinion, that plants thus procured from cuttings become better rooted, and grow more freely, than those from layers.

There is still another and a very speedy mode of propagating the vine, especially the more tender varieties, which will be described when we come to speak of the Vinery.

130. In forming a border for vines, a matter of primary consideration is, that the roots shall not be able to penetrate to a wet subsoil: to guard against this, it is common to take out the earth, and lay lime rubbish, which is firmly beat down, in the bottom. Any fresh and light, but rich soil, to the depth of a foot and a half, or two feet at most, answers perfectly well.

In France and Italy the most experienced vignerons are very scrupulous about permitting any gross or strong manures, such as dungs, to approach the roots of their fine vines, for fear of altering or deteriorating the flavour of the grapes. Rotted turf or clippings of box trodden under foot in the highway, are the manures there preferred. They who apply dungs, are considered as more anxious about quantity than quality. In this country, however, we must partly compensate for the want of a bright sky and hot sun, by giving vigour to the plants by means of manures, even if we should make some sacrifice of flavour. Marshall repeatedly urges the necessity of this, and recommends the digging in of some sheep's droppings, or the cleanings of a poultry-house, every year. Nicol too is a strenuous advocate for applying the essence of dungs, by watering vine-borders with dunghill drainings, which he declares to be the "nectar of vegetable life."

131. In planting vines, it is customary to cut clean at the end the strong root from which the fibres proceed. A hole or trench is then made in the border, corresponding to the length of the main root; this trench is formed with a ridge in the middle; and on this ridge the woody part of the root is laid, the fibres sloping down on each side. If the main root be three inches under the surface of the border, it is deep enough.

132. Hitt long ago recommended the training of the principal stem of the vine in a serpentine form; leading from it parallel horizontal shoots, at the distance of eighteen inches from each other: from these, bearing branches are produced, which are nailed in, in an upright position, by which means, in his opinion, they are less apt to put forth collateral shoots, which rob the fruit. Forsyth has since shewn the advantage to be derived from training the bearing shoots also in the serpentine manner. This, it must be confessed, renders the laying in of the summer wood more troublesome; but, with a little practice, and due attention, all confusion or difficulty of that kind might be surmounted. It is evident that a good deal more bearing wood can thus be laid close to a wall, paling, or trellis, than by the ordinary method. Nicol approves either of the horizontal or the zigzag manner being adopted on low walls or trellises; but for the grape-house he prefers training directly up the roof. It is well known that in vineyards in the wine countries, the standard vines are seldom allowed to rise higher than three or four feet. It is found, that against our walls vines grow much stronger and afford larger grapes when not allowed to exceed four feet in height. They thus enjoy the reflected heat from the earth as well as from the wall. Vines are therefore frequently placed in the low intermediate spaces between peach and nectarine trees.

133. The watering of vines in the open border, in very dry weather, is sometimes necessary; but not oftener, perhaps, than once a week. After the fruit is set, the garden-engine is occasionally used, and water sprinkled over the whole plant, this being found to promote the swelling of the berries.

134. During summer the vine may be said to be constantly in a state of pruning. This consists in the regulation of all the new shoots, selecting the bearers for next year, and displacing all lateral, straggling, and superfluous shoots. In July, when the fruit is formed, the bearing shoot itself is shortened, in order to give vigour to the bunches. The vine is seldom, by judicious gar-

deners, divested of any of its leaves, which seem in this plant almost indispensable to the health and swelling of the fruit.

135. The removal of a small ring of the outer and inner bark from the stem or principal branches, has been found to hasten the production and maturity, and increase the size and flavour of grapes; and this practice is now followed to some extent in the south-west of England. The width of the ring of bark taken out may be from an eighth to a quarter of an inch; the former being sufficient if the plant be weak, the latter proper if it be luxuriant. Care must be taken not to injure the alburnum. The proper time for performing the operation is when flowering is nearly over, and when the berries begin to be formed. In the course of little more than a fortnight, granulations of new bark make their appearance on the upper side of the incision; these gradually increase, till nature has restored the covering of bark. The ring of newly deposited bark is rough, and becomes protuberant; so that a gibbosity remains at the place. The vine-shoot swells, and becomes much larger *above* than below the incision. On vines thus treated, the berries are said to be earlier, to swell much faster, and to become larger and better flavoured, than on neighbouring vines left uncut. In England, the vine usually flowers in the open air towards the end of June or beginning of July. If the circle of bark be removed at either of these periods, the part will be covered with new bark before the ensuing winter, and no injury will be sustained by the vine. In forcing houses, the circle should not be removed till after the vine has flowered, the precise time depending on its state of forwardness. In very old vines it is not recommended that the incision be made on the main trunk, but on the middle-sized branches; and it may either be made on all the principal branches, or only on every other branch.

136. In connection with this practice may be mentioned another, not altogether new, but which has of late been brought into particular notice, in a pamphlet published in 1815 by the Right Hon. Sir John Sinclair, Bart. This consists in entirely removing the parenchymatous outer bark from the stem and principal branches, but carefully preserving the inner concentric bark. The operation is performed in November, or the beginning of December. At that season it is easily done with the common garden knife, and there is then little danger of injuring the liber. The removing of old and rugged bark from vines has long been practised, with the view of preventing the lodging of insects, particularly the red spider; but besides being insured of exemption from these, the decorticated vines are said to make stronger shoots, and the quantity, quality, and flavour of the grapes to be thereby improved. This plan has been followed for several years by Mr King, a fruit-gardener at Teddington, in Middlesex; and as his profit must depend on the quantity of grapes he raises, and the price upon their quality, it is evident that if the practice did not prove useful, it would not be continued by him.

137. Vines seldom produce bearing shoots from wood that is more than one year old, unless the old wood be healthy and well cut back. The great object therefore is, to have abundance of wood of this age in every part of the wall or trellis. The bearing shoots for the following year are commonly left with four eyes each; the undermost does not bear, and consequently only three are expected to be productive; but each of these yields two or three bunches of grapes, which grow from the new shoots of the current year, the fruit-buds being always opposite to the wood buds. Sometimes more eyes are left, and more fruit is naturally produced; but it is not only inferior in size but in flavour. The shoots are laid in about eighteen inches asunder on the wall, to give room to the side shoots. Miller, Forsyth, and Speechly, unite in recommending, for the time of winter pruning, the end of October, when the fruit is all gathered. Hitt proposes to delay it till the end of January, or beginning of February, affirming that vines cut in October make weaker shoots than those pruned after mid-winter. The shoots which were lately bearers are cut back to some good lateral shoot, and a few extended naked old branches are entirely removed, or cut back to some promising young shoots. In either case, the cut is made about an inch above the bud; and sloped backwards from it, so as to convey away the juice which may exude.

If the wounds made in the autumn or winter pruning have not fully healed over, vines are apt to bleed when vegetation commences. Various remedies have been proposed. Hitt recommends, that after wiping the part dry, it should be basted with soot or with unslaked lime. Nicol is for searing the bleeding point, and then smearing it over with hot wax. Mr Knight, from his own experience, recommends a composition of four parts scraped cheese and one part calcined oyster-shells, or lime, to be pressed strongly into the pores of the wood; the sap almost immediately ceases to flow; and if this composition be properly applied, even a large branch may be taken off at any season without detriment from bleeding.

On the open wall or trellis, grapes are very subject to the attacks of wasps. Some of the finest bunches may be saved by surrounding them with bags of crape or gauze. It may be mentioned, that bunches which have arrived at maturity only in the end of October, may be gathered by cutting off the shoots on which they grow: if these be suspended in a cool apartment, the fruit will keep for a month in a tolerably good state.

138. Early in the 18th century a kind of flued walls were first used for the forwarding, or rather for the thorough ripening of grapes, at Belvoir Castle in Rutlandshire, where Hitt, the author of the Treatise on Fruit-trees, was an apprentice: mats were at the same time thrown over the vines at night, to save them from the chilling dews and hoar-frosts that occur in April and May. Since that time flued walls, with moveable glass frames, have been much used; the same vines being brought into bearing every second or third year, and, in the intermediate time, prevented from exhausting themselves, by the removal of the flower-stalks as they appear. Glazed houses for the culture of grapes have also been formed, under the name of Vineries,—to be afterwards described. Speechly remarks, that good crops of grapes may be obtained from vines trained against walls not more than six feet high, by making use of melon-frame glasses, a temporary narrow roof being made to receive the glasses. A slight degree of fire heat, he adds, would be of great advantage; and in no situation, we may remark, would *can-flues*, such as are described in the first volume of Scottish Horticultural Memoirs, be more suitable, these being easily removed, and as easily restored when wanted again.

In a very few places in England, vines are planted in the vineyard form, in ranges, about twelve feet asunder, the shoots being trained in a horizontal direction, to a series of stakes, three or four feet high, placed along the ranges.

139. We must not omit to mention, that one sort of vine may be grafted on another, in the ordinary way: the operation, however, must be performed with great care and exactness. In this way, if a wall have been planted with kinds injudiciously selected, they may, by grafting,

be very speedily changed, preserving all the advantages of having strong well-rooted plants. In a small vinery or vine-frame, various kinds of grapes may thus be inserted on one stock. Speechly mentions a Syrian vine, which in this way produced sixteen different sorts of grapes. The principal advantage of grafting, however, is looked for in the modifying and improving of the various kinds; the weak and tender being grafted on such as are robust and vigorous; for example, the black frontignac, placed on the Syrian, is said to produce well-shaped large bunches, with berries nearly the size of those of the black Hamburgh. This Syrian vine is excellent for stocks; and by some horticulturists, seedling stocks of it, grafted with other kinds, are accounted preferable to cuttings or layers of those kinds themselves. Vine-grafts are gathered at the time of the winter pruning, from bearing branches; and they are kept sunk in light earth till the proper grafting season, which is about three weeks before the stock break into bud. Those in a hot-house must of course be grafted several weeks before those out of doors. The finer sorts are generally grafted by approach.

### *Fig.*

140. The *Fig-tree* is the *Ficus Carica* of Linné, Polygamia Diœcia; belonging to the *Urticæ* of Jussieu; it is the *Figuier* of the French. It is considered as a native of Asia, but it has been cultivated for time immemorial in the south of Europe. It was first introduced into this country in the 16th century. Two very large trees, still remaining in the Archbishop of Canterbury's garden at Lambeth, are reported to have been the first planted in England, and to have been brought hither by Cardinal Pole. They are at any rate of great age. They are of the white Marseilles kind, and still continue to produce fruit.

141. Miller introduced several new varieties of the fig from Venice: he enumerates 14 sorts as deserving of cultivation in this country; but of these little more than one-half are now in repute. Those most esteemed are the following:

| | |
|---|---|
| Brown Ischia. | Malta fig. |
| Black Ischia | Murrey fig. |
| Black Genoa. | Common blue. |
| White Genoa. | Brunswick. |
| Small early white. | Brown Italian. |
| | Black Italian. |

The *Brown Ischia* is a very large globular fruit, of a chestnut colour on the outside, and purple within; pulp sweet and of good flavour. It ripens by the middle of August, and the tree seldom fails to afford a crop.

The *Black Ischia*, also called Blue Ischia, is a very good sort. The fruit is short, of middling size, a little flatted at the crown; when fully ripe, the skin is dark purple or almost black, and the inside of a deep red: the pulp very high flavoured. The tree is a good bearer, and the fruit is ready early in September.

The *Black Genoa* is a long-shaped fruit; the skin of a dark purple, almost black, with a purplish bloom over it; the inside bright red; the pulp high flavoured. It ripens from the middle to the end of August, and the tree is a good bearer.

The *White Genoa* is a large, almost globular fruit, of good flavour; the skin thin, of a yellowish colour when ripe, and light red within. The tree is considered as rather a shy bearer.

The *Small Early White* has a sweet pulp, but without much flavour. It ripens early, and is therefore well suited to our climate: indeed it seldom fails to produce a crop.

The *Malta fig* is a small brown fruit; the pulp sweet, and well flavoured. When permitted to hang on the tree till it be shrivelled, it forms a fine sweetmeat.

The *Murrey fig*, or brownish-red Naples fig, is a large globular shaped fruit, of pretty good flavour; it is distinguished by the murrey-coloured skin. It ripens in September.

The *Common Blue* or purple fig, is of an oblong shape; the tree is a copious bearer; and the fruit ripens in the end of August.

The *Brunswick*, or Madonna, is a long pyramidal fig; the skin brown, the pulp with little flavour. Like the common blue, it is an early kind, and in this respect suited to Britain.

The *Brown Italian* is a small roundish fig, of high flavour; the skin becoming of a brown colour when the fruit is ripe; the inside red. The tree is a great bearer.

The *Black Italian* fig is likewise small and roundish; the pulp high flavoured, and of a dark red colour; the skin purple. The tree bears freely.

142. In this country, fig-trees require good walls, with south-east, south, or south-west aspects, and they occupy a good deal of space. It is proper, therefore, to select only such kinds as are likely to be productive, chiefly the four first enumerated. The trees likewise require careful management. Britain is certainly not the country for fig-trees; yet, with due attention, fresh figs matured on the open walls may grace the dessert from the middle of August to the end of October; and, by means of a fig-house, or even of dwarf fig-trees planted in front of a vinery, the season may be prolonged till December. It may here be remarked, that the fig, in a green or fresh state, being a scarce fruit in this country, is often cut into longitudinal slices at the dessert: a good deal of the flavour is thus lost. Abroad, the person who eats a fig holds it by the small end, and making a circular cut at the large end, peels down the thick skin of the fruit in flakes, the soft interior part forming only a single *bonne bouche*.

A friable loamy soil is best for fig-trees. French writers recommend light and poor soil, even sandy and gravelly; but in such situations in this country, the tree does not succeed; and in any very dry soil the fruit is apt to fall off. If, however, the soil be otherwise good, the recurrence of this last inconvenience may in general be prevented by watering and *mulching*. A free exposure to air and sun is indispensable to the perfection of the fruit.

143. In the public nurseries, fig-trees are often propagated by suckers, and sometimes by cuttings. The cuttings are taken off in autumn, sunk in the ground, and protected with old bark and haulm during winter. Neither cuttings nor suckers form nearly so good trees as those procured by layers, provided the layers be formed of bearing branches. Indeed a single plant thus procured, by *layering*, from a tree in a full bearing state, and from the bearing wood of such a tree, is worth many others.

In general, a young fig-tree is at first trained with three branches, nearly upright, this direction encouraging their rapid growth. If horizontal training be adopted, the two outer branches are afterward laid down horizontally, and from these, upright branches are suffered to rise, at the distance of a foot or sixteen inches from each other. From the central shoot, other shoots spring, and these are successively laid in horizontally, at the distance, perhaps, of two feet from each other. The mode of training, however, generally adopted in this country, and approved by the best gardeners, is the fan-shape; keeping the outer branches nearly horizontal, so as to allow ample space for laying in the central ones. In some instances they are trained in the Dutch mode, with only two low horizontals, and upright shoots from these. In a few places in England, fig-trees are trained to espalier-rails. Sometimes these trees are untied, and during the severity of winter, the branches are laid close to the ground in bundles, and well covered with straw or haulm, over which some earth is heaped. Another method of protecting them, employed both in England and France, is the erecting of two screens of reeds, one on each side of the rail.

144. The fruit proceeds immediately from the eyes of the shoots, without visible blossom; indeed, the parts of fructification are entirely within. In warm countries, two crops are produced yearly, one upon the former year's shoots, and another on the shoots of the same year. In this country, the first of these crops is the only one to be depended on; the second often makes its appearance, but the figs are little larger than peas, when arrested by the cold of approaching winter. Some gardeners direct that these young fruit be carefully swept from the branches at the winter's dressing; but a more cautious observer, Mr Smith at Hopetoun House, has found, that while he frees the trees of all half-ripened fruit, if he can save the very young fruit over winter, they afford, as might be expected, the earliest figs in the following season. While the fruit is ripening, such leaves as cover it should be braced to the wall with small cross-sticks, and not cut off, as is sometimes done.

145. In pruning fig-trees, the shoots of the former year must not be shortened, the fruit being produced at the upper part of these. When a branch becomes naked, or destitute of *laterals*, some advise the cutting it entirely out from the base; but if it be shortened, plenty of young shoots will in general be the result. Nicol remarks, that the most fruitful shoots are short-jointed, round, and not of length proportional to their thickness. The time usually chosen for pruning, is April, or early in May; but some gardeners still prefer the autumn, as recommended by Miller, when less sap issues from the wounded parts.

In preparing the trees for winter, the branches are closely nailed to the wall; and when frost approaches, coverings of bass-mat, straw-screens, or some such means of defence, are employed. Perhaps the best mode of protecting them is described by Mr Smith, in the second volume of Scottish Horticultural Memoirs. He recommends the use of spruce-fir branches, four or five feet long; these are fastened to the wall, each branch by two different points of attachment; and the tree is thus covered as equally as possible. The spruce-fir possesses this advantage, that the branches remain green over winter; and in March, when the days lengthen, the leaves begin to fall off, thus gradually admitting more and more air to the trees as the season advances. By adopting this method, Mr Smith has never failed to have good crops of figs. At Argenteuil, near Paris, the culture of fig-trees is one of the chief employments of the people. The custom there, is to protect the branches by laying them down in the earth, and keeping them covered with soil for the space of two months and a half during winter. The principal pruning is there performed in the spring, by rubbing off the superfluous wood-buds, which are pointed, and leaving the young fruit-buds or embryo figs, which are round. Careful gardeners in our own country likewise perform most of their pruning in this neat and easy way.

146. We must not here entirely pass over the subject of the *caprification* of figs. By this is meant, in eastern countries, the introducing, into the interior of the young fruit, a sort of fly or gnat, which seems to act beneficially, not only by probably carrying in pollen and dispersing it, but by puncturing the pulp, and occasioning a defluxion of nutritious juices. Impregnation is thus not only more certainly accomplished, but the ripening of the fruit is greatly promoted. Caprification is imitated in France, and also occasionally in England, by inserting straws dipped in olive-oil. It has often been remarked, that the pricking of plums or pears hastens their maturation, and renders the fruit of richer flavour. It has been proposed to hasten the maturation of figs, by cutting out circles of the bark of the tree, from near the base of the bearing branches, thus retarding or interrupting the descending circulation of the sap: as in the case of vines above mentioned, § 135, both the outer and inner bark must be removed, but great care taken not to injure the alburnum.

### *Mulberry.*

147. The *Mulberry-tree* (*Morus nigra* of Linnæus; class *Monœcia*, order *Tetrandria*; nat. fam. *Urticæ* of Jussieu) is a native of Persia; but has been cultivated in England since the end of the 16th century. It is generally trained as a standard or half-standard; in a few places it appears as an espalier; and in Scotland it is often placed against a wall. It flourishes most in a rich and deep mellow soil. In old gardens, frequently one or two large standard mulberry-trees, perhaps a century old, may be observed; and these, in the autumn, are covered with fine and large fruit. Where it can conveniently be done, grass should be sown below such old trees: notwithstanding care in gathering, the best of the fruit falls from the tree; and in this way it may be daily collected from the sward, without being injured. On this account, and because of the large size to which the tree ultimately attains, the mulberry is better suited to the lawn than the garden. The fruit ripens in September, and must be used soon after it is gathered, not keeping more than two days.

148. Young trees seldom prove fruitful; and Professor Martyn has stated the true reason, to wit, that monœcious trees, while young, bear male flowers or catkins principally, and of course produce little or no fruit. Mulberry-trees purchased from public nurseries, are not likely soon to prove fruitful, being generally layers from small stock plants, or stools, which have never fruited. The true way to procure fruitful plants, is to take cuttings, in the spring, from fruit branches of bearing trees, endeavouring to have a part of two years growth to each cutting. These may be about a foot and a half long, and planted about a foot deep, in a sheltered place: if covered with glasses, and regularly watered, they strike the more certainly. Mr Knight has observed, that by grafting a young mulberry with a cion from a bearing branch of a full grown tree, a plant is procured which will bear fruit in the course of three years. As mulberry grafts do not *take* readily in the common mode, approach-grafting (§ 70.) is to be preferred.

The fruit being produced chiefly on the young wood, no pruning is applicable to standard mulberry-trees, farther than removing cross branches which rub on each other. Wall mulberry-trees are of course treated like the peach-tree.

149. A circumstance connected with the welfare of these trees may here be deserving of notice. The leaves of the black mulberry, not less than those of the white, forming a favourite food of silk-worms, they who amuse themselves with the breeding of these insects, often go to the gardens of their acquaintances, and collect leaves from the mulberry trees, without supposing that they are doing mischief; probably the proprietor of the trees may be as little aware of the evil: but the truth is, that wherever there is a leaf, there is a bud preparing for the next year; and when the leaf is plucked off, the bud perishes. If the successive

leaves be withdrawn, it is evident that the tree must soon be exhausted, and unable to put forth buds in the spring. In this way we have seen black mulberry trees of considerable size, destroyed in a very few years. The white mulberry (*Morus alba*, L.) is often cultivated in the shrubbery; of the leaves of this, as already noticed, the silk-worm is equally fond: by increasing the number of white mulberry plants, and robbing them only moderately of their leaves, the other kind may be saved.

*Medlar.*

150. The *Medlar-tree* (*Mespilus Germanica*, Linn.; *Icosandria Pentagynia*; *Rosaceæ*, Juss.) is a native of the south of Europe, but appears to be naturalized in hedges in England, and is therefore figured in "English Botany," t. 1523. The variety now commonly cultivated is called the *Large Dutch Medlar*, the fruit of which is large, approaching in shape that of an apple. The *Nottingham Medlar*, or English Medlar, is a smaller fruit, but of a more poignant taste, and by some preferred on that account.

151. Medlars are propagated by grafting or budding the variety wished for, upon seedling medlar stocks, sometimes on hawthorn stocks. The tree is of a middling size; it is chiefly trained in standards; in a few places in espaliers. It is managed very much in the manner of the apple-tree, only the tree is kept rather more thin of wood. The flowers appear late in May. The fruit remains on the tree till the end of October, and is afterwards kept in the fruit-room till it mellow, and acquire a buttery softness, or be "rotten ripe," when only it is fit for the table. This may not take place till past mid-winter: if soft medlars be wanted more speedily, their maturation is forwarded by depositing them in moist bran for a few days.

Two or three medlar trees in the garden are sufficient, more being generally planted in the pleasure-grounds.

*Small Fruits.*

142. We now proceed to notice what are called *Small Fruits*, Currants and Gooseberries, Raspberries and Strawberries.

153. *Currants* and *Gooseberries* belong to the genus *Ribes* of Linné; *Pentandria Monogynia*; *Cacti* of Jussieu. The genus is divided into *Ribesia* or Currants, without spines; and *Grossulariæ* or Gooseberries, with spines. Currants and gooseberries are northern fruits; they seem to have been unknown to the ancient Greeks or Romans. Even yet they are not very generally cultivated in Italy or France; one obvious reason being, that these countries possess a climate suited to much finer fruits. Currants were comparatively but lately introduced into Holland; yet from the industrious Dutch gardeners have we derived improved and large-fruited varieties, both red and white, which have deservedly banished all others from our gardens.

*Red and White Currants*

154. Our common *red* currant is *Ribes rubrum* of Linnæus; and our *white* currant is merely a variety of this. R. rubrum grows naturally in different places in England and Scotland, and is figured in English Botany, t. 1289. Having been long cultivated, several improved varieties have been obtained. The kinds chiefly planted at present are, the large red; the champagne; the pale red, sometimes called grizzly; the long-clustered red; the large white Dutch; the white crystal; and the pearly. The finer and larger bunches, both of the white and red currant, are used in the dessert, particularly late in the season: more commonly, however, the red is made into a jelly, with an equal weight of white sugar; and the white is much in request for the making of wine.

Currant bushes are propagated chiefly by cuttings. These are commonly prepared early in the spring. They should consist of last year's shoots, proceeding from bearing branches, and may be from nine inches to a foot in length. They are planted in a border of light earth, about four or five inches deep. In the spring, if the weather prove dry, they are occasionally watered till the leaves be expanded. In the course of the summer, all the shoots are displaced excepting three: indeed, some gardeners prevent the growth of more shoots, by extracting, at the time of preparing the cuttings, all the eyes or buds but three. In autumn these young bushes are transplanted, and sufficient space allowed them to grow for two years, during which time, if neat bushes be wanted, they are repeatedly pruned or trained. The currant thrives best in a rich loam, and in a free situation. The usual season for transplanting is October or November. They are often placed by the sides of walks or alleys, and allowed to remain many years; but it is better to plant them in quarters by themselves, and to renew them every seventh or eighth year, young bushes yielding fruit more plentifully, and of finer quality. When considerable plantations of currant bushes are formed, much ground is occupied by them, the distance between the rows not being less than seven or perhaps nine feet. But in these spaces coleworts may be planted in October, to be used in the early part of spring, before the currant trees come into leaf. If the ground be not cropped in this way, it should lie rough all the winter.

155. Mr Macdonald, gardener at Dalkeith-House, raises currants, both red and white, of the finest quality. A good deal depends on the way in which he manages the bushes, especially during the ripening of the fruit. He prunes the bushes at the usual season of mid-winter, shortening the last year's shoots down to an inch or an inch and a half. Next summer the plants shew plenty of fruit, and at the same time throw out strong shoots. As soon as the berries begin to colour, he cuts off the summer shoots to within five or six inches before the fruit. This is commonly done with the garden shears, with which a man may go over half an acre of bushes in a day. Sun and air thus get free access, and more of the vigour of the plant is directed to the fruit: the berries are found not only to be of higher flavour, but larger than usual.

156. Currant trees are sometimes trained against a wall. Two branches are led in a horizontal direction along the bottom of the wall, perhaps half a foot from the surface of the earth, and the growth from these of all upright shoots, which will admit of being arranged at the distance of five or six inches from each other, is encouraged. The fruit is produced plentifully on spurs or snags some years old, either on wall or standard bushes; but the largest berries are afforded by young wood, and this is therefore to be occasionally supplied. On a south or south-west wall, the fruit is about three weeks earlier than on standards; and on a north or east wall, if the fruit be defended from birds, by means of netting, it will remain good till October; if matted over when ripe, it will endure even till November. Sometimes a few standard bushes are likewise matted up, and on these the fruit will sometimes hang, in pretty good condition, till the approach of frost. On espalier rails the fruit comes early, and of fine size and flavour. Currants, it may be remarked, should be gathered only when in a dry state; if collected in rainy weather, they lose their flavour.

*Black Currant.*

157. The *Black Currant* (*Ribes nigrum*, Linn.) is also considered as a native of Britain, and is described and figured as such in English Botany, t. 1291. It is very generally cultivated, though not in great quantity, in private gardens. The berries have a very peculiar taste, which however to many people is not disagreeable. In England, they are used in puddings and tarts. A well known jelly is made from them; and if a small proportion only of sugar be used, an agreeable rob is formed. The flavour of the young leaves in spring is strong; a small leaf, laid for a few minutes into an infusion of bohea tea, communicates its flavour, which has been compared to that of green tea.

The black currant bush agrees with a damp soil better than the red. The management of both is much the same; only the shoots of the black are not cut to spurs as in the red, the fruit being produced in a different way. The plants are regularly pruned every winter, from a third to a fourth part of the old or exhausted wood being cut out annually, and the straightest and best placed shoots being preserved. In summer, all superfluous growth is displaced, especially from the centre of the bushes. The black currant-tree produces more fruit as a standard than when trained against a wall; but in the latter way, the berries are considerably larger.

*Gooseberry.*

158. The *Gooseberry-bush* (*Ribes grossularia*, Linn. rough-fruited gooseberry, Eng. Bot. t. 1292, and *R. uva crispi*, L. common or smooth-fruited, Eng. Bot. t. 2057,) if not a native plant, is at least completely naturalized in this country. It often appears in woods, and not unfrequently on the walls of ruinous buildings; but to these places the seeds may no doubt have been carried by birds. The culture of this fruit has for a number of years been particularly attended to in the north-west of England; and the size and beauty of the Lancashire gooseberries have procured them the first character. In the south of Europe, we believe, the fruit is generally small and neglected; and when foreigners witness our Lancashire berries, they are ready to consider them as forming quite a different kind of fruit. In France, the gooseberry is called *groseille à maquerau*, from its being used as a seasoning to mackerel.

159. The varieties of the fruit are very numerous, perhaps not fewer than two hundred. They are distinguished by names not less sonorous, nor less fanciful and unmeaning, than those bestowed by the Dutch on their tulips and hyacinths; such as, Glory of England, Glory of Eccles, Bank of England, Nelson's Victory, &c. Many new ones are constantly coming into notice, and others are falling into neglect. They are classed according as their colours are red, green, yellow, or white. The names of a very few of each of these, which are at present most in esteem, shall be mentioned.

*Red.*

| | |
|---|---|
| Old Ironmonger, | Smooth Red, |
| Early Black, | Hairy Red, |
| Damson, or dark red, | Red Champagne, |
| Large Rough Red, | Nutmeg, |
| Red Walnut, | Captain, |
| Warrington, | Wilmot's early red. |

*Green.*

| | |
|---|---|
| Green Gascoigne, | Green Globe, |
| Green Walnut, | Green-gage. |
| White Smith, | |

*Yellow.*

| | |
|---|---|
| Great Amber, | Sulphur, |
| Globe Amber, | Conqueror, |
| Great Mogul, | Yellow Champagne, |
| Hairy Globe, | Golden-knap, |
| Golden Drop, | Royal Sovereign, |
| Honeycomb, | Tawny. |

*White.*

| | |
|---|---|
| Large Crystal, | White Dutch, |
| White-veined, | White Walnut. |
| Royal George, | |

It must be admitted, that although the large gooseberries make a fine appearance on the table, they are often deficient in flavour, when compared with some of smaller size. Many of them have very thick strong skins, and are not eatable unless thoroughly ripened. Some of the large sort, however, are of very good quality, such as the red champagne and the green walnut. Among these, also, *Wilmot's early red* deserves further notice. It was raised by Mr Wilmot at Islesworth in 1804, and has been cultivated by him very extensively on account of its valuable properties, being early ripe, of excellent flavour, and extremely productive. It usually ripens from the middle to the end of June. For culinary use in the month of May it is larger and better than most others, the skin not being tough, but the whole berry melting to a fine consistence. The gooseberry, it may scarcely be necessary to notice, is used not only for tarts, pies, and sauces, or gooseberry creams, before being ripe; but, when at maturity, it forms a rich addition to the dessert for several months.

Gathered unripe, gooseberries can be preserved in bottles against winter: the bottles are filled with berries, close corked, and well sealed; they are then placed in a cool cellar till wanted. By plunging the bottles after being corked into boiling water for a few minutes, (heating them gradually to prevent cracking,) the berries are said to keep better.

160. Gooseberry-bushes, like currants, are propagated chiefly by cuttings, preferring for this purpose clean and strong shoots of the former year, about a foot in length. They may be planted any time early in the spring. They are trained for two or three years, and should have a stem six or eight inches high. Strong suckers of straight growth are sometimes used, but they are considered as apt to produce suckers again.

In many places little attention is paid either to the soil in which the gooseberry-tree is planted, or to its pruning and management; yet the fruit is greatly improved by attention to these circumstances. The best practical gardeners now prune the bushes so as to form them somewhat like a hollow sphere; no main stem is encouraged, as was formerly done; but the centre is cut out, and eight or ten side branches preserved, according to the size of the plant. All water-shoots of the former season are removed; but any young shoots wanted for branches are left at full length. In this mode of pruning or training, the stem may be short, perhaps half a foot, instead of a whole foot. The bushes may also be planted nearer to each other than such as are allowed to rise many feet in height. They should not, however, be less than five or six feet asunder in every direction, the free admission of light and air being quite necessary. If the bushes be attended to in the month of June, and all central water-shoots and suckers be displaced, the additional light and air thus admitted, will be found very beneficial to the fruit, while the labour of winter pruning will be at the same time diminished. In many gardens gooseberry-bushes are still placed in single rows along the sides of borders; but this is not so good a plan as having a separate quarter for them. They may be planted in November, or any time before February; and the plantation should be renewed every seven or eight years.

161. The plan above described for prolonging the season of currants, by matting up the bushes when the fruit is ripe, it is still more important to adopt in regard to gooseberries, as this fruit forms a more desirable ingredient of the dessert. If some of the late yellow sorts be matted in September, they remain good till November. A few plants of the finer kinds are sometimes trained against a south or east wall; here the fruit not only comes earlier, but attains greater size than usual. They also do very well on a low espalier-rail. In some places, gooseberry-trees on the sides of the borders are trained to a single tall stem, which is tied to a stake: this, though six or eight feet high, occasions scarcely any shade on the border, and it does not occupy much room, nor exclude air; while at the same time the stem becomes closely hung with berries, and makes a pleasant appearance in that state. Some sorts of gooseberry-bushes, and those producing the largest fruit, have a natural tendency to bend their branches downwards. In this case the branches must be supported with small forked sticks, in order to admit air, and to save the fruit from touching the ground.

It may be observed of the currant and goosebery trees in general, that they are very easily raised from the seeds, these often, however, lying a year in the ground before vegetating. The seedling plants generally shew fruit in the third year of their growth, when an estimate of their merits can be formed: it is to be observed, however, that the fruit both of currant and gooseberry seedlings may improve in the fourth and fifth year.

*Raspberry.*

162. The *Raspberry-bush* is the *Rubus idæus* of Linnæus (*Icosandria Polygynia*; *Rosaceæ* of Jussieu) and the *Framboisier* of the French. It is indigenous to several parts of Britain, and is figured in English Botany, t. 2442. The styles being persistent, the fruit has a bristly appearance, from which the name *raspis*, or rasp, has been given. The fruit is very desirable both for the dessert, and for making jam, tarts, and sauces. Eaten fresh with cream and sugar, it makes an excellent supper-dish, and may be had from July to November. It also forms the chief compound in a liqueur called Raspberry Cordial, for which purpose great quantities of the fruit are reared near London

163. The varieties chiefly cultivated are the following: Common red and common white; large red Antwerp; large yellowish-white Antwerp; cane or smooth-stalked, also called reed raspberry; twice bearing white, and twice-bearing red. Some still prefer the common kinds of red and white, thinking that an increase of size in the larger varieties has been purchased at the expence of flavour; but the new varieties are, upon the whole, to be accounted preferable. The second crop of the twice-bearing kind is in general deficient both in flavour and size; but by means of it the raspberry season is prolonged till the beginning of November. It is to be particularly noticed, however, that the fruit should be regularly gathered as it ripens, and should be almost immediately used after being gathered: it will remain good on the bush for a few days after being ripe, but a dish of raspberries, kept in the house for two days, will generally be found to have lost flavour, and possibly to be tainted by maggots.

164. Sucker-shoots rising abundantly afford plenty of plants; but they should always be taken from stools in full bearing. They are planted any time from October to February. The distance is seldom less than three feet between the plants, and the quincunx order is generally adopted, five feet being left between the rows. If the larger varieties be planted, the distances are increased. A raspberry plantation continues good for six or seven years; but after the lapse of that period, it should be entirely renewed: it is generally in perfection the third year after planting; so that a new raspberry quarter should be prepared two years before the old one be grubbed up.

165. During summer raspberry-plants receive little attention. The ground is repeatedly hoed, and a few of the superfluous suckers are sometimes removed. Before winter, the ground is commonly dug and left rough. In some places the stools are dressed at this season, (November;) and a slight crop of coleworts is put between the rows. If this be not done, the general pruning is deferred till February or March, when the decayed stems of the former year are cut out, and the new ones regulated and tied: for there is this peculiarity about raspberry-bushes, that the stems which bear fruit in one year die in the following winter; leaving in their place a succession of new stems, which have been produced during the summer. Where the stools are very strong, six or eight stems are allowed to remain; but in young or weak plants, only half that number are suffered to carry fruit. At the same time, the tender tops, which have been injured by frost and hang down, are cut off. Plants pruned or dressed before winter, it may be observed, sustain most injury from frost; the old stems, when left, affording a degree of protection to the young shoots. In exposed situations stakes are found necessary for supporting the stems; but in general it is thought sufficient to twist the shoots loosely together, and to tie them at top with a strand of bass-mat: Sometimes, the tips of half the shoots on one stool are tied to half the shoots of the next; and in this way a series of festoons or arches is formed, producing a very agreeable appearance, and at the same time affording security against the highest winds.

The raspberry-bush grows freely in any good garden soil; but it is the better for being slightly moist. Although the place be inclosed by trees, and even slightly shaded, the plant succeeds. In an inclosed and well sheltered quarter, with rather a damp soil, containing a proportion of peat-moss, we have seen very great crops of large and well-flavoured berries produced; for example, at Melville House, the seat of the Earl of Leven in Fifeshire. Sometimes a few plants are trained against a west wall, or a trellis or rail, and the fruit here comes more early and of larger size. By training against a north wall, the crop is proportionally retarded.

New varieties of raspberry are easily raised from the seed; and they come to bear in the second year.

*Strawberry.*

166. The *Strawberry* (*Fragaria* of Linnæus) belongs to the same class and order, and natural family, as the raspberry; the plant is called *le Fraisier*, and the fruit *la Fraise*, by the French; and it is the *Erdbeere* of the Germans. Several *species* of strawberry are cultivated in our gardens, and many *varieties*; indeed new hybrid productions are yearly appearing. We shall mention the kinds which are at present most esteemed.

167. The *Scarlet Strawberry*, (*Fragaria Virginiana* of the Hortus Kewensis.) This is the only sort of small strawber-

ry cultivated for the Edinburgh market, a place distinguished for excelling all others in abundance and excellence of this kind of fruit. It is a native of Virginia, and very different in habit from our wood plant, the leaves being dark green, of a more even surface, the flowering stem shorter, and the fruit commonly concealed among the leaves. It is a hardy species, producing plenty of fruit on high and rather bleak situations, near Edinburgh, where the Chili strawberry does not prosper.

168. The *Alpine* (*F. collina*) is larger than our wood species, the stem higher, the leaves broader; the fruit red, (sometimes white,) tapering to a point, and of considerable size. The fruit is of excellent flavour; and being produced from June to November, the plant is well deserving of culture. The summer shoots, it may be mentioned, must not be cut off; for they flower and yield fruit the same season, and it is on this property that the autumn crop depends. From observing this, Mr Knight was led to a new mode of treating the alpine strawberry. He sows the seeds early in the spring, in pots which he places in a moderate hotbed in April. As soon as the plants have attained sufficient size, they are planted in the open ground, where they are to remain. They begin to blossom soon after midsummer, and continue to produce fruit till stopped by the frost. The powers of life in plants thus raised, Mr Knight remarks, being quite energetic, operate more powerfully than in plants raised from seeds even in the preceding year; and he therefore concludes, that the alpine strawberry might with propriety be treated as an annual plant.

169. The *Carolina* (*F. Caroliniana*) is very regular in form, and of a fine red colour; but inferior in flavour to the scarlet. It does not appear to be a distinct species.

170. The *Wood strawberry* (*F. vesca*, Lin.) has been cultivated from time immemorial, and in some places it is still preferred. It is a native of most of the woods of Britain, and figured by Sowerby, t. 1524. There is a variety with white fruit.

171. The *Pine strawberry* (*F. grandiflora*, Hort. Kew.; *F. ananas* of some writers.) The leaves resemble those of the scarlet, but are somewhat larger, and evidently of a thicker substance; the flowers also are larger, and the fruit approaches in size and shape to the Chili, being large, tapering, very pale red on the exposed side, and greenish on the shaded side. When the plants are kept free from runners, this kind is very productive of fruit, and is therefore highly deserving of cultivation.

172. The *Chili* (*F. Chiloensis*, Hort. Kew.) is distinguished by its very thick oval leaves, which, with the leaf-stalks, are set with hairs. The flowers and fruit are both uncommonly large. Some English gardeners speak slightingly of this kind, saying that it is a bad bearer: it has therefore been rather neglected. In the neighbourhood of Edinburgh, however, it proves abundantly productive: 50 Scots pints have frequently been gathered from an acre, by a single person, in the course of a day. It is the only large strawberry cultivated for the Edinburgh market, and is generally sold there under the name of hautboy. The Chili, it may be noticed, has a red berry; while the true hautboy is of a greyish colour.

173. The *Hautboy*, or *Hautbois* (*F. elatior*, Smith, *Fl. Brit.*; *Eng. Bot* t. 2197.) is remarkable for its very large oblong fruit, with a musky flavour. There is a variety called the Globe Hautboy, which is much esteemed, but apt to degenerate.

174 Of late years many new varieties have been raised from seed: Some have for a time acquired a name, and have again been forgotten: others, however, are likely to retain their character. When ripe seed is wished for, the fruit should be allowed to wither somewhat on the plant before being gathered. It may, in passing, be observed, that although, in compliance with popular practice, we term the fruit a berry, it is not such in correct botanical language: a berry (*bacca*) contains the seeds within a pulp; but here we find the seeds on the outside; it is, in fact, a fleshy receptacle, having the surface studded with the seeds.

In Covent Garden market, strawberries are sold in small pottles, the fruit having the calyx-leaf attached. In the Edinburgh market, they are sold in wicker-baskets, each basket containing a Scots pint, or four English pints, the fruit being freed from the calyx-leaves.

175. As it is generally admitted that the market-gardeners in the vicinity of Edinburgh excel in the culture of strawberries, their mode shall here be detailed.

A clayey soil or strong loam is considered as best suited to the strawberry; on a sandy or very light soil it never succeeds. Indeed, as the fruit naturally ripens in June, when drought may be expected, we might conclude, *à priori*, that a retentive soil would be much more proper for it than an open one. New plantations are formed either in September or in the beginning of April, the soil being trenched or at least deeply delved, and at the same time manured. The offsets are always taken from the runners of plants of the preceding year, in preference to those from plants of longer standing. They are placed in rows two feet distant, thus affording sufficient room for delving, or turning over the surface earth between them, a practice which is found very beneficial, both during summer and winter. Three plants are commonly put in together at each place: the distance between each stool or cluster of plants is at least fifteen inches; sometimes a foot and a half. When the weather is dry at the time of planting, they are watered every day till they be well established. For the first year few berries are produced; and the common practice is, to sow a line of carrots, or some such crop, between the strawberry rows. In May the runners are cut off, this being found to promote the swelling of the fruit. Every stool is rendered quite distinct and free from another, and the earth between them is stirred with the spade or hoe. In the dry weather of summer, strawberries are (by some careful cultivators, for it is not a general practice) watered, not only while in flower, and when the fruit is setting, but even when it is swelling off: as the berries begin to colour, however, watering is desisted from, lest the flavour should be injured.

About eighty acres in the vicinity of Edinburgh are occupied by market-gardeners, in strawberry crop, for the supply of the Scottish capital; and the amazing average quantity of 60,000 Scots pints (240,000 English) are yearly sold in Edinburgh and its neighbourhood. In a favourable season, about 75,000 Scots pints (300,000 English) have been brought to market; and it will be remembered, that the berries are freed from the calyx-leaves, which leaves in the English market greatly swell the measure. When the distance is considerable, the wicker baskets are packed over each other in a hamper-creel, and conveyed to town on a light cart hung on springs. The highest price is commonly half a guinea a Scots pint; but this is only got for a few pints at the beginning of the strawberry season: the average price is about 1s.; the lowest 9d. a Scots pint. The berries are picked as they ripen, by women and children hired for the purpose, to whom the strawberry harvest is a profitable time.

As soon as the strawberry season is past, the plants are shorn over, and all runners are again cut off. Towards the end of October, the ground between the rows is delved over. The cultivation of strawberries is thus attended with a good deal of expence, requiring much labour and constant assiduity in digging and hoeing between the plants, clearing them of weeds, cutting off runners and leaves, watering (where that is practised,) and picking the berries for market. They may, with success, be continued on the same land for an indefinite space of time, but the plants must be renewed every fourth or fifth year, and manure at that time supplied. It is however found preferable to change the crop altogether after twelve or fifteen years.

176. Strawberries are generally placed in a quarter of the garden by themselves, and it should be one which is freely exposed to sun and air. They are sometimes, however, planted in single rows, as edgings to borders, and in this way they often produce great crops. In either case, care must be taken to replant them every fourth or fifth year at farthest. The alpine and wood species may be placed in situations rather cool and shady; perhaps as an edging in the shrubbery. In such places they produce their fruit perfectly well, and late in the season, which is desirable.

177. The fruit has evidently received its English name from an old practice of laying *straw* between the rows: in clear weather, the ground is thus kept from drying too much, and less watering is requisite; while, in drenching rains, the berries are preserved from being soiled by the earth. This custom is still followed in some parts of France; and it has of late been partially revived in the neighbourhood of London, through the recommendation of Sir Joseph Banks, contained in the first volume of the English Horticultural Memoirs. When the fruit is formed, some lay tiles or moss around the plants; these answer the same purpose as straw, but certainly not more effectually, and the procuring and applying them must be attended with more trouble.

178. Strawberries are a favourite dessert fruit, and by different means they are brought to table from February till November. By various kinds of forcing (to be afterwards noticed) they are procured from February till June; they are produced abundantly in the open air during the months of June and July; and by means of the alpine and wood sorts, the strawberry season is prolonged till the end of October. The fruit should be used very soon after being gathered. If kept only for a few hours, the flavour is found to have considerably diminished. The berries are generally eaten along with cream and pounded sugar.

179. Strawberries are readily raised from the seed, and new varieties are thus procured. If sown early, they seldom fail to produce flowers and fruit in the succeeding year. In collecting the seeds, it is proper to observe that the berries be perfectly ripe, so that the seeds may be brushed from their surface, or may part with facility.

Having thus given an account of the fruits which are usually cultivated within our walled gardens, in the open air, it may be proper in this place to take some short notice of several other fruits, and nuts, which are occasionally cultivated in the garden, but more commonly in the lawns or pleasure-grounds surrounding it, or in the orchard and its environs; and likewise to mention more particularly some of the native fruits which are still gathered for use in the country.

*Fruits occasionally cultivated.*

180. The *Pomegranate-tree* (*Punica granatum*, L.; *Icosandria Monogynia; Myrti*, Juss.) is a native of the Levant, but naturalized in the South of Europe. It was introduced into England toward the end of the 16th century. At first it was treated as a delicate plant; but now it stands in the open border. It is only, however, in sheltered situations, against a south wall, and in favourable seasons, that it produces tolerable fruit: it acquires indeed a considerable size, nearly that of an ordinary pippin, but is quite deficient in flavour. The tree requires a rich strong soil; in a poor and dry soil, it will not even show flowers. To the northward of London, the fruit scarcely ever approaches maturity. A variety with double flowers is frequently planted against the sides of houses by way of ornament; and when clothed with its scarlet flowers, it is not only very beautiful, but grateful by its odour. The pomegranate is generally propagated by layers. The flowers proceed from the extremities of branches produced the same year. The stronger branches of the former year are therefore shortened, in order to obtain a supply of new shoots. The best time for this pruning is November.

181. The *Olive*, (*Olea Europæa*, L. *Diandria Monogynia*; *Jasmineæ*, Juss.) which constitutes much of the riches of the south of France, Italy and Spain, with difficulty survives in the mildest parts of our island. Protected during winter in the same way as the myrtle, generally by short litter laid around the stem, and by a slight temporary screen of evergreen branches, it sometimes flowers; and in some very warm seasons, it has produced a few unripe fruit.

182. The *Pishamin*, or date-plum, (*Diospyros Lotus*, L.; *Polygamia Diæcia; Guaiacanæ*, Juss.) is chiefly cultivated on account of its fine shining leaves. Its fruit, however, is relished by some. It is the size of a cherry, of a yellow colour, and eaten, like the medlar, in a state of over-maturity or incipient decay. The plant is tender for the first year or two; and even afterwards requires a sheltered situation, and rich but dry soil. It was known in the time of Gerarde, but is still very little attended to in gardens.

183. The *Cornelian cherry* (*Cornus mascula*, L.; *Tetrandria Monogynia; Caprifoliaceæ*, Juss.) was formerly much cultivated as a fruit-tree, and it is enumerated as such in all the old books on gardening. The fruit was used in making tarts, and a rob *de cornis* was kept in the shops. It is now transferred to the shrubbery, where its early flowers, appearing in February and March before the leaves, render it ornamental. The wood is remarkably hard; so that spears were in ancient times formed of it.

184. Besides the common apple, pear, and quince, several others of the Pyrus genus are cultivated. The *Chinese apple* (*P. spectabilis*, L.) is planted in many gardens and shrubberies in the south of England, chiefly on account of its fine show of deep red buds and large blossoms, which appear early in May. It is increased by grafting on crab stocks. Beautiful trees of this kind, some of them above twenty feet high, are to be seen in gardens in the neighbourhood of London. The *Siberian crab* (*P. prunifolia*, L.) is prized chiefly for its elegant little fruit, resembling large Duke cherries, which are very ornamental in shrubberies, in the autumn and early part of winter. The *Small-fruited crab* (*P. baccata*, L.) is planted with the same view. From the fruit of this sort, as we learn from Pallas, the quass or cider of Siberia is made; and we may add, that it makes an excellent preserve with syrup. The *Japan apple*, (*P. Japonica*, L.) blossoms and bears fruit, if trained against a south wall; but the fruit is of no value. The plant requires to be covered with a bass-matt or close straw-net during winter. The *Sorb*, or *Service-tree*, (*Pyrus torminalis* of Hort. Kew.; *Cratægus torminalis*, L.) is a large tree, growing naturally in some parts of England, as in Hertfordshire, from whence the fruit is brought to London in large quantities in autumn. It is figured in Sowerby's "English Botany," t. 298. The fruit is of the shape of the common haw, but larger; of a brownish colour when ripe; if kept till it be soft, in the same way as medlars, it has an agreeable acid flavour. It

succeeds in any strong clayey soil; it is scarcely ever cultivated as a fruit-tree, but is often planted in lawns and about orchards.

185. The *Azarole-tree* (*Cratægus azarolus*, L.; properly a Mespilus) has a still larger fruit, but does not produce it so freely, being a native of the Levant. When fully ripe, the fruit has an agreeably acid taste, for which it is so much esteemed in Italy and the south of France, that it is frequently served up in desserts. It is the *pomette* of the French. In this country it is seldom used.

*Native Fruits.*

186. Of the genus Prunus, we have several species growing naturally in our woods, and by the banks of rivers. The small black cherry or guigne, (*P. cerasus*, Eng. Bot. t. 706,) and the red-fruited variety, commonly distinguished as *Prunus avium*, have already been mentioned, as well as the common wild plum, (*P. domestica*,) which, if not native, is at least completely naturalized. To these may be added the bullace, the sloe, and the bird-cherry. The *Bullace plum* (fruit of *P. insititia*, Eng. Bot. t. 841,) when mellowed by frost, is not unpleasant; indeed it is one of the best of our native productions. It may be made into an excellent conserve, by mixing the pulp with thrice its weight of sugar. It varies with dark purple or almost black fruit, and light or wax-coloured fruit. The *Sloe* (fruit of *P. spinosa*, Eng. Bot. t. 842.) likewise requires to be mellowed by frost. To home-made wines, it is calculated to communicate the colour and roughness of red Port; indeed it is said to enter as an ingredient into the manufacture of this wine. The juice of the unripe fruit forms the German acacia. When the fruit is ripe, the juice affords an almost indelible ink, which is sometimes used for marking linens. Mr Knight (in the London Horticultural transactions, vol. i.) seems to consider the sloe as the original species from which all our cultivated plums have been derived; but on what grounds he passes over the common wild plum and the bullace, which are more nearly allied, he does not enable us to determine. The *Bird cherry*, (fruit of *P. padus*, L. Eng. Bot. t. 1383.) in Scotland the Hag-berry, is, to most palates, nauseous. The fruit is scarcely used, unless occasionally that in Scotland an infusion of it is made in the favourite liquor of the country, whisky.

187. The *Barberry bush* (*Berberis vulgaris*, L.; *Hexandria Monogynia; Berberideæ*, Juss.) is a native of various parts of this country; and is figured in "English Botany," t. 49. The fruit is in considerable demand for preserving; and the berries of the variety without stones are prepared for this purpose. If planted in good soil, and pruned somewhat in the manner of gooseberry-bushes, barberry plants yield both larger bunches and larger berries. In the shrubbery, while in flower, they are ornamental; and the sensitive stamina may afford entertainment; for when the antheræ are ready, if the bottom of the filament be irritated with the point of a knife or a straw, the stamen rises with a sudden jerk, and strikes the anthera against the pistillum. In autumn, the scarlet fruit makes a fine appearance.

188. The *Elder* (*Sambucus nigra*, L.; *Pentandria Trigynia; Caprifoliaceæ* of Ventenat,) is a well known native tree, figured in English Botany, t. 476. In Scotland it is called Bourtree. Elder berries may be included in the list of native fruits; for they are still sometimes gathered for the making of elder wine.

189. The *Mountain ash* (*Sorbus aucuparia*, L.; *Icosandria Trigynia; Rosaceæ*, Juss.; Eng. Bot. t. 337.) is perhaps the most ornamental native tree we possess. It is deservedly planted in pleasure grounds; its foliage, flowers, and berries being all beautiful in succession, and the whole tree forming a fine object. Roanberries are still held in some esteem in the Highlands of Scotland, and in Wales; and in both countries, the boughs of the tree are used in many superstitious ceremonies.

190. Of the genus Rubus, the raspberry has been already mentioned. The *Common bramble* (*R. fruticosus*, L.; Eng. Bot. t. 715.) may be added as one of our native fruits, and not one of the worst. The *Stone bramble*, (*R. saxatilis*, Eng. Bot. t. 2233.) is another: In Scotland, the fruit has a distinct name, Roebuck-berry. *Cloud-berries*, or knotberries, (the fruit of *R. chamænorus*, Eng. Bot. t. 716.) are perhaps the most grateful and useful kind of fruit gathered by the Scots Highlanders: on the sides and near the bases of the mountains, it may be collected for several months in succession. It is not cultivated without difficulty, and it very seldom yields its fruit in a garden. With this may be coupled the *Dwarf crimson bramble*, (*R. arcticus*, Eng. Bot. t. 1585.) This is found only on the highest and wildest mountains of Scotland. The berry is excellent; but it is not easily obtained in sufficient quantity; for though the plant grows freely in gardens, and shews its flowers, it rarely produces its fruit in low situations.

191. Of the cranberry (*Vaccinium*, L.; *Octandria Monogynia; Ericæ*, Juss.) there are various species, three of them native; but the most important is a transatlantic species, which however we may be excused for introducing in this place. It is called the smooth-stemmed *American cranberry*, (*V. macrocarpon*.) This is an addition made within these few years to our list of cultivated fruits. The plant was indeed known; but the opinion given in Miller's Dictionary was general, that "they can only be cultivated for curiosity in gardens, for they will not thrive much, nor produce fruit, out of their native swamps and bogs." To the indefatigable Sir Joseph Banks, we are indebted for pointing out the practicability of cultivating it for use. Wherever there is a pond, the margin may, at a trifling expence, be fitted for the culture of this plant, and it will continue productive for many years. All that is necessary is to drive in a few stakes, two or three feet within the margin of the pond, and to place some old boards within these, so as to prevent the soil of the cranberry bed from falling into the water: then to lay a parcel of small stones or rubbish in the bottom, and over it peat or bog earth to the depth of about three inches above, and seven inches below the usual surface of the water. In such a situation the plants grow readily; and if a few be put in, they entirely cover the bed in the course of a year or two, by means of their long runners, which take root at different points. From a very small space, a very large quantity of cranberries may be gathered; and they prove a remarkably regular crop, scarcely affected by the state of the weather, and not subject to the attacks of insects.

192. The native species of *Vaccinium*, which afford berries in the highlands of Wales and Scotland, are the following. The *Common cranberry*, or moss berry, (*V. oxycoccos*, Eng. Bot. t. 319.) Great quantities of this berry are gathered in upland marshes and turfy bogs, both in England and Scotland. The berries are made into tarts, and have much the same flavour as the Russian imported cranberries, or those procured by cultivation. The *Bilberry*, blaeberry, or whortleberry, (*V. myrtillus*, Eng. Bot. t. 456.) is gathered in autumn for making tarts: in Devonshire the berries are eaten with clotted cream: in the Highlands of Scotland, they are sometimes eaten with milk, but more commonly made into jellies. The *Red bilberry*, or Cowberry, (*V. vitis idæa*, Eng. Bot. t. 598,) is

acid and rather bitter, and decidedly inferior to the cranberry. It makes, however, a very good rob or jelly, which in Sweden is eaten with all kinds of roast meat, and forms a sauce for venison, which is thought superior to currant jelly.

*Nuts.*

The *Nuts* which grow in this country, and which form part of the dessert, remain to be noticed.

193. The *Hazel* (*Corylus avellana*, Lin.; Eng. Bot. t. 723; *Monœcia Polyandria; Amentaceæ*, Jussieu) is a native of Britain, and very common. In September, great quantities of the nuts are collected by the country people, and sent to market. There are several varieties, particularly the White Filberd, and the Red Filberd; the Cob-nut, remarkable for its large size; the Cluster-nut; and the Dwarf Prolific-nut. In some gardens small plantations of dwarf filberd trees are made. The trees are not allowed to rise more than six or seven feet, and they are trained, like gooseberry-bushes, open in the centre. When full grown, the cup thus formed by the expanded branches is about six feet in diameter. Each tree is twelve feet from another. The intermediate spaces are occupied with different crops that require frequent hoeing, the success of the nut trees being much promoted by repeated stirring of the ground. So great is the produce of nuts from small trees managed in this way, that in some parts of Kent such plantations are formed with a view to the supply of the London market. The trivial name *Avellana*, it may be remarked, is derived from a town near Naples, the inhabitants of which have long cultivated the Spanish filberd tree to a great extent, much of their riches depending on the sale of the nuts.

The hazel tree grows vigorously in a strong loam, or in any soil which is somewhat retentive and moist. It is sometimes propagated by suckers, but better plants are procured by layers. In this way only are the different varieties continued: by sowing the nuts, trees may be got for the thickening of a wood, or forming a coppice, but not for cultivating with a view to the fruit. A few trees of the different varieties are ornamental on the side of any bank which may occur in the pleasure grounds. Early in spring, generally about the end of February, the catkins, or male flowers, and the female gems with their bright red styles, are displayed, and make a pleasing appearance at that still dreary season.

194. The *Constantinople hazel* (*C. colurna*, L.) produces nuts which are twice the size of the common hazel nut, and grow in large racemes. It seldom, however, yields its fruit in this country, nor is it much attended to. Indeed a large bush or tree of it is seldom to be met with in our gardens. In the Botanic Garden, Leith Walk, Edinburgh, one of the finest specimens in Britain occurs: it is now (1816) about 25 feet in height, and fifty years old.

195. The *Walnut tree* (*Juglans regia*, L.; *Monœcia Polyandria; Terebinthaceæ*, Jussieu) is considered as a native of Persia, but as having come to us from France, the name *walnut* being regarded as a corruption of *Gaulnut*. The date of its introduction is not known. Large and old trees of it are very common in many parts of England, where it ripens its fruit regularly. In Scotland, however, the fruit comes to perfection only in fine seasons: in ordinary years it attains merely that state in which it is fit for pickling. Several varieties are cultivated, particularly the round and the oval walnut; the large walnut; and the tender shelled. The chief thing to be attended to in the culture of the tree is to induce it to spread its roots near the surface, and to prevent their getting down into cold wet soil. As it generally attains a large size, it must stand in the lawn or park, or a row of walnut-trees may form part of the screen of the orchard. Mr Boutcher of Edinburgh long ago recommended the inarching of a branch of a bearing tree, the quality of whose fruit was known, upon a common stock, and added, that fruit was thus produced in one-third less time. The same idea has lately occurred to Mr Knight, and in this way he has procured plants which proved fruitful in three years. It is evident that the peculiar varieties can only be continued by *layering* and grafting; for large plantations, however, the nuts are sown. The nuts are ready in October, and are gathered by beating the trees with long poles; they may be kept through the winter, by covering them with earth in the manner of potatoes, and mixing some dry mould among them to fill the interstices; for this last purpose, dry sand being preferable.

196. The *Chesnut-tree* (*Fagus castanea*, L.; or *Castanea vesca* of Brown; *Monœcia Polyandria; Amentaceæ*, Juss.) is considered as a native of the southern parts of England, where, at any rate, it has long been naturalized. It has a place in "English Botany," t. 886. It is not much cultivated for its fruit in this country. As a forest-tree it is well known, though perhaps scarcely duly prized. The variety preferred is called the Spanish chestnut. It may be proper to observe, that when fruit is the object, *grafted* trees should be resorted to. The grafting of chestnut-trees has long been practised in Devonshire, and it is now likely to become general. The stocks may be raised from the common nuts, but the grafts are to be taken from bearing branches of such trees as yield the largest and fairest fruit. The timber of these grafted trees is of little value; indeed the tree generally continues in a dwarf state: but the fruit is not only sooner produced, but is of better quality and more abundant. The nuts are not so large as those imported from Spain; but they are more sweet. They may be kept in earthenware jars, in a cellar somewhat damp, or covered with earth or sand, in the manner recommended for walnuts. The French call these grafted trees *marroniers;* and the forest trees, *chataigniers*. The chestnut is suited to the same kind of situations as the walnut-tree above spoken of.

197. The *chinquapine*, or dwarf Virginia chestnut, (*Fagus pumila*, L.) has long been known in English gardens; but the fruit is small, and has not been much attended to.

198. In this country, even in ordinary seasons, several of the fruits which have now been treated of, such as the grape, the peach and nectarine, and the fig, and more particularly the finer varieties of these, are found to be brought to greater perfection, or the trees are more effectually kept in a healthy and fruitful state, by having recourse to a certain degree of artificial heat. If this be true in the south of England, much more may it be affirmed of all that part of the island which lies to the north of York. Glazed houses, under various names, have therefore been contrived for the purpose of forwarding and defending the blossom of the trees, and the setting of the fruit, in the spring, and for ripening the bearing wood for next year in the autumn, the maturation of the fruit itself, at least in the case of peaches and nectarines, being left as much as possible to the influence of the sun and air. The vinery, the peach-house, and the fig-house, ought not, in general, to be considered as *forcing* houses; but as calculated rather to assist the natural efforts of the plant, and to make up for the imperfections of the climate, every possible use being in the mean time made of the natural climate. They may, however, be converted into *forcing* houses, by varying the time of applying the artificial heat; and in this way, not

only cherries and strawberries, but grapes and peaches, may be obtained many weeks before the natural season arrives. The pine-apple, which has not yet been spoken of, requires continually an increased, and even high temperature; while the orange tribe needs little more than to be saved from frost during winter.

The disposition of hot-houses, in regard to the garden and pleasure grounds, has been already spoken of. A suite or range of glazed houses is generally formed together, with only glass partitions between them. In this case the green-house is sometimes placed in the middle, and the stoves at each end, so that, during winter, a person may pass into either hot-house without opening a direct communication between it and the external air, which, on account of the rarefaction of the air within, is ready to rush in.

Hot-houses are comparatively of modern invention. They were unknown in the days of Gerarde and Parkinson, that is, of Elizabeth and James VI. After the civil wars, horticulture seems to have received more attention; but a glazed house, with a furnace and flues, does not appear to have been constructed previous to 1684. Sir Hans Sloane, writing in that year, mentions that Mr Watts, gardener at Chelsea Garden, then recently instituted, had a new contrivance for preserving tender exotic plants during winter: "he makes under the floor of his green-house a great fire-plate, with grate, ash-hole, &c. and conveys the warmth through the whole house by tunnels, letting in upon occasion the outward air by the windows." The green-house was thus converted into a stove, or made to answer the purpose of both. Separate houses for plants belonging to very warm climates were soon found to be necessary; and in 1724, Bradley describes a stove, or conservatory, with flues and every thing in the manner of a modern dry stove. The bark stove was soon afterwards introduced; the heat resulting from the fermentation of tanners bark being employed, however, in the culture of pine-apples before it was applied to ornamental plants of hot climates. Two kinds of stoves are at present in common use, the dry stove and the bark stove.

*Dry Stove.*

199. The dry stove is generally constructed with upright glass frames in front, and sloping glass frames by way of roof, extending perhaps to within four feet of the back wall of the house, which space of four feet is commonly covered with slates. The angle at which the glass is made to slope is usually about 35°. The floor is raised two feet above the exterior surface, in order to give room for the flues, which, if sunk low, do not draw freely. The flues are carried to the extremity of the house, and returned several times, according to the length and breadth of the building. They are constructed of fire-brick, and the covering is composed of square tiles, about an inch and a half thick. In Scotland, where sandstone abounds, the covers are usually formed of flags, two inches or somewhat more in thickness. The flagstones of the Hailes Quarry, near Edinburgh, are excellent for this purpose: the finer laminæ from the quarry at Carmylie, in Forfarshire, commonly called Arbroath pavement, are apt to crack and shiver from exposure to heat. They are generally made about 18 inches deep, and of nearly equal breadth, and horticultural writers have in general recommended these dimensions; but there can be little doubt that the breadth should be nearly double the depth. Mr Stevenson, civil engineer, founding on some experiments made in constructing a drying-house, has strongly recommended this improvement. (*Scottish Hort. Mem.* i. 143. He observes, that "the flues in general use are of too small dimensions; there is not capacity in them for allowing the heated particles of air to expand; so that the heat passes rapidly through such narrow flues, and makes its escape with the smoke, in what may comparatively be called a latent state, without being allowed to act on a surface large enough to rob it of its caloric." He farther remarks, that an apartment heated with flues of a wide, but shallow, form is less liable to sudden changes of temperature, than where the flues are small; and that such flues possess the advantage of seldom or never requiring to be cleaned. The furnace is generally so situated, as that the upper part of the arch is as high as the top of the flue, where the heat is introduced into the house. The height of the body of a furnace, of the usual dimensions, is two feet four inches, varying, however, according to the slope of the ground; the width is nearly the same; the length of it inside three feet; the door a foot square; and the length of the back of the furnace two feet. In the dry stove a stand is erected for supporting shelves, on which the plants are to be placed; the stand and shelves together being called the *stage*. In this stove all kinds of succulent plants, such as cacti, mesembryanthema, stapeliæ, and aloes, are preserved, with many other tender plants which do not require bottom heat.

It may here be noticed, that it having been found that certain parts of hot-houses, where one furnace only is employed, are not heated equally with other parts nearer to the furnace, it has been proposed to convey to these parts heated air from the furnace by means of tinned iron tubes. Nicol and others object to these tubes resting on the flues, as being apt to diminish the evolution of heat from their surface: they might, however, be carried free of them, and certainly deserve further trials. Such tubes, it is to be observed, are only necessary in hot-houses already built. In the constructing of new houses, a small flue, perhaps 2½ inches or a brick square, can easily be carried along in the back wall. Heated air drawn from the furnace into this flue can be conveyed to the opposite end of the house, and there admitted by a valve or door at pleasure. Matters must of course be so contrived, that no smoke can pass into this small flue.

*Bark Stove.*

200. The bark stove is distinguished by having a large pit, nearly the length of the house, three feet deep, and six or seven feet wide. This pit is formed with brick walls, and has a brick pavement at bottom, to prevent the earth from mixing with the tan, which would hinder its heating. It is filled with fresh tanners' bark, well dried; and in the bark, pots containing plants from the East or West Indies, or tropical climates, are plunged. The bark acquires and long retains a moderate heat; but besides this, it preserves a degree of genial moisture, well calculated to keep the fibres of the roots in constant vigour and action. Experience has shewn that a house of forty feet can be properly heated by one furnace. If thought proper, the house may be made large, and there may be two tan-pits and two furnaces, the house being divided in the middle by a glass partition. In this case a higher temperature may be maintained in the one division, than is thought necessary in the other. Over the flues a wooden grate, or crib trellis, is laid; and on this are placed the most tender of the succulent tribes, such as some of the melon-thistles, cereuses, and euphorbiums. The range of temperature which plants can endure in the bark stove is considerable, from 63° to 81° Fahrenheit, or nine degrees above and below the mark *ananas*, on the botanical thermometer. This instrument is hung in the middle of the house, at a considerable dis-

tance from the furnace, and out of reach of the sun's rays.

201. It is not uncommon to give air to such a hot-house only through the day, and to shut it up close at night, perhaps even increasing the temperature in the evening. Judicious horticulturists reverse the practice. Knowing, for example, that in the West Indies, chilly and cold nights usually succeed to the hottest days, they rather imitate nature, by shutting up the house during the day, and throwing it open at night. This practice, however, can only be followed, in our climate, in the summer and autumn seasons.

202. Forcing stoves are of modern invention. In principle, they differ in no respect from the stoves already described; their application only is different. The bark forcing stove has a tan-pit, in which pots of roses, narcissuses, and other flowers, are plunged, in order to their production at an early season. Pots with strawberries, kidney-beans, or perhaps dwarf-cherry-trees, are likewise set in the pit, or on shelves around. Sometimes small borders are formed in this bark-stove, next to the front, and also next to the back wall; a few dwarf fruit-trees are thus introduced, which yield an acceptable addition to the spring dessert. In some places, the more delicate kinds of grape-vines are here also cultivated, and trained along the rafters of the upper sashes.

Forcing stoves are intended chiefly for peaches, nectarines, vines, figs, early cherries, the best sorts of apricots and plums, sometimes apples, and occasionally gooseberries, currants, and raspberries. The whole area of the house is filled with well prepared rich compost, two feet deep. The trees, having been previously trained to near a bearing size, are transplanted into the prepared border. These stoves are begun to be worked early in the spring; and when the crop is gathered, the glass frames are opened wide, or perhaps altogether removed, in order to admit air and rain, and thus harden the annual shoots of the trees. In this open state, the houses remain till after mid-winter, when they are partially shut, in order gradually to prepare the trees for the increased temperature. Different kinds of trees require different modes of management, and also a variation of temperature: in all first-rate gardens, therefore, a separate hot-house is allotted to the peach-tree, called the Peach-house; another to cherries, called the Cherry-house; a third to the production of grapes, called the Vinery or Grape-house, and in some places, a fourth, to figs, called the Fig-house. The difference in the structure of these houses is not considerable.

203. In general it may be remarked, that what is called *forcing* is the more perfectly performed in proportion as less forcing or violence is employed. All the operations of nature are gradual; and a good gardener will always follow these as the safest examples. He will never willingly apply artificial heat before buds have naturally swoln; he will then increase the temperature gradually for some weeks; he will, in particular, guard against any sudden decrease of warmth, it being most necessary towards success, to continue the course of vegetation uninterruptedly, through foliation, inflorescence, and fructification. In all kinds of forcing, it is of importance that free admission of air be given according to the state of the atmosphere; and it too should be given and withdrawn by degrees, especially in the early and cold time of the year: the sashes, or the ventilators, may, for instance, be partially opened by 8 in the morning, top air being given before front air; full air may be allowed about 10; a reduction should take place before 3 P. M., and the whole be closed between 4 and 5, according to the season and other circumstances.

We shall now proceed to notice the peach-house, cherry-house, vinery, and fig-house, in succession; then the pine-stove and appendages; and the orangery. Here we shall take occasion to introduce a short description of the magnificent and commodious suite of hot-houses at Dalmeny Park, near Edinburgh, plans and elevations of which we are enabled to lay before the reader; and we shall subjoin some account of improvements which have lately been adopted or proposed in this branch of horticulture. The cultivation of the melon, being allied to that of the cucumber, will lead us to the kitchen-garden.

### *The Peach-House.*

204. A peach-house intended to be commanded by one furnace, is commonly made about 40 feet long, 10 or 12 wide, and about 14 in height. It has sometimes no upright glass in front; merely a parapet 18 inches high, upon which the rafters immediately rest. In some places the peach and nectarine trees are trained to a trellis next to the glass, none being placed on the back wall; in others the trees are trained only to the wall, or to a trellis placed against it; but in the greater number of cases, small trees are trained nearly half way up the glass roof, and at the same time others of full size are placed against the back wall. The flue passes in front, but at some distance from the parapet, and is returned also at some distance from the back wall; so that both flues taken together, with the space between them, occupy nearly the centre of the house. The old practice of having the back wall itself flued, is now discontinued, *standing flues* within the house being found preferable. Both parapet and flues rest on pillars, so as to allow the roots of the trees free egress to the border on the outside of the house. If early or forced fruit be wanted, the house is made narrower and shorter, so as to give a greater command of temperature. In such houses, either three or four dwarf trees, with intermediate *riders*, are planted; the riders being taken out at the end of four years at farthest. When small trees are also trained in front, three are commonly sufficient there, or nine or ten trees in all. Fire-heat is generally applied about the middle of February, the temperature being for a time kept at 45°; and afterwards gradually increased to 50° or 55° Fahr. The temperature is regulated by a thermometer every morning and evening; during sunshine, air is admitted, to keep down the heat, as near as possible, to the average point. Trees thus forced, generally shew their blossoms in March. While in flower and till the fruit be *set*, gentle steaming is practised, by sprinkling water on the surface of the warm flues. After this, washing the foliage with the garden engine is found very conducive to the health of the plants. When the stones of the fruit are formed, the temperature is raised to about 60°, and the crop is thinned, if thought necessary. Water is now liberally applied to the border. After May, little fire-heat is given, and air is very freely admitted through the day.

Mr Knight strongly recommends the exposing the fruit, when ripening, to the full influence of the sun in warm and bright days, and covering it with the glass roof during cold night air or rains. He has, in the *London Horticultural Transactions*, vol. i. p. 199, described an improved peach-house. The angle of the roof is only 28° in Lat. 52°. In order that the lights may be moved to the required extent with facility, they are made short, and divided in the middle. The back wall does not exceed nine feet high. Two rows of trees are planted; one in front, trained on an almost horizontal or very slightly inclined trellis; and the other on the back wall. The house is 50 feet long, but commanded by a single furnace.

The usual displacing of useless buds and spray, and laying in of new shoots, are operations which must, of course, be attended to, as in the management of peach and nectarine trees on the open wall.

Some of the best fruits for the peach-house are, the red magdalen, the white magdalen, royal George, noblesse, late mignone, early Newington, teton de Venus, and Catherine peaches; and of the nectarines, the Newington, the red Roman, and the violet. But all the kinds formerly mentioned, § 88. are occasionally placed in the peach-house.

*The Cherry house.*

205. The cherry-house, if one furnace only be employed, is nearly of the dimensions mentioned for the peach-house. The cherry-house is always considered and managed as a forcing-house. There is commonly a glass front between two and three feet high; thus giving room in the fore-part of the border for some dwarf trees, either cherry or fig, or perhaps apricot; the principal cherry-trees being trained against a trellis in the back wall. The flue along the front and at each end, is covered with a small horizontal grate or trellis of wood, and on this pots of strawberries or of kidney-beans are forced. For the dwarf trees in front, such as have been kept in pots or tubs for some time, are to be preferred. Forcing in the cherry-house is usually begun about the new-year; but for a month before the fire is lighted, the house is shut at night, so as gradually to accustom the plants to the confined air and increased temperature. At first the temperature is kept at 40°. Till the flower-buds appear, air is admitted, in the day-time, freely; but after this, till the season become mild, with great caution, by the upper sashes only. When the fruit is setting, in the beginning of March, the temperature is kept as steadily as possible about 50°. After it is set, water is given plentifully at the root, and also dashed over the foliage, and air is freely admitted when the weather will permit. When the fruit is colouring, little water is given, the temperature is raised, and as much air as possible is given. When the crop is gathered, the house is generally thrown quite open; in many cases, even the glass-roof is taken off. By much the best cherry for forcing is the common Mayduke.

206. The kinds of strawberries preferred for forcing, are the scarlet, the alpine, and wood strawberry. The plants undergo a course of preparation for a year before they be forced. They should always be taken from the most fruitful plants; and the offsets nearest to the parent plant are to be preferred. During the first summer, they are not only regularly deprived of all runners as they appear, but the flowers are also picked off: vigorous plants, filling the pots, are thus secured for fruiting in the following spring. If the fruit be wanted very early, the plants are placed in a hot-bed frame in the end of October, and there brought to flower, being transferred to the forcing-house when the furnace is set agoing. They generally yield ripe fruit early in March, and continue to afford successive gatherings till the end of April, making a pleasing appearance at this season, and a rich addition to the spring dessert. Water is pretty liberally supplied till the fruit begin to ripen, when it is given sparingly. It may here be remarked, that if strawberry plants which have been prepared as for forcing, be planted in front of a hot-wall, they can scarcely fail to ripen fruit early in May.

207. Of kidney-beans, the best kind for forcing is the early speckled dwarf. The beans are sown, in small pots, (called 24's or 16's,) in many sorts of light rich earth, three beans in each, and placed in the house when fire-heat is begun. As they advance, they require frequent watering, and as much air as circumstances will permit. The pods should be gathered when rather young, as in this way the plants continue longer to yield them.

*The Vinery or Grape-house.*

208. A vinery with two furnaces is generally fifty feet in length, and fourteen or fifteen in width within; the height of the back wall being ten or twelve feet, and of the parapet about eighteen inches. When one furnace only is employed, the length of the house should never exceed thirty or thirty-five feet. The parapet wall is generally supported on small arches or lintels, as already described in the peach-house, so that the vines, which are planted inside the house, may send abroad their roots in search of suitable nourishment. Sometimes the vines are planted without, and introduced through slanting apertures.

209. Very commonly the roof is formed of sashes, which can be let down for the admission of air. In a grape-house described by Mr Knight, (*Hort. Trans. Lond.* vol. i. p. 100,) the air is admitted at the ends, where all the sashes are made to slide; a free current may thus be made to pass through the house. Besides, about four feet of the upper end of every third light of the roof is made to lift up, being attached by hinges to the wood-work on the top of the back wall; and in this way, air is given in hot and calm weather, without any additional shade. Here it may be remarked, with great submission to that eminent horticulturist, that *currents* of air are seldom wanted in hot-houses; they often indeed prove hurtful. To give air, therefore, principally by means of currents seems not a good plan; for the small openings in the roof are not likely to be able to counteract the rush of cold air at the ends. In giving air to vines, it is of great importance to have a free and soft circulation: this will prove highly salubrious to the plants, while, in the same temperature of the atmosphere, a current would be hurtful.

210. In planting a new grape-house, the young vines are put in in February or March, and little or no fire-heat is given; they make strong shoots the first year, but only such as are wanted for trellis are preserved, perhaps three on each plant, and in general these are trained straight towards the roof, ten or twelve inches separate from each other. In September, if the wood be not properly ripened, a little fire-heat is given for this purpose. Next year a good deal of fruit begins to appear; but only a few bunches are permitted to come forward, in order to prove the kinds. In the third year, if well managed, they fill the roof; and if the wood be thoroughly ripened, they may be considered as established plants.

211. We shall here mention an incomparably more speedy mode of storing a new grape-house, which may be adopted wherever a vinery previously exists in the garden, or where there is a friend's vinery in the neighbourhood. This mode is frequently practised at the gardens of Dalkeith House, by Mr James Macdonald, and we have witnessed its complete success.

In the end of June or beginning of July, when the vines have made new shoots from ten to twelve feet long, and about the time of the fruit setting, he selects any supernumerary shoots, and, loosening them from the trellis, bends them down so as to make them form a double or flexure in a pot filled with earth, generally a mixture of loam and vegetable mould; taking care to make a portion of last year's wood containing a joint, pass into the soil in the pot. The earth is kept in a wet state; and at the same time a moist warm air is maintained in the house. In about a week or ten days, roots are found to have proceeded plentifully from the joint of last year's wood, and these may be seen by merely stirring the surface of the earth, or sometimes they may be observed penetrating to its surface. The layer may now be safely detached. Very frequently it contains one or two bunches of grapes, which continue to grow and come to perfection. A layer cut off in the beginning of July generally attains, by the end of October, the length of fifteen or twenty feet. A new grape-house, therefore, might in this way be as completely furnished with plants in three months, as by the usual method, above described, in three years. Supposing the layers to be made on the 1st of July, they might be cut, and removed to the new house on the 9th: by the 9th of October, the roof would be completely covered with shoots, and next season the house would yield a full crop of grapes. It is not meant that they should be allowed to do so, if permanently bearing plants be wished for: on the contrary, they should be suffered to carry only a very moderate crop, as it is pretty evident that the roots could not sustain the demand of a full one; or at any rate, that the plants would necessarily shew their exhausted state, by barrenness in the following season. By this means the more delicate kinds, as the frontignac, may be quickly propagated: we have seen layers of the Gibraltar or red Hamburgh, made in the beginning of July, reach the length of thirteen feet before the end of the month, yielding at the same time two or three bunches of grapes. The more hardy, such as the white muscadine, form still stronger plants in that space of time. Little difficulty is experienced in removing the plants from the pots into the holes prepared for them: if there be fears of preserving a ball of earth to the new roots, the pots may be sunk with them, and then broken and removed; or the plants may be kept in the pots till autumn, when they may very easily be taken out of them without detriment. Mr Macdonald's experience does not lead him to think that plants propagated in this way are less durable than those procured by slower means, and where the roots and branches bear a relative proportion to each other. But supposing they were found to be less durable, it is evident that one may thus very easily keep grape-houses constantly stored with healthy fruit-bearing plants, and that the kinds may be changed almost at pleasure. When it happens that too much bearing wood has been trained in, the plants are relieved, and sufficient sun and air admitted, by thus removing two or three shoots; and supposing these to contain each several bunches of some fine sort of grape, they are not lost, but may be ripened, by setting the pots on the side-shelves, or flue trellis, of the pinery, or any hot-house.

212. The proper management of the grape-house has now become an important part of the duty of a gardener. To lay down particular rules in this place is impossible; a few general hints only can be given. A great deal of useful information on this subject may be found in the excellent Treatise on the Culture of the Vine, by Mr William Speechly, London, 1789; and in the Forcing Gardener, by Mr Walter Nicol, Edinburgh, 1809. These and similar books the gardener should study, as containing the results of experience; but many cases will occur, in which he must depend on his own practical knowledge, and be guided solely by his own judgment.

The forcing of the earliest grape-house is often begun in January. Till all the buds be broke, air is daily admitted by the sashes, and the heat is kept moderate, so that the thermometer may indicate only 50° or 55° in the mornings and evenings, when the sun has no influence. The temperature is then gradually raised, in the course of a fortnight or three weeks, to about 70°. When the flowers appear, it is increased nearly to 75°, and the house is frequently steamed, by sprinkling water on the flues, or on the walk when the sun shines, grapes being found to set best in a strong moist heat. The gardener now selects his bearing wood for next year, and trains the shoots to an upper trellis, a foot above the other, and the wires of which are perhaps two feet apart; while he nips off all lateral and superfluous produce, and at the same time shortens the bearing shoots at an inch beyond the uppermost cluster. While the berries are swelling, water is moderately given. Nicol, indeed, recommends, that it should be given liberally till they begin to ripen; but this has been considered as likely to deprive the grapes of their proper raciness and flavour.

The thinning of the bunches deserves attention. This is sometimes neglected; but in many kinds, without this attention, the berries in the middle of the bunch are apt to get mouldy and to rot; and in all cases where thinning is practised, the berries become larger and more equal in size. In the operation of thinning, particular care should be taken that the left hand, with which the bunch is held, be kept cool, and also quite free from perspired matter. For this purpose, the gardener should have a vessel with pure cold water beside him, into which he may now and then dip his hand, to keep it cool and clean. Without this precaution the berries oftener suffer from being handled, acquiring a rusty diseased look, and not swelling freely.

When the grapes approach maturity, all are agreed that no more watering is proper. Air, however, is freely admitted. In general, a proportion of the foliage, especially on the stubs on which the clusters hang, is removed. The fruit ought to remain till it be fully ripe; but this the impatience of the owners seldom permits. When the fruit is all gathered, the stubs which bore it are cut off, and the new shoots are let down from the upper trellis to their proper places. Watering both of border and foliage is now resumed, and the house is usually left fully exposed to the atmosphere. The general pruning is performed from the middle to the end of October, and time is thus given for the healing of the wounds before forcing be again commenced. At this pruning the loose part of the outer bark on the old wood is carefully peeled off, and the whole plant and the trellises are washed with some penetrating liquid, calculated to destroy the minute eggs of insects. For about a fortnight after this severe pruning the house is kept shut, but it is afterwards freely exposed as before.

The management of the late grape-house entirely resembles that of the early, making due allowance for the difference of season. It is not intended for *forcing* the fruit, but merely for supplying the deficiencies of our natural climate in spring and autumn.

As the vinery may remain without its glass-covers for many months in the year, in some places, especially in the south and west of England, the peach-house is formed exactly of the same dimensions; and, when the peach season is over, the glass frames are transferred to the vinery, and, if the blossoms have escaped, a crop of ripe grapes, of the best sorts, is thus procured in September or October, and the new wood is thoroughly ripened.

### *Fig-House.*

213. The fig-house is generally constructed on the same plan as the cherry house, with fig-trees on the back wall trellis, and either dwarf figs, cherries, or apricots in front, the flues being likewise covered with a small trellis for holding pots of strawberries or kidney-beans. A separate hot-house, however, is but seldom erected for the cultivation or the forcing of figs; a few dwarf trees, such as the

brown Italian, and purple Italian, introduced into the peach or cherry house, being by most people thought sufficient. It has been found by experience, that dwarf standard fig-trees, planted in the middle of a vinery, between the flues, and so under the shade of the vines, bear fruit plentifully, ripening both the spring and autumn crops. This may be seen in the vinery which forms a part of the splendid range of hot-houses at Preston Hall near Edinburgh, designed by Mr John Hay.

*The Pinery.*

214. Three sorts of frames, pits, or houses, are required for the successful or extensive culture of the pine-apple: a bark pit, for nursing the crowns and suckers; a low stove, generally called the succession pit, where the plants are kept till they be ready for fruiting; and a pine-stove or fruiting-house.

215. The *Pine-apple* is the *Bromelia ananas* of Linnæus. (belonging to the class and order *Hexandria Monogynia*, and to the natural family *Bromeliæ* of Jussieu.) Some have supposed it to be a native of Africa; but Linnæus considered it as a Brazilian plant. It was introduced into this country as a curiosity about 1690; and Bradley has preserved to us correct information concerning its first cultivation for the sake of the fruit. In 1724, Henry Telende, gardener to Sir Matthew Decker, at Richmond, had forty ananas, which ripened their fruit by means of the artificial heat arising from the fermentation of tanner's bark; and by the year 1730, pine-stoves, of various kinds, were established in all the principal English gardens.

The name *pine-apple* seems to be derived from the general resemblance of the fruit to some large cone of a pine-tree. The fruit may be described botanically as a kind of pulpy scaly strobilus, composed of a number of coadunate berries. In richness of flavour it cannot be surpassed; and it is one of the greatest triumphs of the gardener's art to be able to boast, that this fruit can be produced in Britain in as high perfection as in a tropical climate. Its culture is however very expensive, the plants requiring constant attention for at least two years, very commonly for three.

216. The following are the most approved varieties:

| | |
|---|---|
| The Queen pine. | The King pine. |
| Brown sugar-loaf. | Green pine. |
| Striped sugar-loaf. | Black Antigua. |
| Montserrat. | Black Jamaica. |

The *Queen pine* is perhaps the most common in this country, and in Europe, as it is the hardiest. The fruit is of an oval or rather tankard shape, of a yellowish colour, but the pulp pale. It grows to a large size, sometimes weighing 3lb.

The *Brown sugar-loaf* is of a pyramidal or conical shape, with a yellow or straw-coloured pulp, and brownish leaves. The plants may be distinguished by the leaves having purple stripes on the inside throughout their whole length. The fruit also grows to a large size. Its juice is accounted less astringent than that of some other varieties, and consequently it may be eaten more freely.

The *Striped sugar-loaf* is so named, from its green leaves being striped with purple; in one sub-variety they are prickly, in another smooth. In colour and flavour, the fruit resembles the Queen pine, and it is nearly as hardy.

The *Montserrat pine* is distinguished by the leaves being of a dark brown, inclining to purple on the inside; and by the pips or protuberances of the fruit being larger and flatter than in the other kinds.

The *King pine* is a large fruit, first raised in this country by Miller; its leaves are of a grass green colour; the pulp is hard, and rather stringy, but of good flavour when ripe.

The *Green pine* is not common; when ripe, the fruit is of an olive hue.

The *Black Antigua pine* is shaped like the frustum of a pyramid. The leaves of the plant have a brownish tinge, and fall down; they have strong prickles, thinly scattered. The pips of the fruit are large, often an inch over; it attains a large size, weighing sometimes 3lb. or 4lb.; it is of a dark colour till it ripen; very juicy, and high flavoured.

The *Black Jamaica* is likewise a very large kind, and similar in habits and character to the black Antigua.

217. In gardens of the first order, the pinery is now generally placed in a detached situation, and the three kinds of pits or houses above mentioned conveniently form a continuous range or suite by themselves; the fruiting-house, being higher in the roof, occupies the centre, and the nursing pit and succession house are placed to the right and left.

218. The *nursing pit* is commonly about three or four feet high in front, and between seven and eight at the back wall, or the difference between the height in front and in rear does not exceed one-third of the breadth, whatever that may be. The front and roof are of glazed frames. These pits are generally furnished with small flues; but as a much less degree of heat (from 55° as the minimum, to 65° or at most 70° Fahr. as the maximum) is required in these than in the fruiting-house; sometimes no flues are employed, the heat being trusted entirely to the fermentation of a dung hot-bed, lined when necessary. When flues are used, tree-leaves or tanner's bark are still proper for receiving the pots, and equalizing the heat.

The pine-apple is propagated, by planting either the crowns or tufts which grow on the fruit, or by the suckers which appear on the fruit-stalk, or which proceed from the base of the plant. The crowns are therefore in general returned to the gardener, after having been presented at table attached to the fruit; and they are kept four or five days longer, till the place of separation be healed over or dried; they may however be almost immediately planted, if the parent plant have not received water perhaps for a fortnight before, in order to heighten its flavour. The stocks also from which fruit has been cut, if thought of superior quality, may be encouraged to set out many suckers, by plunging them in a hot-bed, and regularly watering them; such suckers making excellent plants.

Some writers give nice and curious directions for forming a compost for pine-apple plants; but vegetable mould, such as rotted tree leaves afford, may be considered as perfectly good. Even kitchen garden mould which has not been exhausted, answers very well. If old pasture soil be used, it should be mixed with well rotted dung, and laid in heap for a year before being used, during which time it should be repeatedly turned. The pots used for crowns and suckers are three inches in diameter, inside measure, and 4½ deep, for the smaller plants; 4 inches in diameter, and 6 deep, for the larger; but it is much worse for the plants to have pots too large than too small. Dry shivers or chips of broken pots, or clean gravel, to the depth of an inch, are placed in the bottom of the pots. No water is given for a few days, till the plants shew signs of growing. The principal potting is naturally in July and

August, after the fruiting season. Next April, or as soon as the growing season has fairly commenced, the plants are shifted into larger pots, 5 inches in diameter within, and 7 deep. They are shaded by a canvas sheet for a few days, at least during sunshine; and when the plants begin to grow again, water is given both at root and over the leaves with a fine rosed watering-pot. During winter, it may here be remarked, water is given only once a week, or even seldomer; and it is kept for some time in the pit or stove before being applied. To the roots of young plants, dunghill drainings are sometimes supplied. Minute rules for admitting air are laid down by Speechly, Macphail, Nicol, and Abercrombie: these should be studied by the gardener; but much must still depend on his own experience and sagacity.

219. The *succession pit* resembles in structure the nursing pit. In this, during the second autumn and winter, the plants are kept merely vegetating. If they be maintained in health, it is not expected that they should increase in size, unless perhaps that, having more room, they may swell at bottom: the temperature therefore is kept rather lower than in the nursing pit. When plants are shifted into this, which is commonly when they are about a year old, the business should if possible be completed in one day. The pots now used are 24's, or 7 inches across, and 9 deep. Any injured parts of the roots are carefully cut off, and a few of the oldest or lowest leaves are removed.

220. In the *fruiting-house*, more room, greater height, and at the same time a higher temperature, are required. The pots here used are from 8 to 10 inches in diameter, and 10 inches deep. In the bottom of these fruiting-pots, it is better to put half rotted grass-turf than shivers or gravel. From the time that the plants begin to shew fruit, the temperature is not suffered to fall below 65° Fahr.; it is kept generally at 75°, or at least above 70°: in sunshine it is allowed to rise to 85°, or even 95°, as fresh air can thus be more freely admitted. Water is given very cautiously, sufficient only to keep the plants healthy, but not to injure the flavour of the fruit. Pine-apples should be cut a short time before they attain complete maturity, or be dead ripe. When the fruit changes colour, in most varieties when it becomes greenish-yellow or straw-coloured, and when it also diffuses its peculiar odour to some distance, it may be considered as fit for cutting.

221. A clearer idea of the course of culture, in the nursing pit, succession pit, and fruiting-house, may perhaps be obtained from the following compendious view of the operations, suggested by Abercrombie, in which specific days or months are assumed, merely in order more distinctly to mark the anniversary or relative periods.

NURSING PIT.

1816. Aug. 15. Crowns or suckers planted.
—— Oct. 30. If the plants, from rapid growth, require more room, some are removed to another pit, and the remainder set at increased distances.
1817. Mar. 30. Such plants as need it, are shifted into larger pots. Plants of the same standing are now distributed to houses where the treatment differs, as the plant is expected to fruit at the end of two or of three years. It may be noticed, that the large varieties, such as the black Antigua and black Jamaica, always require three years culture; and that crown and fruit-stalk suckers are seldom so forward as those from the base or root of the plant.

| *Three-year fruiting plants.* | *Two-year fruiting plants.* |
| --- | --- |
| NURSING PIT *continued.* | SUCCESSION PIT. |
| 1817. May. Plants intended to complete a year in this pit, are repotted; having the ball of earth shaken away, and the old root-fibres pruned off. | 1817. Mar. 30. Forward plants from the nursing pit are put into larger pots, and brought for culture here. |
| | —— May or June. Succession pines are sometimes intermediately shifted without disturbing the balls of earth. |
| SUCCESSION PIT. | |
| —— Aug. 15. Plants that have been in the nursing pit the previous year, are shifted and transferred to this house. | |
| FRUITING HOUSE. | FRUITING HOUSE. |
| 1818. Aug. 15. Plants which have remained one year in the nursing pit, and a second year in the succession pit, are removed to this house. | —— Aug. 15 Plants from the succession pit, after being only *one* year in the first and second stages, are shifted into the largest pots, and placed here. |
| 1819. Aug. 1 Such plants ripen their fruit. | 1818. Aug. 1. Such plants afford fruit fit for cutting. |

222 Success in the culture of this fruit, it may be remarked, very much depends on two circumstances; on giving them plenty of room in the nursery pit and succession frame, so that the lower part of the plant may swell out and increase in bulk, without being drawn up; and on keeping the fruiting plants in a continued healthy or vigorous state: for this last purpose, early in the spring the tan of the fruiting house should be stirred, and a fresh quantity intermixed, so as to raise a new fermentation and accompanying heat. In the different pine-stoves it is found very advantageous frequently to white-wash the plaster, and to repaint the wood work.

223. The plants, especially if weak or not healthy, are subject to the attack of a small species of coccus (*C. hesperidum*, Lin.) commonly called the pine-bug. The insects adhere closely to the leaves, often near the base, and seem almost inanimate. Mr Miller recommends turning the plants out of the pots, and cleaning the roots; then keeping them immersed for four-and-twenty hours in water in which tobacco stalks have been infused: the bugs are then to be rubbed off with a sponge, and the plants, after being washed in clean water and dripped, are to be repotted. Mr Muirhead, a gardener in the north of Scotland, has described a similar mode, (*Scottish Hort. Mem.* vol. i. p. 209,) only in place of tobacco juice he directs flowers of sulphur to be mixed with the water. With a bit of bass-mat fixed on a small stick and dipt in water, he displaces as many of the insects as he can see. He then immerses the plants in a tub of water, containing about 1 lb. of flowers of sulphur to each garden-pot full. They remain covered with the water for twenty-four hours, as desired by Miller. They are then laid with their tops downwards, to dry, and are repotted in the usual manner. What share of the cure, in either of these ways, may be due to the sulphur or to the tobacco liquor, does not clearly appear; the rubbing off or loosening the insects is evidently important; and it is not unlikely that immersion, in simple water, so long continued, may alone be sufficient to destroy them. Indeed, the experience of one of the best practical gardeners in Scotland (Mr Hay) leads him to conclude, that even moderate moisture is destructive to these insects. During many years, he regularly water-

ed his pine-plants over head with the squirt, during the summer months: this was done only in the evening; it never injured the plants; and the bug never appeared upon them.

*The Orangery.*

224. This is merely a green-house, and indeed is generally employed in part for protecting ornamental plants and shrubs. In a few places the orange trees are planted in the border soil, in the manner of shrubs in a conservatory. The genus *citrus* includes not only the orange, but the shaddock, lemon, citron, and lime: it belongs to the class and order Polyadelphia Polyandria, and natural order Aurantiæ of Jussieu. In warm countries the trees rise to the height of perhaps fifty feet; here they seldom exceed the size of shrubs. The species may readily be distinguished by the petiole or leaf-stalk: in the orange and the shaddock, this is winged; in the lemon, citron and lime, which are considered as varieties belonging to one species, it is naked. The orange and shaddock fruits are almost spherical, and of the yellowish-red colour known by the name of orange; the lime is spherical, but of a pale yellow; the lemon is oblong, with a nipple-like protuberance at the end; the citron is oblong, and distinguished by having a very thick rind.

225. Of the *Orange* (*Citrus aurantium*, Lin.) there are two principal varieties; 1. The sweet orange, including the China orange, the Portugal orange, and similar kinds; and, 2. The bitter orange, including the Seville orange, and other varieties called *bigarades* by the French. The Seville orange-tree produces its fruit more readily in this country, and has larger and more beautiful leaves than the China orange: the former is therefore more generally cultivated, but the latter also succeeds very well in some places. There are, besides, the willow-leaved or Turkey orange, the dwarf or nut-meg orange, the double-flowering, and many other varieties, some with the leaves variegated yellow and white.

Sir Francis Carew is said, by Mr Lyson, (*Environs of London*, vol. i.) to have introduced orange-trees into this country, in the reign of Elizabeth; but whether he brought plants, or raised them from the seeds of oranges brought home by Sir Walter Raleigh, is not clear; it may be remarked, however, that it has long been known from experience, that in this climate orange plants raised from seed shew no inclination to produce fruit; whereas Sir Francis Carew's yielded plenty of fruit. What is further curious in the history of these early orange trees is, that they were planted in the open border, and protected during winter merely by a moveable shed. They grew on the south side of a wall, not nailed against it, but at full liberty to spread; they were 14 feet high, and extended about 12 feet wide. They were finally cut off by the great frost of 1740, after having stood a century and a half. Professor Martyn informs us, (Miller's *Dict.* in loco), that they had, the year before, been inclosed in a permanent building like a green-house; and he very justly remarks, that the dampness of new walls, and the want of the usual quantity of free light and air to which they had been accustomed, might probably have killed them, even had the great frost never occurred.

226. The orangeries of this country are supplied in two ways; either by plants raised from the seed, and budded, inarched, or grafted by our nurserymen and gardeners; or by small budded trees imported in chests from Italy.

The best stocks are common citrons, this tree making strong straight shoots, and receiving readily either orange or shaddock buds; they are procured by sowing ripe citron seeds. Next to these, Seville orange stocks are desirable; the seeds may be taken from rotten Seville oranges, which are generally the ripest. They are sown in pots sunk in a bark hot-bed, and, about two months afterwards, each plant is transferred to a small flower-pot, about five inches in diameter. They are gradually hardened, by admitting air, till the end of September, when they are transferred to the green-house for the winter. Next spring they are forwarded, by being again plunged in a moderate hot-bed; but after midsummer they are hardened as much as possible, and in August they are ready for budding. The buds should be taken from trees in a bearing state, and which are known generally to afford a good crop, preferring buds from round shoots to those from flat shoots. The plants are again preserved in the green-house through the winter; and in the following spring, they are once more planted in a gentle hot-bed, the stocks at the same time being cut off about three inches above the buds: By this means, the stem of the future tree generally grows up straight in one season.

Trees raised in the way now described, require no less than fifteen or sixteen years to attain the size of those imported in boxes from the Mediterranean. The latter, if they be good plants, if they have not suffered greatly from the voyage, and if they be properly managed on their arrival, will bear fruit in three or four years. But it is chiefly the shaddock and citron that are thus imported. Those stocks which have two buds inserted in them, it is observed, make finer heads than such as have one only. To recover the trees after their being so long out of the earth, requires some care and attention: they are planted in fine vegetable mould, in pots having channel to the depth of some inches in the bottom, so as to drain away superfluous moisture, and are placed in a hot-bed; at the same time, hay bands are wrapped round the stems, to prevent the sun's rays from over-drying the bark.

227. Young orange trees are every season repotted, generally in April, for successive years, till they produce fruit. The earth or compost must be prepared at least a year before, so that any dung mixed with it may be very completely rotten. When the trees become large, that is, six or eight feet in height, they are generally planted in wooden cases or tubs. When old orange trees have been mismanaged, it is found very useful to plunge them into a hot-bed: this is accomplished by planting them in baskets, and sinking these into the bed. The baskets are made of less size than the tubs, and when the trees are restored to these, the baskets are cut away, and the empty space filled with prepared earth. It is a rule to remove, every season, a considerable portion of the earth, taking great care not to injure the roots; its place is supplied with a fresh quantity of the prepared soil.

228. In the orangery, during winter, the trees receive regular but moderate watering, and as much free air as the nature of the season will permit. In May, they are removed to the open air: the place should be sheltered from high winds, and it is found best that the plants should be exposed only to the morning and afternoon sun, and shaded from the mid-day glare and heat. Here they remain till about the middle or near the end of October. They produce their pure white and very fragrant flowers in June; and after the first season of flowering, blossoms and fruit are seen together on the same plant, the latter remaining a year or fifteen months on the tree before it be ripe. The clusters of blossom and fruit are thinned progressively, as there seems to be occasion.

In different places of England, Seville orange trees have of late been planted in the open border, in emulation of Sir Francis Carew's trees, and covered during winter with moveable glass frames. It is found generally indispensable, however, that the walls should be flued, and that some slight fire heat be in this way afforded during severe frosts. The bottom of the border on which orange trees are planted must absolutely be dry; it is necessary, therefore, to lay at least two feet of lime rubbish, or some similar material, beneath the border soil.

229. The *Shaddock* (*Citrus decumana*, L.) is the pampelmous of the French, Delaunay however describing the *chadec* as a large variety of *C. aurantium*: the denomination *Shaddock* was given from the name of the English officer who first conveyed the plant from the East to the West Indies. It is managed like the orange tree, but is somewhat more tender, and must be treated accordingly. In a well-arranged orangery, however, and under the care of a judicious gardener, it produces large and ripe fruit. Even in Scotland this is the case; as at Woodhall, near Hamilton, the seat of Mr Campbell of Shawfield.

230. The *Citron* (*Citrus medica*, L.) is also cultivated like the orange; but being rather more tender, must be less early exposed in the spring, and sooner put under glass in the autumn. The summer situation should be the warmest and most sheltered in the garden. There are several sub-varieties of the citron, particularly one with very large fruit, the *poncire* of the French.

231. The *Lemon* is generally budded or inarched on a citron stock. Its culture is the same as that of the orange; but it is more hardy than that species, and requires more free air during winter. It should also be watered somewhat more liberally. In some parts of England, lemon-trees succeed very well in the open border against south walls: they are sheltered during winter by moveable glass frames, and produce plenty of large fruit, making a pleasant variety on the wall.

232. The *Lime* is propagated and treated much in the same way as the lemon.

233. Having thus given a general account of forcing houses, or hot-houses for producing fruit, taken separately, we shall now describe a range or suite, and at the same time shall illustrate what we say by reference to the plans, elevations, and sections, contained in Plates CCCX. and CCCXI. The magnificent suite of glazed houses represented in the former Plate, it will be observed, is by no means ideal, but exists in the garden of Dalmeny Park, the seat of the Earl of Rosebery near Edinburgh; and the accuracy of the plans may be relied on, Mr Hay, the designer employed at Dalmeny, having, with permission of the noble proprietor, favoured us with them. We shall at the same time give a short description of the garden, and particularly of the walls, as illustrative of some improvements in this branch of horticulture introduced by Mr Hay.

234. The garden at Dalmeny Park lies on the face of a bank having a considerable declivity to the south and southeast. It is bounded on the north by a low hill crowned with trees, perhaps about 40 years old; on the west, by rising ground with trees of the same standing; and on the east, by hollow marshy ground, likewise covered with trees. On the south flows a little rill, the bed of which terminates the slope on which the garden is placed: from this lowest point the ground rises gradually to the south, to some height. Part of this rising ground on the south side of the streamlet is included within the ring fence which surrounds the garden, and is laid out in shrubbery and parterres; through these the walk from the house to the fruit-garden is conducted. The soil of the lowest part consists chiefly of bog or peat earth, admirably adapted for the growth of American shrubs, such as rhododendrons and kalmias. The garden contains about two Scottish acres within the walls. The fruit-tree borders are 18 feet wide, and the walks seven feet broad; the soil beneath the gravel of the walks was prepared with the same care as that of the borders. The walls in general are 14 feet high; the east wall is somewhat more. They are built of bricks manufactured at Leven in Fife, and regular bricklayers were brought from Newcastle for the purpose of rearing them. The whole extent of the south wall, 361 feet in length, is flued, the heat being supplied by twelve furnaces placed on the north side of the wall, six on each side of the central door. The tops of the furnaces are covered with flags, which are on the same level as the soil of the garden; and the stock holes or entrances to the furnaces have hatchway covers, in which are two ventilators to admit air. In this way the furnaces produce no disagreeable appearance. The trees on this wall may, at the same time, be covered with the osnaburg canvas mentioned in § 84. From the corners of the walls, where they meet at right angles, a wall is extended diagonally about 17 feet. This extension is found very useful in breaking the force of the wind when ranging along the walls. At the same time it does away in a considerable degree the formal box shape of the garden, when viewed from the higher grounds in the neighbourhood. The apex of the projecting wall is rounded: here a jargonelle pear-tree is planted; the branches are trained to both sides of the wall, and the fruit of course ripens at different times.

235. The contrivance for watering or washing the foliage of the wall-trees in this garden deserves particular notice. Water is supplied to the garden from a reservoir, situated on an eminence a considerable height above the garden walls. Around the whole garden, four inches below the surface of the ground, a groove between two and three inches deep has been formed in the walls, to receive a three-quarter-inch pipe for conducting the water. About 50 feet distant from each other are apertures through the wall, two feet and a half high and ten inches wide, in which a cock is placed, so constructed, that on turning the handle to either side of the wall, the water issues from that side. It has a screw on each side, to which is attached at pleasure a leathern pipe, with a brass cock and director, roses pierced with holes of different sizes being fitted to the latter. By this contrivance all the trees, both outside and inside the wall, can be most effectually watered and washed in a very short space of time, and with very little trouble. One man may go over the whole in two hours. At the same time, the borders, and even a considerable part of the quarters, can be watered with the greatest ease when required. The conveniency and utility of this contrivance must at once be perceived by every practical horticulturist. The same plan of introducing water is adopted in a garden which Mr Hay planned and executed for Lord Viscount Duncan at Lundie House near Dundee; and, after the experience of several years, it has been greatly approved of. The water at Lundie is conveyed to the garden from a considerable height, and is thrown from the point of the director with great force and to a good distance. A sketch of the cock, pipe, and director, is given in Plate CCCX. Fig. 6; *a* the cock; *b b* the leathern pipe; *e* the director.

236. In the middle of the north wall of the garden is the great range of hot-houses, consisting of seven, a central one, and three on each side. The entire suite extends from east to west 181 feet. The elevation of this fine range is seen in Plate CCCX. Fig. 2. The houses differing considerably in breadth, the eye is not offended with monotonous uniformity; and the addition of a central door, with a diamond-trellis arch, ornamented with tender and

showy climbing plants, is a great improvement in point of appearance. The ground plan of these houses is given at Fig. 1. of the same Plate. The middle division A, with those on the right and left of it, B and C, are peach-houses. On the back wall are placed trellises, to which the principal peach-trees are trained. Small trees are also trained on low sloping trellises in the front, over the flues. The farthest east division D, is what is called a *Double Peach-house;* peach trees being trained on the back wall as in the other houses, and likewise in front on a wire trellis on the roof of the house, reaching upwards as far as the first or under sash only. The trees on the front part of the house may be forced before those on the back wall. To accomplish this, the upper sashes of the house are kept off, thus admitting air freely to the trees on the back wall; while meantime the front trees are inclosed within the first two returns of the flues, by means of moveable shutters made for the purpose, one of them being placed on hinges, and used as a door. Hence the name of Double Peach-house. The partition remains only until the fruit be set; at which time it is removed, and the roof-sashes put on. By these means the fruit season in this house is protracted a considerable time, perhaps a month or more. Fig. 5. in Plate CCCX. is a section of this double peach-house.

The other three divisions of the range, E, F, G, are grape-houses. The back walls are all covered with trellises. A vine is planted in the middle, and trained on the trellis at the top of the house, where in general there is plenty of light in the early time of forcing. The lower part of the trellis is covered with fig-trees, which, as already mentioned, § 213. have been found to succeed very well in such situations. Fig. 3. Plate CCCX. is a section of division F.

In all the houses of this suite, air is given by moving the upper sashes by means of weights and pulleys placed in a cavity in the back wall, as seen at *a a a*, in the sections, Figs. 3, 4, and 5.

Into each of the hot-houses is introduced a three-quarter-inch pipe, coming from an inch one, which passes along the back of the walls. The cocks are of the same kind as those in the walls already described; and the directors, when screwed upon them, water the houses with very little trouble, and are exceedingly useful in keeping under the red spider, and other insects.

237. On the north side of this range, opposite to the middle hot-house, is a mushroom-house, constructed on Oldacre's plan, (to be afterwards described). It has a large and a small pit, with four shelves on the back wall, and three shelves on each of the two ends, all of which may be used for the purpose of raising mushrooms, either at the same time, or in succession. The large pit is partly filled with earth, and kitchen vegetables are kept in it in time of severe frost. Sea cale can also occasionally be forced in this pit. Fig. 4. Plate CCCX. is the section of the mushroom-house, and also of the middle peach-house, the ground plan of the mushroom-house being at H, and of the peach-house at A.

238. On the east side of the garden is situated the melon ground. The garden wall is extended on the north of it to the length of 152 feet, of the same height as the other walls, and flued like the rest of the wall having a south aspect. The pine-stoves are situated here. The ground on which they stand falls considerably from north to south. The furnaces are placed on the south side of the stoves; and, on the same side, there is a narrow nursing pit, four feet broad, the whole length of the house. This pit may, at pleasure, be divided, at the furnaces, into three divisions, D, D, D. The glass-roof of the pit covers the top of the furnaces, and from thence heated air is introduced, by means of apertures with dampers, into either pit as it may be wanted. Heated air can also be admitted from the stove to the small pit, by means of openings in cast iron doors, which can be shut when required. When still more of the warm air is wished to be communicated from the stove to the small pit, the doors are made to lift out altogether, and as the front flue of the stove passes these doors, the heated air has free access to rush in; or it can be admitted from the vacuities between the flue and front wall. As the tan in the small pit is of no great body, and cannot long maintain its heat, the front of the pit is built of brick, with pillars and holes similar to a pigeon house; and there is an inclosed space in front of it, to receive a lining of warm dung, when the heat is wished to be increased. This lining is covered over with flooring, which forms part of the walk, tends to prevent the dissipation of the heat, and gives the whole a neat and clean appearance.

The spaces over the top of the furnaces can at pleasure be converted into distinct or separate forcing places, by putting in the covers of the dampers, and fixing two wooden divisions across, at the extremities of the furnaces. In these places, potatoes may be forced in early spring; or, if a taste for fine flowers be indulged, the single and the double Cape jasmine, (*Gardenia florida*, L.) which are not easily brought to blossom, may here be made to flower, by placing the pots among wet mosses, (*hypnums*,) the moist heat thus supplied proving very congenial to the plant. From the spaces over the top of the furnaces the heated air can at pleasure be directed into either of the two succession houses, being admitted by removing one or other of the covered dampers at *d*, *d*, Fig. 1. Plate CCCXI.

There are niches along the back wall of the pine-stove, nearly opposite to the middle of each sash. They are narrow on the outside, but are bevelled inwards to at least double their exterior width. The bevelled sides are plastered, and covered with a trellis; on these, grape vines are trained, the principal shoot, after reaching the roof, being conducted down the rafter, as far as the first row of pine plants in the back of the pit. To these recesses two sets of shutters are adapted, one for the outside, the other for the inside. During winter the outer shutter is removed, and the inside shutter employed. The vine, after being pruned, is led without, and fixed there during winter, exposed to the cold of that severe season. When brought in to be forced, the inner shutter is of course removed, and the outer shutter put in. The time of forcing these vines may thus, in a great measure, be regulated by the gardener, and made to suit the conveniency of the family. Fig. 1. Plate CCCXI. is the ground-plan of this pine-stove. A is the first succession-pit, containing nine sashes; B the second succession-pit, with ten sashes; and C the fruiting-pit, with eleven sashes. Fig. 2. is the elevation. Fig. 3. is the section; and it will be observed, that, for the sake of distinctness, this section is drawn to an enlarged scale, nearly double that employed in drawing the ground plan and elevation of the stove, Plate CCCXI. At *k* is a moveable gangway, eighteen inches broad over the glass roof of the narrow pit, for giving access to the front of the stove. It may be mentioned, that there are two returns of the flue beneath the pathway at the back of the pit. The heated air is drawn from between these two flues by means of cast metal covered dampers, *b*, *b*, &c. in Fig. 1,; the covers being only put on while the workmen are changing the tan in the pit, or on similar occasions. The small holes seen in the back wall of the ground plan, Fig. 1. *a a*, &c. communicate with the cavities of the flue on the side next to the back wall. Those seen in the *curb* or back wall of the tan-pit *c c*, &c. communicate with the cavity of the flue next to it; and those in the path-way *b b* with the cavity between the flues. In this way, heated air is drawn from the sides of the flues at thirteen places on the back wall of the house, and at ten places on the *curb* of the pit.

The line *e f g h i*, Fig. 3. in Plate CCCXI. extended to the north wall, shews the declivity of the ground on which the pine-stoves are placed. Nearly opposite to the door in the back wall of the pine-stove, there is a door in the garden wall, leading to the pine-shed, where the plants are kept in time of shifting. In front of the pine-stoves, it may be noticed, are situated the general forcing-pit, the melon-pits, and the cucumber frames.

Before leaving the subject of glazed houses, we may notice some improvements which have of late years been proposed.

239. Mr Knight remarks, that where sunshine and natural heat do not abound, the form which admits the greatest quantity of light through the least breadth of glass, and which affords the greatest regular heat with the least expenditure of fuel, must be the best. It is evident that the sun's rays ought to fall as perpendicularly as possible on the glass roof; because the quantity of light which glances off without entering the house, must be inversely proportionate to the degree of obliquity with which it strikes upon the surface of the glass. Mr Knight made many experiments to ascertain by what elevation of the roof the greatest quantity of light can be made to pass through it; and he found that in latitude 52°, the best angle of elevation is 34°. But it cannot be denied, that the rays of the sun will fall, in a directly perpendicular direction, on this inclined plane, only twice in the year, and then for only very short spaces of time: at all other periods, they must fall in an inclined direction, and never perpendicular to the plane of the glass. Without expecting, therefore, that the rays will ever fall precisely perpendicular upon it oftener than twice in the year, it is of importance that they should do so as much as possible, during those periods when the influence of the sun is most desired. Mr Knight, (in *Hort. Trans. Lond.* vol. i. p. 100.) and the Rev. Mr Wilkinson (same volume, p. 162.) do not agree as to the proper inclination of the glass-roof: instead of 34°, proposed by the former, the latter would have the angle 45°. It seems unnecessary to detail the reasons assigned by either writer.

240. It has been remarked by Sir George Mackenzie, that if a form for the glass roof can be found, such that the rays will be perpendicular *to some part of it* during the entire period of the sun's shining, not on two days, but on every day of the year, that form must be considered the best. This form is to be found in the *sphere*; and he proposes the quarter segment of a globe, or a semi-dome; though, to catch the sun at all times, the segment would have to correspond with the greatest segment of the circle which the sun describes. He does not propose to bring each pane of glass into the form of a small segment of a sphere; this would not only be expensive, but unnecessary. The size of a glazed house of this kind, can scarcely, with propriety, exceed a radius of fifteen feet, that is, thirty feet of length for training. The plan, elevation, and section of a vinery, constructed on the principles thus suggested by this ingenious and scientific horticulturist, have been published by the London Horticultural Society, in the second volume of their Transactions; and in Plate CCCXII. we have given these, with considerable improvements since made by the author. It has been found, that the frame for the glass-roof may easily be formed of ribs of hammered iron; each rib consisting of three slips of iron, such as shewn at full size at Fig. 4. The ribs are fixed in an iron plate at the bottom. The distance between them at the base, is about fifteen inches; and when the gores contract to half that width, every alternate rib may stop. The word *gore*, we may remark, is that commonly used for a slip of any material, so cut, as when joined to others, to form a globe or any round figure. The frame-work might also be made of wood; but the wrought iron is not only much cheaper at first, but far more durable. The under frames may be about thirteen feet high; they are rivetted into an iron ring at top, and made fast all round to the coping and upright wall. Iron rods may be placed for supports at *x*, *x*, *x*, *x*, Fig. 3. if thought necessary. The width of the panes at the bottom is about a foot, diminishing to six inches at the second set of ribs; when they begin again at one foot, and contract upwards to four inches. Air is admitted by sliding shutters, which may be glazed, if thought proper, in the parapet wall in front; and also by wooden shutters, moving on pivots, and opened or shut by means of cords along the back wall; and by windows in the pediment roof. The glass-roof itself is immoveable; but the upper part of it may be made into moveable sashes, if required, by forming a sufficient number of ribs with grooves, and fixing stay rods on the under sashes, to receive the upper ones when let down; and Sir George Mackenzie mentions, that, from viewing the structure of the roof of Short's old observatory at Edinburgh, he is convinced that the glass semidome might be made in two parts, and placed on rollers, so as to expose, at pleasure, every plant in the interior to the direct influence of the sun. If it is wished at times, to defend the plants from the sun, a *gore* of canvas may be so contrived as to cover one-half of the glass. The general appearance of such a house (as seen in the elevation, Plate CCCXII. Fig. 1.) is doubtless highly elegant; and it seems pretty evident, that several such houses, tastefully disposed in a garden, would have a much finer effect than one great range, although the latter must necessarily be more economical. Mr Knight, we understand, highly approves of this invention, and is of opinion that it will answer every purpose, better than any form hitherto contrived.

242. It may here be mentioned, that Mr Robert Fletcher, at Bonnyrig, near Edinburgh, a good many years ago, constructed a grape-house, in the form of a regular polygon of 24 sides, having a base 24 feet in diameter. A thin brick wall, two feet high, passes around, forming the proper angles: on this wall rest the couples which support the central or flat part of the roof, which is eight feet in diameter. An iron ring connects the couples at the base as well as at the top. The length of the couples is 10 feet 3 inches. Between these are glazed sashes, 3 feet wide at base, and tapering to 1 foot at top. In this way the ceiling is 8 feet 6 inches from the ground, and the sashes incline at an angle of 40°. The door of the house is to the north; the furnace close by one side of the door; the flue makes a circuit around the house at the distance of 2½ feet from the wall, and the smoke escapes on the other side of the door. Air is admitted, as wanted, by means of three ventilators on the south-west side; but in point of fact air can pass in by many crevices, particularly at the flat part of the roof, and no putty has been used in glazing. The brick wall being founded merely on the surface of the ground, the roots of the vines pass under it in any direction. The soil is dry and rather shallow. In the end of June, Mr Fletcher forms a heap of vegetables, commonly the weeds from his garden, in the centre of the floor of the house: when this heap begins to decompose, some degree of heat is produced, a good deal of vapour rises, and nutritious gases are exhaled: the heap is occasionally fed, so as to keep up the fermentation till about the middle of September. In this house, and under this sort of management, has this ingenious person, for a number of years, raised very good crops of grapes of different sorts, particularly the black Hamburgh, the Lombardy, and the white sweetwater, the berries of all these kinds becoming large and of high flavour.

243. It may also be noticed, that Mr Henderson, nurse-

ryman at Brechin, has constructed a small hot-house, which he styles the *triple meridian*. The narrow end of it is placed to the south, and the roof, which is ridge-shaped, is inclined in the same direction, by a slope of one foot in six. In consequence of the position of the house, one side has the sun's rays approaching to perpendicular at 9 A. M. and the other at 3 P. M.; and, on account of the slope to the south in the roof, the sun's rays are enjoyed partially all the time he is above the horizon. Air is admitted by ventilators. After several years trial, Mr Henderson has found such a construction to answer all his expectations.

If melons be the crop raised, no furnace is necessary. In place of fire heat, the warmth arising from the fermentation of weeds, or a mixture of grass and rushes, is sufficient; proper chambers for holding these, and enabling them to communicate their heat, being prepared within this house. The employment of refuse vegetables in such a melon-house, or in Mr Fletcher's grape-house, must operate as a premium for the destruction of nettles, thistles, and other weeds.

244. At Lord Mansfield's garden at Scone in Scotland, the hot-houses are constructed on a new plan, inasmuch as they have no *upright* front glass, and all the sashes are *fixed*, or not calculated to slide up and down. Air is admitted by ventilators in front, and at the top of the back wall. The houses are 12 feet high; the back wall two feet higher, or 14 feet; and the front or parapet wall only two feet. The advantages of this plan seem to consist in saving the expence, at first, of upright wooden rafters or pillars, and in preventing the breakage of glass, which must to a certain extent be occasioned by the moving of sashes up and down. But it is not to be concealed, that these immoveable sashes are attended likewise with some disadvantages. A liberal circulation of air is sometimes necessary to the health of the young fruit, which, without it, drops off at the time of the first swelling; and an equable exposure to the air is highly important for communicating flavour to peaches and nectarines when just approaching to ripeness. Air admitted, however, only by openings in the front parapet and in the top of the back wall, must in some measure form currents, which, as formerly remarked, (§ 209.) are seldom desirable. Even in avoiding injuries to the glass, the advantages cannot be very considerable, particularly if the moveable sashes be drawn up and down in a steady manner by means of pulleys and weights. Whoever erects a house with a glass roof, must of course lay his account with occasional accidents, whether the roof be fixed or moveable, and one would be apt to think, that the repairs of panes accidentally broken on fixed roofs, could scarcely be accomplished without very considerable risk of increasing the damage, in clambering over them with ladders.

*Gathering and keeping of Fruits.*

245. Fruits in general should be gathered in the middle part of a dry day: not in the morning, before the dew is evaporated, nor in the evening, when it begins to be deposited. Plums readily part from the twigs when ripe: they should not be much handled, as the bloom is apt to be rubbed off. Apricots may be accounted ready when the side next the sun feels a little soft upon gentle pressure with the finger. They adhere firmly to the tree, and would over-ripen on it. Peaches and nectarines, if moved upwards, and allowed to descend with a slight jerk, will separate if ready; and they may be received into a tin cup or funnel lined with velvet, so as to avoid touching with the fingers or bruising. If this funnel have a handle two or three feet long, the fruit may be gathered with it from any low or ordinary wall. The old rule for judging of the ripeness of figs, was to observe if a drop of water was hanging at the end of the fruit; a more certain one is, to notice when the small end becomes of the same colour as the large end. The most transparent grapes are the most ripe. All the berries on a bunch never ripen equally; and it is therefore proper to cut away unripe or decayed berries before presenting the bunches at table. Autumn and winter pears are gathered, when dry, as they successively ripen. The early varieties of apples begin to be useful for the kitchen in the end of June; particularly the codlins and the jenneting; and in July they are fit for the dessert. From this time till October or November, many kinds ripen in succession. The safest rule is to observe when the fruit begins to fall naturally. Another easy mode of ascertaining, is to raise the fruit level with the foot-stalk; if ripe, it will part readily from the tree: this mode of trial is also applicable to pears. A third criterion is to cut up an apple of the average ripeness of the crop, and examine if its seeds have become brown or blackish; if they remain uncoloured, the fruit is not ready for pulling. Immature fruit never keeps so well as that which nearly approaches maturity; it is more apt to shrivel and lose flavour. Winter apples are left on the trees till there be danger of frost: they are then gathered on a dry day.

In all cases the fruit is plucked with the hand, and great care taken to avoid bruising. For collecting the fruit from half standard and full standard trees, a step-ladder is employed. This ladder may be so contrived that the back shall come away by removing a bolt. The same ladder may thus be used for high wall-trees; but in this case two rods of iron should be made to project six or eight inches from the top, to keep it from resting on the branches of the trees, and injuring them.

246. Hitt's method of keeping pears may be shortly mentioned. Having prepared a number of earthen-ware jars, and a quantity of dry moss (different species of hypnum and sphagnum,) he placed a layer of moss and of pears alternately till the jar was filled; a plug was then inserted, and sealed around with melted rosin. These jars were sunk in dry sand to the depth of a foot; preferring a deep cellar for keeping them, to any fruit-room.

247. Miller's plan may also be noticed. After sweating and wiping, in which operations great care must be taken not to bruise the fruit, the pears are packed in close baskets, having some wheat-straw in the bottom and around the sides to prevent bruising, and a lining of thick soft paper to hinder the musty flavour of the straw from infecting the fruit. Only one kind of fruit is put in each basket, as the process of maturation is more or less rapid in different kinds. A covering of paper and straw is fixed on the top, and the basket is then deposited in a dry room, secure against the access of frost, "and the less air is let into the room, the better the fruit will keep." A label should be attached to each basket, denoting the kind of fruit; for the basket is not to be opened till the fruit be wanted for use.

248. Mr James Stewart, an experienced gardener at Pinkie, in Scotland, has long preserved his choice apples and pears in glazed earthen-ware jars, provided with tops or covers. In the bottom of the jars, and between each layer of fruit, he puts some pure pit sand which has been thoroughly dried on a flue. The jars are kept in a dry airy situation, as cool as possible, but secure from frost. A label on the jar indicates the kind of fruit; and when this is wanted or ought to be used, it is taken from the jars, and placed for some time on the shelves of the fruit-room. The less ripe fruit is sometimes restored to the jars, but with newly dried

sand. In this way he preserves colmarts and other fine French pears till April; the terling till June; and many kinds of apples till July, the skin remaining smooth and plump. Others, who also employ earthen-ware jars, wrap each fruit in paper, and in place of sand use bran.

249. Mr Ingram at Torry in Scotland, a very intelligent gardener, has succeeded uncommonly well in the management of the fruit room. For winter pears he finds two apartments requisite, a colder and a warmer; but the former, though cold, must be free of damp. From it the fruit is brought into the warmer room as wanted; and by means of increased temperature, maturation is promoted, and the fruit rendered delicious and mellow. Chaumontels, for example, are placed in close drawers, so near to a stove, that the temperature may constantly be between 60° and 70° Fahr. For most kinds of fruit, however, a temperature equal to 55° is found sufficient. The degree of heat is accurately determined, by keeping small thermometers in several of the fruit-drawers, at different distances from the stove. The drawers are about six inches deep, three feet long, and two broad; they are made of hard wood, fir being apt to spoil the flavour of the fruit. They are frequently examined, in order to give air, and to observe the state of the fruit, it being wiped when necessary. Mr Ingram remarks, that, in Scotland particularly, late pears should have as much of the tree as possible, even although some frost should supervene; such as ripen freely, on the other hand, are plucked rather before they reach maturity.

250. Winter apples are generally left on the trees till there be danger of frost. They are then gathered, when dry, as formerly noticed; and are laid in heaps, and covered with mats or straw, or short grass well dried. Here they lie for a fortnight or more, to *sweat*, as it is called, or to discharge some of the juice of their skin, which thus contracts in a certain degree. After this they are wiped dry with a woollen cloth, and placed in the fruit-room. Sometimes, when intended for winter dessert fruit, they are made to undergo a farther sweating, and are again wiped and picked; they are then laid singly on the shelves, and covered with paper. Here they are occasionally turned, and such as shew any symptoms of decay are immediately removed. Baking fruit is kept in a close but cool place, where the temperature undergoes little variation. It is found to be advantageous to keep each sort separate. Sometimes apples and pears for baking are kept in baskets or hampers. Thick paper is considered a better material for lining and covering such baskets or hampers than straw, and straw is better than hay.

It may be proper to mention, that some entirely disapprove of the sweating of fruit, affirming that it thereby acquires a bad flavour, which it retains, or at any rate that the natural flavour of the fruit is deteriorated. They consider it better to carry the fruit directly from the tree, carefully avoiding all sort of bruising, and to lay it thinly on the shelves of the fruit-room; afterwards wiping, if it appear necessary. The room, they say, should be dry; but the only use that should be made of a stove is, to take off the damp.

As connected with the forcing department, we now proceed to speak of the culture of the melon under frames placed upon a hot-bed.

### *Melon.*

251. The *Melon* is the *Cucumis Melo*, L.; *Monœcia Monadelphia*; and belongs to the natural order *Cucurbitaceæ*; The genus cucumis affords the rich melon for the dessert; the cucumber well known for its cooling qualities; and the coloquintida of the apothecaries. The water-melon, the squash, and the pumpkin, belong to the same natural family, but to a different genus, Cucurbita, distinguished chiefly by the swelling rim of the seed. The melon has been cultivated in England since before 1570; but the precise period of its introduction is uncertain.

252. Many are the varieties of this fruit, but a few only are worth cultivating: particularly different sorts of Cantaleupe, the Romana, Polignac, oblong ribbed, rock, Portugal, and Salonica. The largest kinds are in general of inferior quality, being valuable chiefly to the market gardener, who finds his advantage in having a large and shewy fruit, rather than one whose only merit consists in being high-flavoured.

The *Cantaleupes* are well known, and generally cultivated. In most of them the outer coat is rough and warty. The fruit is of middling size, rather round than long. There are several subvarieties: one has a greenish pulp; another and more esteemed sort has the pulp of an orange colour: there is likewise a scarlet and a white cantaleupe; besides the black rock cantaleupe, and the netted cantaleupe, the last possessing excellent qualities. The cantaleupe has received its name from a seat of the Pope near Rome, where the fruit was either originally produced, or is supposed to have been so.

The *Romana* is an early melon, small in size, but of fine flavour; and the plants are very plentiful bearers. There are two or three subvarieties, of which the large netted Romana is the best; it is of an oval shape, high-flavoured, and at the same time very solid and ponderous.

The *Polignac* is a rich-flavoured fruit, pretty generally cultivated.

The *Oblong ribbed*, sometimes called the musky melon, is of agreeable flavour, and the plants produce abundantly.

*Rock* melons, or carbuncled melons, are of different sorts; with green pulp, scarlet pulp, black and silver rock.

The small *Portugal* melon is an early variety, not destitute of flavour, and it is produced very plentifully.

The *Salonica* melon was little known in this country till recommended by Mr Knight. Its form is nearly spherical, and without any depressions on its surface; its colour approaches that of gold, and its pulp is pure white. It is allowed to remain upon the plant till it be completely matured, for it improves in flavour and richness till it become quite soft, and even shew symptoms of incipient decay. The consistence of its pulp is nearly that of a water melon, and it is very sweet. A full grown specimen of the fruit generally weighs about 7lb.

253. In the cultivation of the melon, it is a matter of much importance to procure proper seed. Some gardeners are so scrupulous on this point, that they will not sow the seeds, unless they have seen and tasted the fruit from which they were taken. It is proper at least not to trust to seeds which have not been collected by judicious persons. Some make it a rule to preserve always the seeds of those individual specimens which are first ripe, and even to take them from the ripest side of the fruit. A criterion of the goodness and probable fertility is generally sought by throwing them ino a vessel containing water; such as sink are considered as good and likely to prove fertile; those that float, as effete. It is remarked of seeds brought from the continent, that they must have more bottom heat, and the young plants less water, than are necessary for seeds ripened in this country, or young plants sprung from these.

The seeds are seldom sown till they have been two or three years kept; from this age till they be five years old, they succeed very well. The plants produced from such seeds are not so luxuriant, and are therefore more tractable and more prolific. The cause is supposed to be, that the albumen of the seed is deteriorated by the keeping, and the plants thus starved, in a certain degree, at their first germination; the fruitfulness of plants in general being promoted by checking their luxuriance. When gardeners intend to sow seeds which have been kept only for one year, they are in the practice of carrying them for some months in the pockets of their small clothes; the warmth from the body being found to promote the desirable maturation or siccity. If, on the other hand, the seeds have been kept for many years, steeping them for some days in weak oxymuriatic acid (chlorine) might probably tend to excite germination.

254. The seeds are sown at two or three different periods of the season; the first sowing taking place early in February, the next about the middle of March, and another later. They are sown in broad shallow pans, or in common flower-pots sunk to the brim in a small hot-bed, called the seed-bed, covered with a one-light frame. Here the temperature is kept as near as possible to 65°; a little air is given in the day time, but during night the frame is closed, and covered with single or double mats, according to the state of the weather. When the plants are about an inch and a half high, they are pricked into nursing pots, three in each, and placed generally in an intermediate frame of two lights, till they shew one or two of their rough leaves, when they are ready for final transplanting.

255. The melon ground, or quarter in which the melon beds are formed, should have a dry bottom, a free exposure to the south, and be sheltered from the north and east. It is desirable also to have it inclosed by a hedge of yew, beech, holly, or privet; and it is an advantage to keep it under lock and key, no kind of plants being so apt to be disordered or injured by the curiosity of ignorant intruders. In many places, the melon ground is formed in the slip, or on the exterior of the garden; and where this is the case, there is generally a cart access, which, considering the quantity of stable-dung required, proves very convenient.

256. The soil or compost for melons is prepared at least a year before it be used, and, like other composts, it is frequently turned over and thoroughly mixed. Two-thirds of fresh hazel-coloured loam, from the surface of an old pasture, and one-third of rotten cow-dung, or of the remains of old hot-beds, form an excellent soil. This compost is generally passed through a screen; but there is no need for its being made very fine.

257. The site of the hot-beds is scooped out to the depth of a foot, that the surface and lights may be kept low. The bed is generally made between three and four feet high, and the back four inches higher than the front. Stable dung and litter are the usual ingredients of these as of other hot-beds; but some use tanner's bark, in which case it is necessary to have a brick pit, or a strong wooden frame erected. The earth is not put on till the temperature become steady and moderate, which it generally does in the space of a week. The beds are covered with large frames, each having three sashes or lights. These are generally about four feet wide, and six feet in length; but sometimes they are made eight feet in length, by three feet wide.

258. In some places, pits are built with brick in the following manner. After the size of the glass-covers is fixed upon, and supposing that a three-light pit is intended, the brick work is made 3 feet 6 inches deep on the fore-side, and 4 feet 6 inches or 5 feet on the back; the bottom part all around, to the height of 2 feet 6 inches, is built with small openings, the more numerous the better: for this purpose no mortar is used in this part of the building; but above it, mortar is used; the walls are the thickness of brick on bed. If three such pits be required, they are placed one in front of another, at the distance of three feet: the whole is surrounded with a wall, the top of which is six inches higher than the open building of the pits, and so far sunk as that the height may not appear offensive to the eye. The pit is filled with tanners' bark or tree-leaves to a little above the open building, and covered with earth as in the common way; and the vacant space around the outside of the pit, to a little above the open building, is filled with stable dung, or with weeds, in the season when these are to be had; for either of them, in fermenting, produces a sufficient degree of heat. When the heat of this lining is abated, and when a continuance of increased temperature is required, the exhausted matter is removed, and a new lining supplied. It may be proper to add, that the eave of each pit should have a small spout to carry off the water, otherwise the lower side of the bed is apt to become too damp.

259. In laying on the earth on the bed at first, a hillock or ridge is formed in the middle, somewhat more than a foot high, the covering in all other parts of the bed not exceeding two inches in thickness. In the beginning of March the young plants are transferred thither with great care, the breaking of the fibres or bruising of the roots being very detrimental. Some are for transplanting as soon as may be, after the unfolding of the third leaf, or in other words the first true or rough leaf; but the more general plan is, to allow two or three of the rough leaves to shew themselves before transplanting. Others put the plants in separate flower-pots for a few weeks, and afterwards turn them out, with all the earth attached, into the melon frame. One plant to each light is generally sufficient, especially of the cantaleupe, or larger melons; but most cultivators put two plants; and some even crowd three under each light. When four leaves are expanded, the top is by many pinched off, in order to promote the setting out of lateral shoots or runners; but some allow the first shoots to extend the length of five or six joints before *stopping* them. Afterwards the points of these lateral shoots are pinched off, to encourage the putting forth of subordinate shoots, from which fruit is to be looked for. But all shoots that are either very luxuriant or very weak are equally useless, and may be removed. A few reed stalks are often spread thinly over the surface of the beds, for the shoots to run upon.

When the plants have established themselves, earth is gradually added, and pressed close down, till the other parts of the bed be almost on a level with the spots on which the plants are situated. This thick layer of earth has one great advantage; it renders very little watering necessary. When water is given, it should scarcely touch the leaves. The heat is regulated by keeping a Fahrenheit's thermometer within the frame; which should as nearly as possible indicate 70°.

If the beds be in good heat, the frames are generally filled with runners in six weeks, and by this time the roots will have extended to the extremities of the beds. Linings are now added; and these being covered with soil, well trodden down, the roots penetrate into it, and thence draw additional nourishment; while, at the same time, the linings assist greatly in keeping up the heat.

260. As there is little opportunity under a glass-frame for the wind to perform its part in conveying the pollen, careful gardeners generally assist by taking off some fully expanded male flowers, and laying them or shaking them over the female flowers, which are situated on the crown of the embryo fruit. Even without fecundation, fruit will

be produced; but it never acquires perfection, and the seeds of such fruit will not germinate. The different varieties of melons, it may be remarked, should not only be kept in distinct frames, but, if possible, at some distance from each other, to lessen the chance of the pollen of one kind accidentally reaching the stigma of another. One fruit is selected on each principal runner, preferring that which is nearest the stem, or has the thickest footstalk; this is encouraged, while the rest are picked off. If the melon be a small-sized variety, sometimes two are permitted on a shoot. It is a general rule, not to leave more than four or five fruit on each plant, if of the larger kinds; or eight or ten, if of the smaller. A more correct way of estimating, perhaps, is to allow each plant only to carry 20 lb. or 30 lb. weight of fruit. It may be mentioned, that where late melons are wanted, an easy way to procure plants is to take some of the superfluous shoots of the first crop; for the plant grows freely by cuttings.

If water be now given, it should be introduced without touching the stems, leaves, or fruit; it is seldom needed more than once a week, even in dry and warm weather. Great attention is requisite in allowing the plants free air as often as possible. Some have contrived bent tin pipes, connecting with the open air, and passing through the body of dung, by means of which a current of slightly warmed air is introduced even in the worst weather. When the weather happens to be very cold, mats are laid over the frames.

261. In the southern parts of Britain, melons are also raised in hot-beds. The plants are at first under hand-glasses; but the shoots or runners are allowed to spread from under the glass, and cover the hot-bed as the season advances. The beds are hooped over, and when heavy rains threaten, they are closely covered with mats. Frames of oiled paper answer very well for the raising of melons. A kind of paper made from parings of skins, and used for packages, under the name of *leather-paper*, is stronger than common paper, and can easily be made so as to possess equal transparency. The leather-paper seems excellently adapted for the purpose.

A piece of clean tile is introduced below each fruit; and during the course of its swelling, it is not uncommon to turn it gently once a week, that both sides may be equally exposed to the sun's rays. But it should not be oftener turned, for fear of twisting and injuring the fruit-stalk, and so preventing the conveyance of nourishment through it. At this time very little water is given, dryness tending to heighten the flavour, and air is as freely admitted as the weather will permit. When the leaves press against the glass, the frame is raised two or three inches; but leaves should never be cut when it can possibly be avoided. Nicol recommends the removing of those which shade the fruit; but it is doubtful whether the advantage arising from the additional sun-light thus acquired, will counterbalance the detriment occasioned by the loss of leaves, these being organs on which Mr Knight found the success of this fruit most essentially to depend.

The fruit should always be gathered before it be dead ripe. It is known to approach maturity, by its beginning to crack near the footstalk, and by the peculiar rich odour it then emits. It is cut, with all its stalk to it, early in the morning, before the sun has had access to it, and it is kept in a cool place till served up. If melons be deficient in external colour, this may be brought on merely by laying them in the frame for a day or two. Melons should in general be eaten exactly when ripe, or *sharp ripe*, as gardeners call it; but rather a day or two before than after maturity.

262. A late crop of melons from seed is often produced in a flued pit. The seeds from this crop are sown in the beginning of July, and the seedlings are planted out towards the end of the month. Tanner's bark, or tree leaves, afford sufficient warmth at this season: indeed, the remains of the bed of bark or leaves on which early kitchen-vegetables, or tender annual flowers, have been raised in the beginning of summer, a little aided by fresh materials, answer all the purposes. No fire-heat is required till September. In the end of October the melons are ready: they are not equal in flavour, certainly, to those ripened under the brighter and more powerful sun of June and July; but are very acceptable at that season of the year,—the more so, that, owing to the caprices of fashion, those in high life chiefly spend the later months of autumn and the beginning of winter in the country, while they waste the summer amidst the smoke of London. The melons which do not ripen are sometimes pickled like mangoes, and are said to make a very good substitute for these.

263. In the first volume of the London Horticultural Transactions, Mr Knight has given a general account of his highly interesting views on the subject of vegetable physiology, and has illustrated this account, by alluding to the habits of the melon, and the mode of culture best adapted to it. This gentleman's gardener, it appears, had not been previously acquainted with the proper management of the melon, and Mr Knight therefore particularly attended to it himself. Experience soon taught him, (what was previously in some measure known,) that much of the flavour of the fruit depends on the plant possessing efficient foliage, that is, healthy leaves, presenting their upper surface to the light, and remaining as much as possible undisturbed in that position. Free use of pegs is therefore to be made, not only with the view of keeping the shoots in their position, but of preserving the leaves upright; and water is to be introduced without touching the leaves, as already recommended.

*Cucumber.*

264. The *cucumber* naturally follows the melon, being not only a species of the same genus, (*Cucumis sativus*, L.) but requiring pretty much the same sort of culture, only the fruit is produced perfectly well in a lower temperature. It is a tender annual, a native of warm climates. It was early known in this country, but did not come into general cultivation till the middle of the 17th century.

265. The varieties most in esteem are the following:

Early long prickly, (green.)
Longest green prickly.
Early short prickly, (green.)
Dutch or white short prickly.
Cluster cucumber.
Smooth green Roman.
White Turkey cucumber.

The fruit of the *Early long prickly* is from 5 to 7 inches long, of a green colour, with few prickles. The plant is a good bearer; and, upon the whole, this is accounted the best cucumber for the general summer crop, the pulp being very crisp and pleasant.

The fruit of the *Longest green prickly* is from 7 to 10 inches in length; it has a dark green skin, closely set with small prickles. This is a hardy sort, but does not come early.

The *Early short prickly* is not more than 4 inches long; the skin green, rather smooth, but with a few small black prickles. This is one of the hardiest and earliest sorts, and is often preferred for the first crop.

The *Dutch* or *white short prickly*, though not much cultivated, is recommended by a very competent judge, the Rev. Mr Marshall, as preferable even to the early long prickly; it has fewer seeds; is evidently different in taste from most other cucumbers, but of agreeable flavour.

The *Cluster cucumber* is a very early sort, named from the circumstance of the flowers appearing in clusters of three or four together; the fruit is seldom more than 5 inches long; it is at first of a fine green colour, but becomes yellowish as it ripens. The stems of this variety are much inclined to climb, by means of their tendrils, upon sticks; the leaves are small, and the plant altogether occupies but little room.

The *Smooth green Roman* is also an early sort; the fruit becomes large and long, and is quite smooth; the plants grow very strong, and require a good deal of room.

In the *White Turkey*, the stalks and leaves are larger than in the other varieties; the fruit also is very long, sometimes from 10 to 15 or even 20 inches; it is quite straight, and has a smooth skin, destitute of prickles; it is produced sparingly, and late in the season. There is likewise a long green Turkey variety, which is sometimes sown for the late crop. Late cucumbers, however, are much less cultivated than the early varieties; most gardeners being of opinion, that those kinds which are best for the early crops are also best for the late.

266. Three crops of cucumbers are generally raised in the year. The earliest are of necessity produced on hot-beds, or in flued pits. Pickling cucumbers are generally raised either on a slight hot-bed or under a hand-glass, and planted in the open air in June. When they have thrown out a few joints, they are topped, in order to encourage lateral or fruit branches; and these are trained on the ground at eight or nine inches apart, and generally kept down by pegs. In some places, the seed is at once sown in drills in the open air; the fruit being produced in August and September, and well adapted for pickling. But drilled cucumbers succeed only in the southern parts of England; in the northern half of the island they will not do. The prickly sorts are chiefly used in the recent state; and the smooth green is much liked for preserving.

The soil recommended by Nicol is composed of three-fourths light rich black earth from pasture land; an eighth part vegetable mould from decayed tree leaves; and an eighth part well-rotted cow-house dung.

For the early crops, the seed is sown about the end of December or beginning of January, on a small hot-bed, covered with a one-light frame. Where there is the conveniency of a stove, this seed-bed is sometimes dispensed with. Seed which is several years old is preferred, being less apt to produce exuberant shoots than what is recent. The plants soon rise, and the seedlings are transferred from this seed-bed to a larger or two-light frame, which serves as a nursery. Here great care is necessary to the giving of air, in order to strengthen the plants, and prevent them from drawing up weak; at the same time, too free access of cold air would probably kill them. When the seed-leaves are about half an inch broad, some of the best plants are pricked into small pots, generally three into each pot, the pots having been previously filled with light rich earth, and sunk into the bed to acquire equal temperature. The plants not potted are pricked out on the surface of the bed, at such a distance from each other, as to permit the lifting of each with a small ball of earth at the time of final transplanting. Less or more water is given, according to the state of the weather, and the warmth of the beds.

The young plants are *stopped* at the first joint. This operation consists in pinching off closely the runner-bud which springs from the axilla of the second rough leaf: it is best performed when the end of the shoot is little bigger than a large pin's head. In this way a stronger and more compact growth is promoted, and the emission of fruitful lateral runners is secured. When the plants have formed one joint, and when the first two rough leaves are from two to three inches broad, which is generally the case in a month, they are ready for final transplanting, or *ridging out*, as it is technically called. There must now be in readiness a fruiting hot-bed, or several beds, covered with two-light or three-light frames. As in the case of melons, a small hillock of earth, somewhat less than a foot high, is formed under the centre of each light, the rest of the bed being covered only to the depth of two or three inches. Into these beds, when of a proper temperature, the plants in pots are placed, preserving the ball of earth entire about the roots; in general, three plants are set in the middle of each hillock. If the plants have not been potted, they are transferred with as much soil adhering to them as may be. The frames are covered with mats at night, which are taken off through the day. Air is given by tilting the upper end of the glass cover, more or less, according to the state of the weather, and of the hot-bed. In a dry season, water is regularly given; and when the heat of the bed declines, linings are applied. As the plants advance in growth, the other parts of the surface of the bed are filled up nearly to an equality with the hillocks. In July, the nightly covering of mats is omitted, and the glass covers are drawn fully off through the day.

When the blossoms appear, some of the male flowers are shaken over the female, as in the case of the melon. So certainly efficacious is this operation, that it is called *setting* the fruit. When cucumbers are grown in drills in the open ground, the impregnation is entrusted entirely to the agency of the winds and of insects.

The subsequent management of cucumbers consists chiefly in admitting air as freely as the state of the weather will permit, and in affording liberal but judicious supplies of water, generally avoiding the foliage; although a sprinkling upon the leaves appears not to be disadvantageous, for we know that cucumbers thrive better in a moist than in a dry heat; and if the red spider appear, water is the remedy.

Sometimes a crop of cucumbers is raised by means of hand-glasses, placed upon cavities containing hot dung. Instead of hand-glasses, oiled paper covers are occasionally used: these remain night and day till the middle of June, and in general answer very well, all danger of frost being then over.

267. For the natural ground crop, or drilled cucumbers, the beginning of June is the proper sowing time. The plan usually followed is this: the ground being made fine and level, shallow circular hollows are formed with the hand, a foot wide, and half an inch deep in the middle. The distance between each hollow is about three feet and a half; the distance between the rows of hollows, between five and six feet. Eight or ten seeds are sown in each cavity, to be afterwards thinned out to three or four. They are watered two or three times a week, according to the state of the weather, preferring the morning or the evening for this operation. Pickling cucumbers are gathered chiefly from the middle to the end of August; and they are best when not more than three inches in length. Cucumbers form a very extensive and profitable article to the London market gardeners. In March they fetch above a guinea a dozen; in August and September they are sold at a penny a dozen. One village (Sandy in Bedfordshire) has been known to furnish 10,000 bushels of drilled cucumbers in one week.

268. Some persons are careless about the seed which they use, or at least are ready to sow any kind that is recommended to them. This is wrong: when one is pos-

sessed of an approved kind, the safest way is to preserve seed of it. With this view, one good fruit is allowed to remain till it become yellow; it is then placed, upright, in the full sun for some weeks, to acquire the most perfect maturation. The individual fruit having most prickles is commonly selected for this purpose. The seeds are afterwards thoroughly washed from the pulp, dried, and tied in paper bags, to remain for a year at least.

269. Curious cultivators sometimes amuse themselves by planting cuttings of late cucumber plants in the beginning of October: these, if placed in a hot-house or a well regulated hot-bed frame, grow freely, and produce fruit about mid-winter. But in order to have cucumbers at this season, a better plan is, to make them succeed melons in a flued pit, these being generally ripened off by the middle or end of October. The seedling cucumbers may be previously reared in small pots beside the melons, so as to be ready to take their places. They are watered once in four or five days, and commonly over the foliage, especially when, as winter advances, the fire-heat is made stronger. All the pruning necessary at this season is, to stop the shoots as they shew fruit, at a joint or two beyond the fruit. A few cucumbers are thus procured at the end of December, or the begining of January.

### *Gourds.*

370. Allied to the melon and cucumber are the different kinds of *gourds*, two or three of which are sometimes cultivated, and may here be mentioned.

The *Pumpkin*, Pumpion, or more correctly Pompion, is the fruit of the Cucurbita Pepo of Linnæus. The pumpkin was the melon or millon of our early horticulturists, the true melon being formerly distinguished by the name of Musk-melon. The pumpkin is now cultivated principally for ornament or curiosity; but in some of the villages of England, the country people plant it on dunghills, at the back of their houses, and train the shoots to a great length over grass. When the fruit is ripe, they cut a hole on one side, and having taken out the seeds, fill the void space with sliced apples, adding a little sugar and spice, and then bake the whole.

The *Water-melon*, or Citrul, (the fruit of the *Cucurbita citrullus*, L.) although it forms both the food and the drink of the inhabitants of Egypt for several months in the year, is little regarded in Britain. It requires the same attention and expence as the common melon; the hot-beds and glass frames, indeed, would need to be even of a larger size. In a few places only, two or three plants of the water-melon are occasionally cultivated with such attention as to procure the ripe fruit.

The *Squash* and the *Warted gourd*, the fruits of the Cucurbita melopepo and C. verrucosa, though commonly cultivated as esculents in North America, are considered in this country only as curiosities. In the same way are viewed the *Bottle-gourd* or false Calabash, C. lagenaria; and the *Orange gourd*, C. aurantia, lately introduced, which last is really ornamental, when trained spirally round a pole, or against a wall, and loaded with its yellow fruit.

The *Succada*, or Vegetable Marrow, is a kind of small green gourd lately introduced. It is raised under a hand-glass, and afterwards transplanted into a good aspect, and trained to a trellis. When the fruit is of the size of a hen's egg, it is dressed in salt and water, squeezed, and served up in slices on a toast.

## KITCHEN GARDEN.

271. The order in which culinary plants are arranged, or treated of, is not a matter of much importance. They may be divided into the cabbage tribe; leguminous plants; esculent roots, either tuberous or fusiform; the alliaceous tribe; spinach plants; boiling salads, including those plants, the stems and leaves of which are generally blanched; fresh salads; plants for soups, and for garnishings; with the various sweet herbs, those used for preserves, and as medicines. The mushroom stands alone, being the only one of the fungi which is cultivated.

Several of the plants may no doubt be considered as belonging to more than one of these divisions; but they shall be treated of under that title to which they seem chiefly allied, and only named under the others. In treating of each article, nearly the same method shall be pursued as has been adopted in speaking of fructiferous plants. The botanical name shall always be given, as the want of this has been found by experience to create considerable embarrassment and uncertainty, in consulting the popular treatises on horticulture published in France and Germany. The class and order of Linnæus or Willdenow, and the natural order of Jussieu, to which the plant belongs, shall also be mentioned; and the French, German, or Italian names shall be set down, wherever it may seem of any importance to mention them. The country to which the plant is indigenous shall be noticed; with the date of its introduction into Britain, if an exotic, or of its being used as food, if a native. Where different *varieties* are cultivated, as of peas, onions, lettuce, or others, the principal varieties shall be enumerated and described. The mode of culture shall then be detailed. The means of keeping or preserving esculent roots and other culinary articles through the winter shall not be omitted; and the way in which each plant is used in the kitchen, it may be proper generally to mention.

### *Cabbage Tribe.*

272. Of all the classes of cultivated culinary vegetables, the cabbage tribe is the most ancient, as well as the most extensive. The *Brassica oleracea* of Linnæus (belonging to the class Tetradynamia, order Siliquosa, and to the natural order Cruciferæ of Jussieu) being extremely liable to sport or run into varieties and monstrosities, has, in the course of time, become the parent of a numerous race of pot-herbs, so very various in their habit and appearance, that to many it may appear not a little extravagant to refer them to the same origin. Besides the different sorts of white and red cabbage, and savoys, which form the leaves into a head, there are various sorts of borecoles, coleworts, and kale, which grow with their leaves loose in the natural way; and there are several kinds of cauliflower and broccoli, which form their stalks or flower-buds into a head. All of these, with the turnip-rooted cabbage, and the Brussels-sprouts, claim a common origin from the single species of *Brassica* above mentioned. This original cabbage-plant grows naturally on the sea-shores, in different parts of England, but it has not been observed in Scotland. It is figured in English Botany, t. 637. It is a biennial plant; the stem leaves are much waved, and variously indented; the colour is sea-green, with occasionally a tinge of purple. Early in the spring the wild cabbage or colewort from the sea-coast is said to be excellent, but it must be boiled in two waters, to remove the saltness.

*Close Cabbages.*

273. *Common white cabbage* (*Brassica oleracea capitata alba*, L.)—some sort of cabbage, as remarked by Mr White, in his History of Selborne, must have been used by our Saxon predecessors, for they named the month of February *sprout-kale*. Cabbage was a favourite vegetable with the Romans; and their Italian kind would doubtless be introduced during the long period of their sway in the south of Britain. To the inhabitants of the north of Scotland, cabbages were first made known by the soldiers of the enterprising Cromwell.

274. Of the common white cabbages there are many subvarieties, some of which are preferable for a summer crop; others for an autumn crop; and a third set, for winter supply. The Small early dwarf, Large early Yorkshire, Early dwarf Yorkshire, Early Battersea, and Early sugar-loaf, are generally preferred for summer use, and are ready from May to July; in some early situations, even in April. The Imperial, Large sugar-loaf, Hollow sugar-loaf, and Long-sided, are excellent for autumn use, and also, in private gardens, for the winter crop. The Large drum, the Scots and the American cabbage, resist the severity of winter, and grow to a large size; but they are better suited to field culture and the feeding of cattle.

275. Very few remarks on the kinds of close cabbages seem requisite. The Long-sided is also called Large-sided; it is an excellent sort, but rather tender, so that it should not be sown till May, nor planted out till July. The Scots cabbage is much cultivated in cottage gardens in Scotland; it grows to a large size, and is seldom affected by the severest frost. The drum is named from its flatness at top, resembling the head of a drum: it is also called White Strasburgh, and of it chiefly the Germans make their sour-krout. The American also grows to a large size, and lasts good till a late period in the spring. The Musk or perfumed cabbage is almost lost, being preserved only in a few private gardens. A small firm cabbage, called the Russian, has also become rare, being very apt to degenerate in this country: it is the least and most humble of the cabbages, but it is hardy, quick of growth, and pleasant to the taste. The French gardeners describe a crisp-leafed early kind, which cabbages in forty days; so that, if planted out in the last week of March, it is ready for cutting in the first week of May.

276. In sowing cabbage-seed, a rich, light, open spot is selected; a covering of earth from an eighth to a quarter of an inch is sufficient for all the brassica tribe. The time of sowing for the early or summer crop is the beginning of August of the preceding year. In about six or eight weeks, or when the plants have got several leaves, they are thinned, and the plants taken out are pricked into beds at three inches distance every way; in this way the transplanted seedlings grow firm and shapely, and keep short-stalked, which is a great property, while those left in the seed bed get more room to establish themselves. Some part of this crop is finally planted out in October and November, and the rest early in the following spring. The plants are set in rows between two and three feet wide, and at least two feet asunder in the rows. Some gardeners, indeed, plant their earliest cabbages considerably closer in the rows, perhaps at fifteen inches between the rows, and eight or nine inches between the plants in the line. This is done merely with the view of securing a full crop; by cutting every second cabbage in April, the others are allowed to have room to come to larger size. By market-gardeners, winter spinach is often sown where the summer cabbages are planted; and when the spinach is cleared off in April, there is thus a crop of cabbage on the ground, which is encouraged, by stirring the earth and drawing it around the plants. These operations, it may be remarked, are not to be omitted in any of the cabbage rows. Indeed, the oftener the ground is stirred, the better is the crop. In the end of April, or beginning of May, the early cabbages naturally begin to turn in their leaves, and to harden in the centre. Some gardeners then bind the leaves close with willow twigs or strands of bass-mat, so as to produce a degree of blanching in the middle; and they are thus a fortnight sooner fit for use.

277. The seeds of cabbages for autumn and winter use are sown in the end of February, or beginning of March. If pricked out into shady borders in May, and allowed to remain there for some weeks, they form more compact plants, and are less apt to have long stalks. In June they are finally transplanted, at the same distances as the early kinds. If the weather prove dry at the time of transplanting, they are watered every evening till they have again taken root. These cabbages come to be fit for use in the autumn months, and they continue good, in sheltered situations, and in ordinary seasons, till February or March. To preserve them from severe weather, some market gardeners trench a piece of ground in ridges in November, and lay the cabbages as close as possible on one side in the trench, covering the stems with earth: the outer part of the more exposed side of the cabbage is generally injured, but the inside remains sound.

The best soil for cabbages is a rich mould, rather clayey than sandy; and it can scarcely be too much manured, as they are an exhausting crop.

In some places, the roots and stems of a portion of the summer crop are allowed to remain in the ground, which is slightly delved and perhaps manured in the autumn. In January or February of the following year, very fine cabbage sprouts are produced, not much inferior in quality to small young cabbages.

278. Young cabbage plants are also used as coleworts or open greens. With this view some of the close-growing middle-sized kinds are sown, such as the large York, or the sugar-loaf. The seed is sown in the latter part of summer at different times, so that the plants may be ready for use during winter and in the following spring.

279. The *Red Cabbage*, (*Brassica oleracea capitata rubra*) is chiefly used for pickling; and the dwarf red variety certainly does make one of the most beautiful pickles that can be presented at table. It is also shredded down in winter salads. In the north of Scotland, a sort of open red cabbage is much cultivated by the common people, under the name of Aberdeen cabbage.

280. Of the *Savoy Cabbage*, (*Brassica oleracea sabauda*,) which is distinguished by having wrinkled leaves, there are two principal sorts, the yellow and the green, the latter being esteemed the hardiest. Savoys are sown about the middle of April, and planted out in June. They may be planted considerably closer than the common cabbage. If savoys are wished before winter, the seed is sown in February, or even in the preceding autumn; in which last case, fine large plants, well cabbaged, are ready for the table in the months of September and October. The later crop affords a supply through the winter, and till February or March: Savoys, far from being injured by moderate frost, are reckoned better when somewhat pinched by it.

The roots of cabbages or savoys, when planted year after year on the same land, are very subject to the attack of a particular kind of grub, the larva of a small fly; the roots swell into knobs, and the plant becomes sickly and stunted. The cabbage ground should therefore be changed every year.

The culinary uses of the close cabbages, are too well known to require notice. The spare leaves or heads are always useful where milch cows are kept; and young open cabbage plants, or such as are just closing in the centre, make excellent coleworts, as already mentioned.

281. The raising of the seed of the different sorts of cabbage, affords employment to many persons in various parts of England. It is well known that no plants are more liable to be spoilt by cross-breeds than the cabbage tribe. Unless the plants of any particular variety, when in flower, be kept at a very considerable distance from any other, also in flower, bees are extremely apt to carry the pollen of the one to the other, and produce confusion in the progeny. Market gardeners, and many private individuals, raise seed for their own use. Some of the handsomest cabbages of the different sorts are dug up in autumn, and sunk in the ground to the head; early next summer a flower stem appears, which is followed by abundance of seed. A few of the soundest and healthiest cabbage stalks, furnished with sprouts, answer the same end. When the seed has been well ripened and dried, it will keep for six or eight years. It is mentioned by Bastien, that the seed growers of Aubervilliers have learned, by experience, that seed gathered from the middle flower-stem produces plants which will be fit for use a fortnight earlier than those from the seed of the lateral flower-stems: this may deserve the attention of the watchful gardener, and assist him in regulating his successive crops of the same kind of cabbage.

In the neighbourhood of all considerable towns, market gardeners and others raise white cabbage and savoy plants for sale, at very easy rates: this proves a great conveniency to those who have only small gardens, and who perhaps require only 200 or 300 cabbage plants.

*Open Kale.*

*Colewort*, *Kale*, and *Borecole*, (*Brassica oleracea*, vars.) are general terms for greens that do not cabbage or form heads, but remain loose and open. The common colewort is plain; the others are generally curled or crumpled.

281. *Common coleworts*, (or Dorsetshire kale), being intended chiefly for winter and spring use, are commonly sown in July, and planted out in August. They are set pretty close together, perhaps not more than eight or ten inches apart every way. They withstand completely the usual frosts of our winters. But young plants of the common cabbages, particularly of the large sugar loaf variety, are now generally used as coleworts, and sold in the markets, under that name, from December to April. So completely, indeed, have these cabbage coleworts supplanted the true kind, which is more hardy, but at the same time coarser, that one of the most popular modern books of gardening (Abercrombie's *Practical Gardener*) describes only the former sort under the title of coleworts.

282. The principal kinds of *kale* are German greens, Scots kale, Buda, Red curled, and Milan.

Of the *German Greens*, a tall growing light coloured kind is preferred, as producing a large quantity of small tufts or loose heads of delicate leaves on the stalk in the spring months, when coleworts are getting scarce. German greens are sown in May, and planted out in June, at eighteen or twenty inches asunder every way. Some are also sown in June, and planted out in August, to be ready for use late in the following spring.

The seed of the *Scots kale*, (Siberian borecole, or choux pancalier), is sown in the beginning of July; and in the course of August the young plants are set out in rows a foot and a half wide, and ten inches distant in the rows. This green bears the severest cold without injury, and indeed is not reckoned good for use till it has endured some sharp frosts.

The *Milan kale* cultivated in this country has a thick stem, the leaves of a dark green colour, and much curled or fimbriated. Milan greens are greatly prized in France, and different varieties are there cultivated. The Anjou kale grows to a large size; as does likewise a sort called Cesarean kale. Neither of these is so tender as the other kinds; but the produce being great, they might probably be found useful in the feeding of cows.

A very tall variety of open kale is described by the late Mr Delaunay, in the last edition of "*Le Bon Jardinier*" published by himself. It is called *Choux palmier*. It frequently rises to the height of six feet, with a straight bare stem, the leaves displaying themselves only at top, and thus producing the appearance of a little palm tree. The leaves are much puckered, and so much rolled back at the edges, that they appear narrow, while at the same time they hang in a curved manner; thus aiding the illusion. This variety is evidently to be considered merely as a curiosity. It was first raised in Italy, and is not very hardy. Another tall sort, sometimes rising nearly to the same height, is described by the same author under the name of *Capousta*, or Russian kale. The leaves are of a fine purple colour, much cut and fringed. This variety is represented as extremely hardy, resisting the utmost severity of a Russian winter.

283. The *Borecoles*, properly so called, are of two kinds, the tall purple and the dwarf purple. But all the curled and cut-leaved kale or colewort plants, are commonly called Borecoles. There is a variegated sort, which is very ornamental when growing, but not so good for the table as those of more ordinary appearance.

All kinds of kale seeds are sown in the beginning of April; the young plants are generally pricked into a nursery bed for a few weeks, to enable them to gain strength; and they are finally transplanted in June or July, in rows three feet asunder, and two feet apart in the rows, giving water, if the weather be dry. A few are generally not planted out till September, that they may afford a supply late in the following spring. The only other attention requisite, is the drawing of earth to their stems before winter, in order to support them in times of snow or storm.

*Brussels Sprouts.*

284. The variety called *Brussels sprouts* may be classed with the kale plants. The leaves come out in small crowns or sprouts all along the stem, and are very delicate when boiled. The culture is nearly the same as that of coleworts in general. The seed is sown in March or April, and the seedlings are planted out in June, preferring showery weather, or watering carefully at root. They grow upright and pyramidal, and may therefore be placed nearer to each other than more spreading kinds. They are earthed up in October, are ready for use by midwinter, and continue good till March or April. Brussels sprouts are much used in London during the spring months; but they seldom appear in the Edinburgh market, nor is the plant so much cultivated in Scotland as it deserves.

*Cauliflower.*

285. Cauliflower and broccoli, (*Brassica oleracea*, var. *botrytis*,) are curious varieties of the cabbage; the flower-buds forming a close firm cluster or head, for the sake of which alone the plants are cultivated. These heads or flowers being boiled, wrapped generally in a clean linen cloth, are served up as a most delicate vegetable dish. *Cauliflower* is a particular favourite in this country. "Of all the flowers in the garden," Dr Johnson used to say, "I like the cauliflower." Its culture, however, had been little attended to till about the close of the 17th century; since that time it has been greatly improved, insomuch that cauliflower may now fairly be claimed as peculiarly an English product. Till the time of the French revolution, quantities of English cauliflower were regularly sent to Holland; and the Low Countries, and even France, depended on us for cauliflower seed. Even now, English seed is preferred to any other.

The two varieties called the early and the later cauliflower, are scarcely different. The first is the kind generally produced under hand-glasses, and the difference consists merely in the seed having been saved from the most forward plants. A variety having the stalks of the head of a reddish or purple colour, has lately been introduced, under the name of Red Cauliflower; and it is reputed more hardy than the other sorts.

286. The seed for the early crop is sown about the 20th August of the preceding year, in frames or beds. In September, the seedlings are pricked, either into a dry border near a wall, where they may be hooped over and defended with bass-mats during the severe frosts of winter, or into common glass frames, with two or three sliding lights. In the month of March they are finally planted out, water being given if the season be dry. They are placed in rows, commonly about two feet and a half asunder, and two feet apart in the rows. If the soil be not rich, less distance may answer. It is a rule, that cauliflower plants should never be set deep in the ground. The subsequent culture consists chiefly in repeated hoeings, and in drawing earth, or manure perhaps, close up to the roots and stems. Cauliflower plants have justly been declared "rough feeders;" in fact, the more liberally the cleanings of stables and cow-houses are supplied, the larger produce may be expected. They also require regular and free supplies of water, at least in dry seasons. As the flower or head advances, some of the large outer leaves are bent or broken over above it, partly to shade it from the sun, and partly to preserve it from too much rain.

287. To diversify the time of forming the heads, some of the early cauliflowers are planted out on different successive occasions. But seeds sown in February or March on a hot-bed, or in the front border of a stove or forcing-house, afford young plants to succeed those kept over winter; and by sowing again in May, pricking into nursery beds in June or the beginning of July, and transplanting proportionally late, this delicate pot-herb is produced till the end of October. Even after this, the cauliflower season is prolonged for nearly two months by various devices. Sometimes the plants are raised with balls of earth, and sunk nearly to the head in the borders of peach or grape houses, or in common glass frames, in sand or very light dry earth; and sometimes they are merely hung up in a shed or out-house, and thus kept for some weeks. They have been preserved in still another way, described by Mr Smith, gardener at Keith-Hall in Scotland, (*Scottish Hort. Mem.* vol. i. p. 129.): He digs a pit, about eighteen inches deep, near the bottom of a wall. On a dry day he takes up the cauliflower stocks in an entire state, and wrapping the leaves round the head, or flower, deposits them in the trench, the heads sloping downwards, and the roots extending upwards, so that the roots of one layer cover the tops of another; he then covers up the whole closely with earth, preserving a slope from the wall, and beating it smooth with the back of the spade, so that rain may run off. In this way, the cauliflower is said to keep good till the middle of January.

288. For the early supply of the London market, very great quantities of cauliflower are fostered under hand-glasses during winter and the first part of spring; and to behold some acres overspread with such glasses, gives a stranger a forcible idea of the riches and luxury of the capital. Two, three, or even four plants are, at first, placed under each glass; in fine weather, the cover is tilted in order to admit air. When the plants are somewhat advanced, in the end of February or beginning of March, the spare plants are removed with a scoop-trowel, and planted out separately, leaving one, or at most two, under the glass. The plants thus left under the covers are ready for market in the end of April or beginning of May, and fetch a high price. A method of producing cauliflower pretty early, and with great certainty, is this:—The plants are set in small pots in the winter season, and kept in any convenient part of the floor of a vinery, or other glazed house. In the beginning of March they are taken out of the pots, with the ball of earth attached, and planted in the open ground. If they be here protected against severe frosts with bell-glass covers, they come into head in the course of April, if the weather prove favourable.

It may be mentioned, that in some places it is not an uncommon practice to sow a little radish seed on the cauliflower ground, a fortnight before planting out the cauliflowers. It is found that the flies, or larvæ, which infest the young plants, prefer the tender leaves of the radish to those of the cauliflower, and that the latter thus escape. Market gardeners often mix spinach seed with the radish, but from a different motive; they thus procure a useful crop soon after the cauliflower is removed. More frequently, however, these gardeners employ the cauliflower ground in producing a late crop of cucumbers for pickling.

When seed is wished for, some of the best early plants are selected, and left to flower, plenty of earth being drawn up to their roots. The seed ripens in September, but at various times, on the different branchlets of the same head, so that it is proper to gather it at successive times, as it appears ripe.

*Broccoli.*

289. *Broccoli* is generally considered as merely a variety of cauliflower. It is indeed nearly allied, and the useful part consists, as in cauliflower, of the clustered unexpanded flower buds; but the broccoli plant is distinguished by its cut leaves, its larger growth, and greater degree of hardiness. There are several varieties of broccoli, two of them particularly distinct, the purple and the white. No culinary plant is so liable to *sport* as broccoli; so that new kinds, slightly different, are continually coming into notice or favour, and as speedily sinking into neglect.

Of the purple, there are several sub-varieties, the early, dwarf, branching, and Cape broccoli, the last but lately introduced. What are called the brown and the black broccoli are likewise slight variations of the purple. They are more hardy, and better suited for exposed situations; but they do not form heads so completely as some other kinds; the tender stems and hearts of the plants, with the small heads on the lateral branches, being the parts chiefly used. The dwarf sulphur-coloured is much esteemed, and cultivated to great perfection near Edinburgh. By many, the sort called green broccoli is accounted the best. The white, Neapolitan, or cauliflower-broccoli plant, is rather more tender than the others, but the flower is at the same time more palatable; it forms a close curdly head of considerable size in the spring months, and the plants do not branch, as most of the purple kinds do. A hardy variety of the white would therefore prove a great acquisition.

290. Broccoli seed is sown in April for an autumn crop, to be planted out in the beginning of June; and, for a spring crop in the following year, the seed is sown late in May, or even in June. The seedlings are afterwards placed in nursery beds, where they remain till the middle or end of July, when they are finally transplanted. A light, but deep and rich soil, in an open situation, is preferred. To those situated near the sea, it may be interesting to know, that sea-weed forms an excellent manure for broccoli. In the second volume of Scottish Horticultural Memoirs, p. 266, Mr William Wood, one of the most successful cultivators of broccoli near Edinburgh, gives an account of his remarkable success with this sort of manure. When drift ware abounds on the shore, he bestows on the quarter next intended for broccoli a very liberal supply, immediately digging it in roughly. The ground is afterwards slightly delved over before planting. From the soil thus treated, very large and fine heads are produced. It may be added, that grubs will not infest the roots, as they are very apt to do when stable manure is used. The broccoli plants are set in lines, two feet asunder, and a foot and a half apart in the lines. Water is given when thought necessary, according to the state of the weather. They are hoed and earthed up like cauliflower plants. Nicol recommends, that, in the end of October, the most forward crops, especially of the tall growing kinds, should be raised and laid over on their sides pretty closely together, placing the heads just clear of one another. If this be done in a dry soil and free situation, the plants are seldom injured by the frost of the severest winters. The heads of winter broccoli generally begin to appear early in January, and they continue till April.

In gathering broccoli, five or six inches of the stem are retained along with the head; and in dressing, the stalks are peeled before boiling.

291. The early purple Cape broccoli, already mentioned as lately introduced into this country, deserves more particular notice. The seed, it was understood, was first brought from the Cape of Good Hope, but the same kind has since been received from Italy. A particular account of the mode of cultivation is given by Mr John Maher, in the first volume of the London Horticultural Transactions, p 116. Three crops are sown: in April, between the 12th and 18th of the month; in May, between the 18th and 24th; and in August, between the 19th and 25th; and by means of these, this kind of broccoli is procured from September till the end of May. The seeds are sown very thin, on a border of light rich earth. In about a month the plants are finally transplanted, at the distance of two feet every way, in a sandy loam, well enriched with rotten dung. Frequent hoeings are given, and the earth is drawn to the stem, as in the case of ordinary broccoli. Mr Maher never pricks the seedlings into a nursery bed. He finds, that the head is by that measure rendered less in size, and more apt to run to flower and seed. A part of the second crop is often transplanted into pots (sixteens), and plunged into the open ground, where the head forms. Against December. these pots are removed into a shed, frame, or pit; and in this way fine broccoli is secured in the severest weather of winter; the head often six or seven inches in diameter. The seed for the third crop is sown in a frame; and about the third week in October the plants are ready for transplanting. A few good plants for affording seed are selected at this time, and planted in a remote part of the garden, covering them with hand-glasses during winter, in the manner of cauliflower.

292. When broccoli seeds are to be saved, plants with the largest and finest heads are selected, observing that no small foliage appear on the surface of the head. Mr Wood, already mentioned, makes it a rule to take up such plants in April, and lay them, in a slanting direction, in a rich compost, (cleanings of old ditches, tree leaves, and rotten dung,) giving, at the same time, a plentiful watering, if the weather be dry. The raising, he thinks, prevents them from producing *proud seed*, or from degenerating. When the heads begin to open or push, he cuts out the centre, leaving only four or five of the outside flower-stalks to come to seed. The centre, it may be remarked, would probably produce the stronger seeds; but the object seems to be, to check the tendency to luxuriancy and consequent sporting in the plant.

### *Kohl-rabbi.*

293. The *Kohl-rabbi* or turnip-rooted cabbage (*Brassica oleracea*, var. *Napobrassica*, not a variety of *B. rapa*, or turnip, as supposed in Salisbury's Botanist's Companion), has large broad leaves, and the stem protuberant like a turnip at the base: there are two varieties, one swelling above ground, the other in it. Both are sometimes used in a young state for the table; but they are not much cultivated in this country. Kohl-rabbi is very hardy, and might probably be advantageously cultivated in the colder parts of the island; for it is found to be a very profitable crop in Sweden and other northern countries.

## *Leguminous Plants.*

### *Peas.*

294. The *Pea* (*Pisum sativum*, Lin. *Diadelphia Decandria*; *Papilionaceæ* or *Leguminosæ*) is an annual climbing plant, so well known as not to need any description. The legumes or pods are commonly produced in pairs; the seeds contained in these are the part of the plant used, and to which, in common discourse, the name *peas* is always given. In some varieties, called Sugar-peas, the inner tough film of the pods is wanting, the pods of such, when young, being boiled with the peas within them, and eaten in the manner of kidney-beans. Concerning the native country of the pea, there is no certainty; it is guessed to be the south of Europe. It has been cultivated in Britain from an early period; but some of the best varieties, such as the sugar-pea above mentioned, were introduced only about the middle of the 17th century.

There are very many varieties, differing in size, time of coming in, colour of flower and fruit, and also in taste: but the principal distinction is as to their being early or late; supposing the sorts to be sown on the same day, the former are ready a fortnight at least before the latter.

295. The early peas are called *hotspurs* and *hastings*. Of these there are different subvarieties, especially the Charlton, Reading, Golden, Double dwarf, and Early frame pea; the last being so called from its being often forced in hot beds, especially for the London market. These being comparatively of dwarfish growth, do not require sticking;

and it is a common remark, that peas supported on sticks yield more, but that those recumbent on the ground ripen soonest. Some of these kinds are generally sown towards the end of October, in front of a south fruit-wall, and at right angles to it, or inclining a point to the east, in order to catch the morning sun. With some slight protection of branches of evergreens or old peas-haulm, the crop survives the winter, and produces young peas by the end of May. Many gardeners prefer sowing in longitudinal rows near the wall, the crop thus ripening more equally. In January and February more peas, of the early sorts, are sown, to follow in succession those sown before winter. Some gardeners are in the practice of raising peas in boxes placed in any hot-house, and planting them out when two or three inches high. They must be handled with care, being very brittle; but, with due attention, few plants fail; and it has long been remarked, that transplanted peas are much more productive of pods or fruit, than such as remain where they have been sown.

296. In March and April full crops of later peas are sown. Some of the smaller kinds are the Blue Prussian, Dwarf marrowfat, and Spanish dwarf. These, if well earthed up, and if the rows be sufficiently distant from each other, succeed very well without sticking. To them may be added Leadman's dwarf, which is smaller than any of them, while at the same time the plant is very prolific, and the pea remarkably sweet. Of the large and late kinds, the Tall marrowfat, the Green marrowfat, the Grey rouncival, and the Sugar pea, have long retained their character; while the Spanish moratto and Imperial egg pea are also in good repute, as hardy plants and copious bearers. The Crown pea or Rose pea is well known; but it is as frequently cultivated for ornament as for use: It is remarkable that Parkinson, in his "Paradisus," ascribes to it a Scottish origin. A new white pea raised by Mr Knight must not be omitted. It is sometimes called Knight's marrow pea; sometimes the Wrinkled pea, the circumstance of the skin of the fruit being wrinkled or contracted, being an obvious mark of distinction. The plant is of luxuriant growth, requiring tall sticks to support it; the pods are large, and the peas are of peculiarly excellent flavour when boiled.

The larger kinds of peas require nearly four feet distance between the rows. They are frequently hoed, and when about three or four inches high, earth is drawn to the rows, this being found greatly to promote their growth. The sticking or supporting takes place when they are about eight or ten inches high. The sticks are of different heights for the respective kinds; three feet is enough for the smallest kinds; the hotspurs and dwarf marrowfats require about five feet; and the larger sorts seven or eight feet. Sometimes double rows of peas are sown, and the sticks placed in the middle, the plants being earthed towards the sticks: Or two rows of sticks may be made to serve three rows of peas, the heads of the sticks being inclined towards each other; but in this way the middle row of peas cannot be earthed up or hoed after sticking. Where branches cannot be procured, two lines of strong pack-thread, on each side of the rows, form a tolerably good substitute. In some places, in very dry weather, the crops of peas are regularly watered when in flower and fruiting.

The small early peas are sweeter and of more delicate flavour than the large kinds. In well ordered gardens, therefore, a small quantity of the hotspur sorts is sown every ten days, from the middle of March till the middle of June, choosing for them a moist strong soil, in order to counteract the effects of the summer heat. It is not reckoned proper to sow peas on land which has been recently manured, as they are, in such situations, apt to run to haulm: This crop is seldom sown, therefore, till the second season after dunging. In large gardens, and particularly in market gardens, instead of delving, a slight plough may be used for turning over the ground; and the one-horse drill for sowing, as recommended by Meager so long ago as 1670.

Among the chief enemies of peas may be mentioned slugs and mice. The former often abound in damp situations, or places surrounded by trees. The remedy usually applied is, the spreading of new slaked lime over the surface of the ground, very early in the morning, when the slugs are abroad. A simple preventive of the attacks of mice consists in being particularly careful, in sowing the peas, to leave none exposed on the surface; if the seed be all duly covered, these animals do not seem to be very expert at discovering the rows.

It is generally thought advisable to change the seed yearly; few gardeners, therefore, ripen their own seed. Indeed, the professed seed-growers possess superior opportunities for saving the kinds in a genuine state; and if they be men of judgment and fidelity, it is better for the gardener to buy from them, than to trouble himself with saving either the seeds of peas, or of any other garden plants, which are apt to degenerate by intermixture of pollen.

### *Beans.*

297. The *Bean* (*Vicia Faba*, Lin.) belongs to the same class and order, and natural family, with the pea. It is the *Fève de marais* of the French. It is perhaps superfluous to mention, that it is an annual plant, rising from two to four feet, with a thick angular stem; the leaves divided, and without tendrils; the flowers white, with a black spot in the middle of the wing; seed-pods thick, long, woolly within, and inclosing the large ovate flatted seeds, for the sake of which the plant is cultivated in gardens. It is a native of the East, but has been known in this country from the earliest times.

298. There are two principal kinds of the plant, the garden bean and the field bean: The first only falls to be spoken of here. Of this there are many varieties. The *Mazagan* is one of the hardiest and best flavoured of the small and early sorts. Mazagan is a Portuguese settlement on the coast of Africa, near the Straits of Gibraltar; and it is said, that seeds brought from thence afford plants that are more early and more fruitful than those which spring from home-saved seed. The *Lisbon* is next in point of earliness and fruitfulness; some indeed consider it as merely the Mazagan ripened in Portugal. The *Dwarf-fan* or *cluster* bean is likewise an early variety, but it is planted chiefly for curiosity: it rises only six or eight inches high; the branches spread out like a fan, and the pods are produced in small clusters. The *Sandwich* bean has been long noted for its fruitfulness; the *Toker* and the *broad Spanish* are likewise great bearers. Of all the large kinds, the *Windsor bean* is preferred for the table. When gathered young, the seeds are sweet and very agreeable; when the plants are allowed room and time, they produce very large seeds, and in tolerable plenty, though they are not accounted liberal bearers. There are several sub-varieties, such as the Broad Windsor, Taylor's Windsor, and the Kentish Windsor. The *Long-podded* bean rises about three feet high, and is a great bearer, the pods being long and narrow, and closely filled with oblong middle-sized seeds. This sort is now very much cultivated, and there are several subordinate varieties of it, as the Early, the Large, and the Sword Longpod. The *White-blossomed* bean is so called, because the black mark on the wing of the blossom is wanting. The seed is semitransparent; when young, it has little of the peculiar bean flavour, and is on

this account much esteemed; it is at the same time a copious bearer, and proper for a late crop. It may be mentioned, that Delaunay, in *Le bon Jardinier*, describes as excellent a new variety cultivated at Paris, which he calls the *green bean* from China; it is late, but very productive; and the fruit remains green, even when ripe and dried.

299. The early sorts, such as the Mazagan and Lisbon, are sown in the end of October or beginning of November, in a sheltered situation, in front of a wall, reed-fence, or other hedge, and in drills about two inches deep. The plants are earthed up in November as they advance. In severe frost, some haulm or fern is laid over them, as in the case of early peas. In March and April, as the beans begin to shew flower, they are kept close back to the fence, by means of lines of pack-thread. When the lower blossoms are fully expanded or beginning to fade, the tops of the stems are pinched off, this being found to forward the production of pods. With this sort of care, a crop is generally procured about the end of May or first of June. Successive autumn and winter sowings are managed much in the same way, being sown in rows, eighteen inches apart, in sheltered borders or quarters. It is necessary to guard against the ravages of mice, which are very apt to attack the new sown rows. Some gardeners sow their winter beans thickly, and cover them with a frame, transplanting them in February or March: in this way they prove very productive.

300. In February and March, full crops of the late and large beans, such as the Windsor, Sandwich, and Long-podded, are planted, in a free and open exposure. The middling sized kinds are allowed two feet between the rows; but the large growing kinds, two and a half or even three feet. The plants in the rows, however, are only five or six inches separate. Sometimes the beans are planted with a blunt setting-stick, observing to close the earth down upon the seed; but drills drawn two inches deep, or a little more, with the hoe, are in general preferred. One of the principal things to be attended to is the earthing up: in performing this operation, it is necessary to take care that the earth do not fall on the centre of the plant so as to bury it; for this occasions it to rot or fail. Nicol says, that topping is not necessary for any but the early crops, and is practised only to make them more early. Most other horticulturists are of opinion that topping improves the crop, both as to quantity and quality; and it is very commonly performed on the late crops as well as the early. The crops of beans, when in flower, it may be remarked, are very ornamental to the kitchen-garden, and render it a pleasant walk, the flowers having a powerful fragrance, not unlike that of orange-flowers. The latest crops in May and June are sown in strong or moist land, as on an arid soil scarcely any return could at this season be expected. For these late crops, the long pods, broad Spanish, and Toker, are preferred. In a dry season, it is found useful to soak the seed-beans for several hours in soft river water, before planting.

An expedient sometimes resorted to, in order to prolong the bean season, may here be mentioned: A bed or quarter of beans is fixed on; and when the flowers appear, the plants are entirely cut over, a few inches from the surface of the ground. New stems spring from the stools, and these produce a very late crop of beans.

In gathering beans for table use, such pods as are too old should as much be avoided as such as are too young, the seeds decreasing in delicacy after they attain about half the size which they should possess at maturity. When beans are to be saved for seed, none of the pods should be gathered for the kitchen, the first pods being the most vigorous, and affording the best seed. The whole plant should be pulled up; and the seeds should be allowed to dry in the pods, these last still remaining on the stems.

*Kidney-bean.*

301. The *Kidney-bean* (*Phaseolus vulgaris*, Lin. Common kidney-bean; and *P. multiflorus*, Willd. Scarlet runner) belongs to the same artificial and natural classes as the pea and the bean. In this country it is often called *French bean*; and it is the well known and favourite *haricot* of France. It is an annual, originally from India; its stem is more or less twining, but in the dwarfish kinds it scarcely shews this propensity; the leaves are ternate, on long foot-stalks; the flowers on axillary racemes; the corolla generally white, sometimes yellow or purple; the pods are oblong, swelling slightly over the seeds; these last are generally kidney-shaped, smooth and shining when ripe, varying exceedingly in colour, white, black, blue, red, and spotted. The date of the introduction of the kidney-bean into this country is not known: it was in familiar use in the days of Gerarde. The unripe pods chiefly are used in Britain; but in France, the ripe seeds or beans are also very much employed in cookery, being dried in the autumn, and kept for winter use.

302. There are many varieties, both of what are called *dwarfs*, and of *runners*. By Dwarfs are meant kinds that do not much exceed a foot in height, and do not need support; by Runners, such as have long climbing stems, and which require stakes. Of the former, the Early white dwarf, Early black or Negro, the Speckled dwarf, Early yellow, and the Battersea and Canterbury white, may be mentioned as principally esteemed. Of the latter, the Scarlet runner is preferred, the pods being tender, especially if gathered young, and being produced in succession for a long time. This was formerly considered as merely a variety of the common kidney-bean; but Willdenow has described it as a distinct species, under the name of *Phaseolus multiflorus*; it is distinguished by its racemes equalling the leaves in length, and by its bracteæ or floral leaves lying close to the stalk; while in the common kidney-bean, the former are shorter than the leaves, and the latter project from the stalk. The scarlet runner is frequently cultivated as an ornamental flower, particularly in forming fancy hedges: when trained near a wall, and led up with lines of pack-thread or spun-yarn, it unites both characters, or is at once shewy and useful. The white runner seems to differ from the scarlet merely in the colour of the blossoms and of the seeds. The Dutch white runner produces long smooth pods, but does not afford so many successive gatherings as the other two.

303. The kidney-bean is too tender for sowing earlier than the middle or end of April. From that time successive crops are sown every fortnight or three weeks, till July: and in this way the young and tender pods are to be had all the summer and autumn. The dwarfish sorts are sown in drills from two to three feet asunder, perhaps three inches separate in the lines, and covered with something less than two inches of soil. As they advance, they are hoed and cleared of weeds, a little earth being at the same time drawn to the stems. As the young pods come to be fit for use, the more regularly and completely they are gathered, the greater is the successive produce. The runners, being rather more tender, are not sown till about the middle of May. As tall slight stakes must be placed for them to climb upon, the distance allowed be-

tween the rows of these is commonly four feet. If the runners be sown in July, they continue to produce pods till stopped by the frost. In dry seasons, frequent watering greatly conduces to the abundance of the crops. For the latest summer crop, the seed is commonly soaked for some hours in milk and water. Mr Marshall recommends laying it in damp mould till it begin to chit or germinate, and then sowing it in watered drills. The white Canterbury is the sort generally sown to produce small pods for pickling.

For a supply of seed, some of the early summer plants, either dwarfs or runners, should be left untouched; the first produced pods being always the best, the whole strength of the plants being thus directed to perfecting the seeds. These will ripen in September. The haulm is then pulled up, and allowed to dry with the pods on it; the seed being found in this way to acquire further maturation.

304. Kidney-beans are easily forced, and they form a very desirable early spring dish. They are sometimes raised in hot-beds; but more generally, and with greater certainty, in hot-houses. They are sown in pots in January and February, and placed on a flat trellis over the flues, on shelves, or in any other convenient situation. Three plants are generally allotted to each pot of a foot in diameter. A light rich earth, or what is called a cucumber mould, is the soil preferred. With frequent moderate supplies of water they make good progress, and afford pods in March, April, and May. The dwarf-speckled is the kind generally used in hot-houses; but, for hot-beds, the early white is perhaps better, as being of more dwarfish growth.

French gardeners have enumerated above two hundred varieties of the haricot, but of these not more than twenty are in esteem. They speak of a new variety called the Yellow Kidney-bean of Canada, which they describe as the most dwarfish, and the earliest of all. The Rice Kidney-bean they mention as a slender runner, rising six feet high, but having seeds which, even when ripe, are not larger than peas. The pods they describe as very good in the unripe state, and quite delicious when prepared under roast fowl.

## *Esculent Roots.*

It is, perhaps, scarcely necessary to explain, that the term *roots* is applied to the tubers of the potato and Jerusalem artichoke only in compliance with popular practice; the true roots of the plants consisting of the small fibres or radicles only.

### *Potato.*

305. The *potato* (*Solanum tuberosem*, L.; *Pentandria Digynia; Luridæ*, L.; *Solanaceæ*, Juss.) may be considered as a perennial plant, as it will continue to spring up for many successive years on the same spot. The stem rises from two to three feet in height, is branched, succulent, and frequently spotted with red; the branches long and weak; flowers white, or tinged with purple; the fruit is a round berry, green at first, but black when ripe, commonly called potato-apple. The part used consists of the tubers, which are produced on runners, proceeding from the stem of the plant.

306. Sir Joseph Banks has satisfactorily shewn, that potatoes were first brought from South America to Spain about the middle of the 16th century, as they are mentioned, under the name of *papas*, in Cicia's Chronicle, printed in 1553, and now a very rare book. They were not introduced into this country till near the close of the century, when they appear to have been brought from Virginia by the colonists sent out by Sir Walter Raleigh, and who returned in 1586; Herriot, one of these colonists, describing the potato, under the name *openawk*, in his account of the country they had visited, preserved in De Bry's Collection of Voyages. It is said, that Sir Walter Raleigh planted them on his own estate near Cork. They were soon carried over into Lancashire; but near half a century elapsed before they were much known at London. Gerarde and Parkinson describe the plant by the title of Batata Virginiana, to distinguish it from the Spanish potato, Convolvulus batatas. It was at first raised only in botanic gardens. Parkinson mentions, however, that the tubers were sometimes roasted, and steeped in sack and sugar, or baked with marrow and spices, and even preserved and candied by the comfit-makers. In 1663, the Royal Society took some measures for encouraging the cultivation of potatoes, with the view of preventing famine. Still, however, although their utility as an article of food was better known, no high character was bestowed on them. In books of gardening, published towards the end of the 17th century, a hundred years after their introduction, they are spoken of rather slightingly. "They are much used in Ireland and America as bread," says one author, "and may be propagated with advantage to poor people."—"I do not hear that it hath been yet essayed," are the words of another, "whether they may not be propagated in great quantities, for food for swine, or other cattle." Even the enlightened Evelyn seems to have entertained a prejudice against them. "Plant potatoes," he says, writing in 1699, "in your worst ground. Take them up in November for winter spending; there will enough remain for a stock, though ever so exactly gathered." The famous nurserymen, London and Wise, whose names have been already repeatedly mentioned, have not considered the potato as worthy of notice in their Complete Gardener, published in 1719; and Bradley, who, about the same time, wrote so extensively on horticultural subjects, speaks of them as inferior to skirrets and radishes.

The use of potatoes gradually spread, as their excellent qualities became better understood. It was near the middle of the 18th century, however, before they were generally known over the country: since that time they have been most extensively cultivated. In 1796, it was found that, in the county of Essex alone, about 1700 acres were planted with potatoes for the supply of the London market. This must form no doubt the principal supply; but many fields of potatoes are to be seen in the other counties bordering on the capital, and many ship-loads are annually imported from a distance.

The cultivation of potatoes in gardens in Scotland, was very little understood till about the year 1740; and it was not practised in fields till about twenty years after that period. It is stated in the "General Report" of Scotland, (vol. ii. p. 111,) as a well ascertained fact, that in the year 1725:6, the few potato plants then existing in gardens about Edinburgh were left in the same spot of the ground from year to year, as recommended by Evelyn; a few tubers were perhaps removed for use in the autumn, and the parent plants were then well covered with litter to save them from the winter's frost. Since the middle of the 18th century, the cultivation of potatoes has made raid progress in that country; so that they are now to be seen in almost every cottage garden.

Professor Martyn, in his edition of the "*Gardener's Dictionary*," has given an account of various notices that occur concerning the introduction of the potato, in the writings of successive horticulturists, and most minute and accurate details respecting its tillage, derived from all the best sources of information, and selected with great judgment and care. To the learned and industrious Professor's labours, and to the article AGRICULTURE in this work, we must refer the inquisitive reader, contenting ourselves in this place, in addition to the short history already given, with some account of the qualities of the plant, of a few of the principal varieties, and of its culture in gardens.

The potato is now considered as the most useful esculent that is cultivated; and who could *à priori* have expected to have found it the most useful among the natural family of the Luridæ, several of which are deleterious, and all of which are forbidding in their aspect! It is at the same time the most universally liked; it seems to suit every palate. So generally is it relished, and so nutritious is it accounted, that on many tables it now appears almost every day in the year. It is commonly eaten plainly boiled, and in this way it is excellent. When potatoes have been long kept, or in the spring months, the best parts of each tuber are selected, and mashed before going to table. Potatoes are also baked, roasted and fried. With the flower of potatoes, puddings are made nearly equal in flavour to those of millet. Bread has also been formed of it, with a moderate proportion of wheat flour; and potato starch is common. To cottagers having a number of children, the potato is of inestimable value. Dr Johnson, in his "Journey," remarks, that before the Scottish peasantry acquired cabbages, they must have had nothing; but with much more reason might it now be said, that they must have been destitute indeed, before they knew the potato. By many cottagers in Scotland, and especially in Ireland, potatoes are cultivated on what are called *lazy-beds*. In constructing these, the manure is laid on the surface; sets of potatoes are placed immediately on it; and a little earth is thrown over all. In this way a very great return is procured.

307. In regard to general qualities, potatoes are of two kinds, mealy and waxy; the former of a loose, the latter of a firm contexture. They are distinguished as to shape, into round, oval or kidney, and clustered; and as to colour, into white and red, or purple. It would be quite an unprofitable task to enumerate the many varieties which have been raised from seed, and have obtained a name for a day. A few of those at present in esteem can alone be named. Kidney potatoes, of various sorts, have long been in repute, particularly the White and the Yorkshire. Red, and White, and Black potatoes, have their admirers. The Early dwarf, Champion, Early frame, Manly, Cumberland early, Fox's yellow seedling, and the Goldfinders, still retain their fame for summer use: but they are perhaps excelled by varieties well known in Scotland by the names of the Ash-leaved, and Mathew Cree's early. The large red-nosed kidney, a white potato with a tinged eye, is a great favourite in the London market, for general culinary purposes: and the Don potato is the kind most esteemed, and most commonly sold in the Edinburgh market. For the feeding of cattle, the Ox-noble, a large round sort with deep eyes; the American cluster; the Yam potato; and Lancashire, or large round rough potato, are held in high estimation.

The raising of potatoes being now considered as rather the business of the farm, in many gardens only a quarter of *early* potatoes is to be found. For the original production of the varieties, called *earlies*, we are indebted to the kitchen gardeners near Manchester. Encouraged by the demand of that populous town, they vied with each other to have potatoes first in the market: they noted those plants that flowered early, saved them, and sowed their seeds; by again watching the earliest of these, they procured varieties which arrive so much sooner at a state approaching maturity, as far as the tubers are concerned, that young potatoes may be had for table two months after planting. The most productive of these, and least apt to degenerate, are such as do not shew a disposition to flower.

308. The potato is chiefly propagated by cuts of the tubers, taking care to leave one or two eyes or buds to each cut, but eradicating all clustered eyes. The best shaped and cleanest potatoes are selected for this purpose. The cuts are the better for being allowed to dry for a day or two before planting. Any light soil, in a free airy situation, suits the potato. Too much manure can scarcely be given, if the quantity of produce be alone looked to; but potatoes of more delicate flavour are procured from ground not recently enriched. About the middle of March some of the early kinds, such as the ash-leaved, are planted on a light warm border. As they are to be taken up soon, sixteen inches between the lines is accounted enough, and seven or eight inches between each plant. They are commonly planted in drills, and covered to the depth of three or four inches. The tubers being small, are generally only cut in two to make sets; but not more than two eyes are left on each set. Rooted shoots, accidentally produced among the stock of early potatoes, have been found to afford a very speedy return. Instructed by this circumstance, some gardeners lay the sets on a floor sprinkled with sand or barley-chaff, till they have sprung four or five inches, thus advancing the growth of the plants as much as possible under a low temperature, so as to avoid all unnecessary expenditure of their excitability. Great care must be taken, however, to preserve their germs and roots from injury in transplanting. By this means the plants are forwarded nearly three weeks in their growth. The young potatoes are fit for use in June and July, and in August the tops of the parent plants change to a yellow colour, indicating maturity. Only a few plants are taken up at once; for the young and immature tubers do not keep good beyond a day or two: it is found better, therefore, to let them remain in the ground till wanted, and in this way they may be made to meet the later sort. About the middle or end of April, the general potato quarter is planted. Two feet is the space commonly allowed between the rows, and from ten to fourteen inches between the plants. For planting, some use the potato dibble; which is an instrument about three feet long, with a cross handle at top for both hands, the lower end blunt and shod with iron, and having a cross iron shoulder, about four inches from the bottom, so that the holes must of necessity be struck of equal depth. The only attention the crop requires is hoeing, and drawing earth to the stems: the oftener this last operation is performed, the greater is the produce. The potatoes are taken up and used in the autumn months; the winter supply being drawn from the fields, as already mentioned. Potatoes are taken up with a fork made for the purpose, and which consists of three or four short flat tines, fixed on a spade handle. The winter store is carefully housed; or, what is better, it is lodged under ground, in pits covered with earth, and with straw during frost.

309. The late or field potatoes, it may be remarked, afford in most places a great part of the supply for spring and summer; and any improvement in the mode of keeping them is deserving of attention. The Rev. Dr Dow of Kilspindie (in the first volume of Scottish Horticultural Memoirs) has described a mode, the advantages of which have in various places been confirmed by experience. The potatoes destined for long keeping he puts into small pits, holding about two bolls each; these are formed under the shade of a tree, wall, or stack of hay, and are covered with earth and straw in the usual way. In the following spring,

about May, when warmth begins, the potatoes are examined; all shoots or buds are rubbed off, and such as shew any tendency to spoil, are laid aside. The pits being cleaned out, are nearly filled with water; and when this is absorbed, the potatoes are returned into it, every parcel or half-boll being watered as it is laid in. A layer of turf is placed with the grass next to the potatoes; a plentiful watering is then given; and the whole is covered with earth to the depth of two feet, and well beaten together with the spade. This operation is repeated once a month, as long as the potatoes are wished to be preserved. Dr Dow states, that he has thus kept them till September, quite plump, and unimpaired in taste; and although, from the liberal supplies of water, we might expect them to be drenched with moisture, he assures us that they continue as mealy as ever.

The potato, although it most fortunately produces its tubers freely in our climate, must be considered as rather a delicate plant. Its leaves are blackened by the first approaches of frost in the autumn. Every body knows how apt potatoes kept in the house or cellar are to be injured by frost. The best means of guarding against this evil in these places are, to bring in potatoes in as clean and dry a state as possible, and, when risk of frost is apprehended, to place over them a covering of straw at least a foot thick.

It is well known, that if any of the larger sorts of potatoes of the former year's growth be kept in the cellar till May or June, they never fail to shoot, producing both roots and runners; but it is not perhaps generally known, that if these be carefully placed in boxes among decayed tree-leaves or other very light vegetable mould, and still kept in the cellar, they will yield a crop of small potatoes about mid-winter. A small supply may thus be procured by way of curiosity; but the potatoes are rather watery, and quite deficient in flavour.

In private gardens of a superior order, the first early potatoes are in some measure forced. In February two or three slight hot-beds are formed, and the potatoes are planted thickly on these. They are hooped over, and covered with mats at night and in bad weather. The more air they have the better, provided frost do not get leave to nip them. They require moderate but regular watering, particularly in March, when there is generally some dry weather. The young tubers are gathered in April and May in succession as they are formed.

310. Many persons amuse themselves with raising seedling potatoes. Some of the largest, first produced, and thoroughly ripened berries, are gathered from several different good varieties; these may be preserved in dry sand till spring; or the seeds may be immediately separated from the pulp, and kept in paper-bags over winter. In April the seed is sown, in any fine light soil, in drills half an inch deep, and perhaps a foot asunder, keeping the kinds carefully separate, and marking them with tallies. When the plants rise, they are thinned out to six inches apart. They are kept clear of weeds, and once or twice earthed up. When the haulm decays, the tubers are taken up; they are carefully preserved from frost during the winter; and being planted next spring, the crop which results will determine the qualities of the different kinds. They should be boiled separately, and regard had to their flavour, mealiness or waxiness, size, shape and colour. When the seed of early varieties can be procured, it is, for different reasons, to be preferred. Mr Knight suspected the cause of these early varieties not producing flowers to be the preternaturally early formation of the tubers, drawing off for their support that portion of sap which should have gone to the production of the blossom. He therefore devised means for preventing the formation of tubers; and when this was accomplished, he found no deficiency in the production of flowers and berries. The means were simple: having fixed strong stakes in the ground, he raised the mould in a heap round the bases of them; on the south side he planted the potatoes. When the plants were about four inches high, they were secured to the stakes with shreds and nails, and the mould was then washed away with a strong current of water from the bases of their stems, so that the fibrous roots only entered the soil, and no runners or tubers could be produced.

311. The disease called *curl* has in many places proved extremely troublesome and injurious. It has given rise to much discussion, and to detail all the various opinions would be a useless task. It may, however, be remarked, that the experiments of Mr Thomas Dickson (*Scottish Horticultural Memoirs*, i. 55.) shew, that it arises from the vegetative powers in the tuber planted having been exhausted by over-ripening. That excellent horticulturist observed, in 1808 and 1809, that cuts taken from the waxy, wet, or least ripened end of a long flat potato, that is, the end nearest the roots, produced healthy plants; while those from the dry and best ripened end, farthest from the roots, either did not vegetate at all, or produced curled plants. This view is supported by the observations of a very good practical gardener, Mr Daniel Crichton at Minto, who, from many years experience, found (*Id.* p. 440.) that tubers preserved as much as possible in the wet and immature state, and not exposed to the air, were not subject to curl. And Mr Knight (in *Lond. Hort. Trans.* for 1814) has clearly shewn the beneficial results of using, as seed-stock, potatoes which have grown late, or been imperfectly ripened, in the preceding year. Mr Dickson lays down some rules, attention to which, he thinks, would prevent the many disappointments occasioned by the curl. He recommends, 1. The procuring of a sound healthy *seed-stock* (stock of tubers for planting) from a high part of the country, where the tubers are never over-ripened 2. The planting of such potatoes as are intended to supply seed-stock for the ensuing season, at least a fortnight later than those planted for a crop, and to take them up whenever the stems become of a yellow green colour, at which time the cuticle of the tubers may be easily rubbed off between the finger and thumb. 3. The preventing those plants that are destined to yield seed stock for the ensuing year, from producing flowers or berries, by cutting off the flower-buds; an operation easily performed by children, with a sickle, at a trifling expence.

Mr John Shirreff (in the same volume, p. 60.) takes a general and philosophical view of the subject, applying to the potato the doctrine by which Mr Knight had accounted for the disappearance of the fine cider fruits of the 17th century. The maximum of the duration of the life of every individual, vegetable as well as animal, is predetermined by nature, under whatever circumstances the individual may be placed: the minimum, on the other hand, is determined by these very circumstances. Admitting, then, that a potato might reproduce itself from tubers for a great number of years in the shady woods of Peru, it seems destined sooner to become abortive in the cultivated champaign of Britain; insomuch, that not a single healthy plant of any sort of potato that yields berries, and which was in culture twenty years ago, can now be produced. Mr Shirreff concludes, therefore, that the potato is to be considered as a short-lived plant, and that, though its health or vigour may be prolonged, by rearing it in elevated or in shady situations, or by cropping the flowers, and thus preventing the plants from exhausting themselves, the only sure way to obtain vigorous plants, and to ensure productive crops, is to have frequent recourse to new varieties raised from the seed. The same view, it may be remarked, had occurred to Dr Hunter, who, in his "Georgical Essays," limits the duration of a variety in a state of perfection to about fourteen years. A fact ascertained by Mr Knight deserves to be particularly noticed: it is this; that by planting late in the season, perhaps in June or even in July, an exhausted good variety may in a great measure be restored; that is, the tubers resulting from the late planting, when again planted at the ordinary season, produce the kind in its pristine vigour, and of its former size.

*Jerusalem Artichoke.*

312. The *Jerusalem Artichoke*, or tuberous-rooted sunflower, (*Helianthus tuberosus*, L.; *Syngenesia Polygamia frustranea; Corymbiferæ*, Juss.) is a perennial plant, originally from Brazil. It has the habit of the common sunflower, but grows much taller, often rising ten or twelve feet high. Though its roots endure our hardest winters, the plant seldom flowers with us, and it never ripens its seed. The roots are creeping, and have many tubers clustered together, perhaps from thirty to fifty at a plant. These are eaten boiled, mashed with butter, or baked in pies, and have an excellent relish. The plant was introduced into our gardens early in the 17th century; and before potatoes became common, it was much more prized than at present. The epithet *Jerusalem* is a mere corruption of the Italian word *Girasole*, or sunflower; the name *artichoke* is bestowed from the resemblance in flavour which the tubers have to the bottoms of artichokes. As the potato is the *pomme de terre*, this is the *poire de terre* of the French.

The plant is readily propagated by means of the tubers. They are cut in the manner of potato sets, and planted, in any light soil and open situation, in the end of March. They are placed in rows, three feet asunder, and a foot or fifteen inches apart in the rows. In September they are fit for use; and in the course of November they are dug up and housed, being kept in sand like carrots. Sometimes they are left in the ground, and dug only as wanted, being best when newly raised. The only disadvantage is, that in this way they cannot be had in severe frosts. It is not very easy to clear the ground of them where they have once grown; and on this account, some gardeners devote a by-corner to them, and allow them to remain from year to year, taking up only what is wanted for the occasional use of the family. But the tubers thus produced are not so clean or well flavoured as those produced on newly delved ground by yearly planting.

*Turnip.*

313. The *Turnip* (*Brassica Rapa*, L.) is a biennial plant, growing naturally in some parts of England, and figured in "English Botany," t. 2176. The root-leaves are large, of a deep green colour, very rough, jagged and gashed. In the second season it sends up a flower-stalk, four or five feet high, having leaves which embrace the stem, very different from the former; smooth, glaucous, oblong, and pointed. The cultivated variety with a swelling fleshy root has long been known. Of this there are several well marked subvarieties, distinguished as garden or as field turnips. To the former belong the Early Dutch, Early Stone, and the Yellow; to the latter, the Large White, the Globe, the Swedish, the Red-topped, and the Tankard or oblong.

314. For the supply of the table during the early part of summer, some of the early Dutch turnip is commonly sown. If the weather prove dry, regular watering is proper. For a general crop, the large green-topped white turnip is accounted excellent, as being soft, juicy, and sweet. One of the kinds with which the London market is often supplied is the stone turnip, a hard sweet sort, seldom of a large size. The yellow is now perhaps less cultivated than it formerly was; but the yellow Dutch may still be considered as one of the best kinds for winter use, as no frost hurts it, and it is of excellent flavour. It is a very distinct variety, the flesh being yellow throughout; whereas, in the other varieties, any difference of colour is only in the rind. The red or purple-topped turnip was formerly much cultivated; but the green-topped has now in a great measure superseded it, though less hardy. The general crop is often sown towards the end of June, when refreshing showers may be expected. It not uncommonly occupies the ground from which early peas have just been removed. But as turnips are most desirable for the table in a young state, a small sowing is commonly made once a month from April to August. If sown earlier than April, the plants are apt to run to seed. To divide the seed more equally when sown broadcast, a little fine earth is mixed with it in sowing. It is frequently sown in drills, an inch deep, and somewhat more than a foot asunder. If rain do not occur, frequent watering is of great advantage to the young crops. A light sandy loam, not recently manured, is best for turnip; in a rich garden soil, the roots are apt to become rank and woody. When the root-leaves are about an inch broad, the plants are hoed; and, if they have been sown broadcast, thinned to six or eight inches distance from each other. When young turnips are daily drawn for the table, they may be allowed to stand somewhat closer, the proper degree of thinning being accomplished by pulling for use. If sown in drills, they may stand at five inches from each other in the lines. Turnips bear transplantation with difficulty; yet in moist and rainy weather, spots where the seed has failed may be filled up. When showery weather has made the leaves spring too much, so as to threaten the production of a flower-stem, it is sometimes found useful to tread them down, by placing the foot gently on the centre of the plant. In some gardens, turnips are sown on a slight hot-bed in February, and thus forwarded by two or three weeks; but the beds must have as much air as can possibly be given.

315. For winter use many families prefer the Swedish turnip, which may either be stored or remain in the ground. The stone and the yellow are also very hardy. The surplus of the garden crop, it may be remarked, may advantageously be given to milch cows; and, if the turnips be slightly boiled, no disagreeable flavour is communicated to the milk.

316. If seed is to be saved, it is of advantage that the plants be transplanted, it being thought, that from those so transplanted a progeny having sweet and tender roots may be procured; while from the untransplanted stock-turnips, larger but coarser roots may be expected. It is very important, at all events, to have the plants intended for seed-stock kept at as great a distance as possible from all others of the brassica genus. This seclusion of the seed-stock plants is often more completely accomplished by seed-farmers, than it can possibly be in private gardens.

317. The turnip-fly, or beetle, (*Haltica nemorum*), is very destructive to the crop when in the seed-leaf. One of the easiest remedies is to sow thick, and thus ensure a sufficiency of plants both for the fly and the crop. Mr Archibald Gorrie, a Scottish gardener of merit, has found, from repeated experience, that if quicklime be slightly dusted over the crop while yet in the seminal leaf, no attack will

be made. A preventive is often found in sowing late, the young beetles being compelled to feed on other herbage, and disappearing before the turnip expands its leaves.

If garden turnips be carefully packed in the store-house, and covered with plenty of straw, they keep in good order till March or April. Some are in the practice of cutting the top close off, but others prefer keeping up the power of growing. In some places both the green tops and the small roots of stored turnips are entirely cut off. It may be mentioned, that when turnips are left in the ground over winter, the top leaves form tender greens very early in the spring, which are particularly good for eating with salted meat.

*Navew.*

318. The *Navew* or French turnip is a variety of the *Brassica Napus*, Lin. or Rape, which grows naturally in different parts of Britain. (*Eng. Bot.* t. 2146). It is the most esteemed *navet* of the French, (who have no appropriate name for our round turnips,) and the *Steckrüben* of the Germans, in some places called *Teltower Rüben.* The root is small, and oblong or carrot-shaped; of excellent flavour: "two of these in seasoning," says Justice, in his Scots Gardener's Director, "will give a higher relish than a dozen of other turnips." It was anciently used throughout the south of Europe, and was more cultivated in this country a century ago than it is now. It is still in high repute in France, Germany, and Holland. It is put whole into soups, and is merely scraped, not peeled. It is remarked by Mr James Dickson, (one of the Vice-Presidents of the London Horticultural Society, but better known as an excellent cryptogamic botanist,) that, "stewed in gravy, the navew is excellent, and being white, and of the shape of a carrot, when mixed alternately with these upon a dish, it is very ornamental." In the paper alluded to, (*Lond. Hort. Mem.* i. 27.) Mr Dickson has given different receipts by an eminent French cook in London, for dressing the navew. It succeeds in any soil, either moist or dry; but in a dry light soil the flavour is highest. In strong garden soil, the roots get as large as parsnips, and resemble them considerably; but they are coarse, and deficient in flavour. The seed is sown in April, and the plants are thinned out to about five or six inches apart. The navew is sold in Covent Garden market, but chiefly to foreigners, who prefer it much to the turnip. For seed, some of the best plants are selected, and planted as remote from other brassicæ as circumstances will permit.

*Carrot.*

319. The *Carrot* (*Daucus carota*, Lin.; *Pentandria Digynia*; nat. ord. *Umbelliferæ*) is a biennial plant. In its wild state, it is a common weed in this country, growing by the road-sides, and known by the name of *bird's-nest*, from the appearance of the umbel when the seeds are ripening. It is figured in *English Botany*, t. 1174. The root of the wild carrot is small, dry, of a white colour, and strong flavoured. The root of the cultivated variety is succulent, and commonly of a yellow or an orange colour; it is universally known, and very generally relished, when cooked in various ways.

Several varieties are cultivated, particularly the Orange carrot, with a large long root, of an orange-yellow colour; the Early horn and the Late horn carrot, of both which the roots are short and comparatively small; and the Red or field carrot, which acquires a large size.

320 Carrots are sown at two or three different seasons. The first sowing is made as early perhaps as new-year's day, or at any rate before the first of February, on a warm border, or in front of a hot-house. Some employ a gentle hot-bed for this first crop; while others only hoop over the border, and cover it with mats during frost. The main crop of carrots is put in in March or April; and in June or July a small bed is sown, to afford young carrots in the autumn months. In some places a sowing is made a month later, to remain over winter, and afford young carrots in the following spring. These, however, often prove stringy, but they are useful in flavouring soups. In light early soils, it is better that the principal crop should not be sown sooner than the end of April or beginning of May; for in this way the attacks of many larvæ are avoided. For the early crops the horn carrot is best; for the principal crops, the orange variety is preferred; but the red is also much cultivated.

The seeds having many forked hairs on their borders, by which they adhere together, are rubbed between the hands with some dry sand, so as to separate them. On account of their lightness, a calm day must be chosen for sowing; and the seeds should be trod in before raking. They are sown either at broad-cast, or in drills a foot apart. When the plants come up, several successive hoeings are given; at first with a three inch, and latterly with a six inch hoe The plants are thinned out, either by drawing young carrots for use, or by hoeing, till they stand eight or ten inches from each other, if sown by broad-cast, or six or seven inches in line. The hoeing is either performed only in showery weather, or a watering is regularly given after the operation, in order to settle the earth about the roots of the plants left.

Carrots thrive best in light ground, with a mixture of sand. It should be delved very deep, or even trenched, and at the same time well broken with the spade. If the soil be naturally shallow, the late horn carrot is to be preferred to the orange or red. When manure is added to carrot ground, it should be buried deep, so that the roots may not reach it, else they are apt to become forked and diseased. In general it is best to make carrots the second crop after manuring. From the Scottish Horticultural Memoirs, however, (vol. i. p. 129.) we learn that pigeons'-dung, one of the hottest manures, far from injuring carrots, promotes their health, by preventing the attacks of various larvæ.

A considerable quantity of carrot-seed, for the supply of the London seedsmen, is raised near Wethersfield in Essex; but much is imported from Holland. Cautious gardeners generally *prove* this and some other kinds of seeds, such as onions, before sowing. This is easily done by putting a sprinkling in a pot, and placing it under a hot-bed frame, or in a forcing-house. Other gardeners transplant a few good roots, and raise their own seed: in this case it is better to gather it only from the principal umbel, which is likely not only to afford the ripest and largest seed, but the most vigorous plants.

321. Carrots are taken up at the approach of winter, cleaned, and stored among sand. They may be built very firm, by laying them heads and tails alternately, and packing with sand. In this way, if frost be excluded from the store-house, they keep perfectly well till March or April of the following year. Some persons insist that the tops should be entirely cut off at the time of storing, so as effectually to prevent their growing; while others wish to preserve the capability of vegetation, though certainly not to encourage the tendency to grow.

Carrots are now cultivated on an extensive scale in the field. They are excellent for milch cows or for horses; so that the overplus of a garden may always be turned to good account.

From old Parkinson we learn, that carrot leaves were in his day thought so ornamental that ladies wore them in place of feathers. It must be confessed that the leaves are beautiful. If during winter a large root be cut over about three or four inches from the top, and be placed in a shallow vessel with water, over the chimney-piece, young and delicate leaves unfold themselves all around, producing a very pretty appearance, enhanced no doubt by the general deadness of that season of the year.

*Parsnip.*

322. The *Parsnip*, (*Pastinaca sativa*, L.; *Pentandria Digynia*; nat. ord. *Umbelliferæ*), is a biennial plant. The wild parsnip is not uncommon by the way sides near London, and in many parts of England, chiefly on calcareous soils: it is figured in *English Botany*, t. 556. The garden variety has smooth leaves, of a light or yellowish-green colour, in which it differs from the wild plant, the leaves of which are hairy and dark green: the roots also have a a milder taste: it does not, however, differ so much from the native plant, as the cultivated does from the native carrot. It has long been an inmate of the garden, and it was formerly much more in use than it is now. It was, in Catholic times, a favourite Lent root, being eaten with salted fish. It is doubtless a highly nutritious esculent, and the increase of its cultivation might be useful to the labouring class in England. In the north of Scotland, parsnips are often beat up with potatoes and a little butter; of this excellent mess the children of the peasantry are very fond, and they do not fail to thrive upon it. In the north of Ireland, a pleasant table beverage is prepared from the roots, brewed along with hops. Parsnip wine is also made in some places. If the crop prove too large for the use of the family, the superfluous part (as has been remarked of turnips and carrots) will be found to be very acceptable and useful to a milch cow.

The soil preferred for parsnips is a light loam, but almost any soil will do, provided it be pretty deep; the parsnip requires, however, a stronger soil than the carrot. The quarter should be trenched, or at least deeply dug, in order that the roots may have liberty to strike freely downwards. The seed is sown, broad-cast, in March, either alone, or together with a proportion of radishes, lettuces, or carrots, and in light soils it is well trodden in: the salad plants being soon removed, or the carrots drawn young, do not materially hinder the growth of the parsnips, which spread and swell chiefly in the latter part of the summer. The parsnips are hoed out to about eight or ten inches asunder, or in strong ground a little wider; and the hoeing is repeated as often as the growth of weeds may render it proper. When the leaves begin to decay, the roots are fit for use. They are taken up as wanted during the winter, the root not being in the least injured by frost. About the beginning of February, however, the remaining part of the crop is raised and stored among sand, as the roots become stringy as soon as the new growth takes place, and the flower-stalk begins to form. In some places, the whole crop is taken up in the end of October, and either stored in sand like carrots, or placed in covered pits in the manner of potatoes. If two or three large roots be transplanted to a sheltered border, they will not fail to ripen their seeds, and to afford a sufficient supply: it is proper to tie the flower-stems to stakes, as they grow high, and are apt to be broken over by the wind. Seed that is more than a year old should never be sown.

In the first volume of the Scottish Horticultural Memoirs, (p. 405), Dr Macculloch has described two varieties of parsnip, which are cultivated in the Channel Islands, and there attain extraordinary size,—the *Coquaine* and *Lisbonaise*. The former runs deep into the soil, perhaps three or four feet; the latter becomes thick, but remains short, and is therefore suited to shallow soils. The French writers describe a variety having the root of a yellowish colour, more tender, and of a richer taste than the common kind: they call it the Siam parsnip.

*Red Beet.*

323. *Red Beet* (*Beta vulgaris*, L. *Pentandria Digynia*; *Atriplices*, Juss) is a biennial plant, a native of the seacoast of the south of Europe. It was cultivated by Tradescant the younger in 1656. It was formerly called in this country *beet-rave* (or beet-radish), from the French name *bette-rave*. The leaves of the cultivated sort are large, thick, and succulent, generally red or purple; the roots large, perhaps three or four inches in diameter, and a foot in length, and of a deep red colour. They are boiled and sliced, and eaten cold, either by themselves or in salads; they also form a beautiful garnish, and are much used as a pickle. The roots of a variety having green leaves are by some accounted more tender than those of the red-leaved sort, and are on that account preferred. Others prefer those with dark red leaves, provided these be small and few in number. There is a short or turnip-rooted variety, also of a purple colour, and used for the same purposes. From its mode of growth, this is much better suited than the others to heavy or to shallow soils.

Red beet requires a light but rich soil, of considerable depth, and which has not been recently manured. The ground should be trenched, or very deeply delved, and at the same time broken small with the spade. The seed is sown in April, in drills, an inch deep, and fifteen inches asunder. If sown in March, many of the plants are apt to send up flower-stalks, and so become useless. Kitchen gardeners often sow red beet along with carrots and onions; and drawing these two last for the market when young, they leave the beet alone to occupy the ground.

324. In lifting beet for the winter stock, care should be taken that the roots be not anywise broken or cut, as they bleed much. For the same reason, the tops or leaves are cut off at least an inch above the solid part of the root. They are cleaned, and laid in close rows along the floor of the cellar or store-house, sometimes without any covering of sand, taking care, however, to exclude frost; but more frequently packed with sand in the manner of carrots.

If a few strong roots of red beet be left standing in the rows, or rather be transplanted to some convenient spot, they will next year shoot up and produce seed. The flower-stems should be tied to stakes, to prevent their breaking over. It is scarcely necessary to add, that they should be removed as distant as possible from flowering plants of the green variety, or of the white species.

325. From a variety of the garden beet, having a red skin but white flesh, sugar is prepared in some parts of France and the Netherlands; a manufacture which was introduced during Buonaparte's government, when West India sugars were utterly prohibited. A small species of beet has been cultivated for a good many years in France, under the name of *Castelnaudari*, but which is very little if at all known in this country. It is described as possessing a fine flavour, something like that of a hazel-nut. It is ready for use in August. The colour of the root is the same as that of common beet-rave; but its leaf is smaller, rounder, and rather of a livid hue.

The *White Beet*, although stated by some writers (as Salisbury, in the "Botanist's Companion") to be only a variety of the red, is in reality a very distinct species, *Beta*

*Cicla* of Linnæus; but as the leaves and not the roots of this species are used, it will fall to be treated of under the section *Spinach plants*.

*Skirret.*

326. The *Skirret* (*Sium Sisarum*, L.; *Pentandria Digynia*; nat. ord. *Umbelliferæ*) is a native of China. It has been cultivated in our gardens since the middle of the 16th century, and was formerly more esteemed and more in use than it is at the present day. In the "*Systema Horticulturæ*, by J. W. gent. 1682," *skirwort* is declared to be the "sweetest, whitest, and most pleasant of roots." It is a perennial plant; the lower leaves pinnated; the stem rising about a foot high, and terminated by an umbel of white flowers. The root is composed of fleshy tubers, of the size of the little finger, joined together in one head: these form the part of the plant used. They are considered wholesome and nutritive, but, having a sweetish taste, are not relished by many persons. They are generally boiled and served with butter like parsnips. In the north of Scotland, the plant is cultivated under the name of *crummock*. It is the *chervis* of the French.

Any light deep soil is found to answer for skirret. If the ground be naturally moist, so much the better. In very dry soils, or during long-continued drought, watering is proper. The seed is not sown sooner than the beginning of April, lest the plants should run to flower the first season, when the tubers would become harsh and stringy. Repeated thinning and hoeing are proper, as in the case of similar crops. When the leaves begin to decay in autumn, the tubers are considered as fit for use; but they are generally left in the ground, and taken up as wanted. Sometimes the plants which remain over winter are dug up in the spring, and the side-shoots, each with an eye or bud, are transplanted for a new crop. These are commonly put in with the dibble, and covered over head with an inch depth of soil. But the tubers yielded by plants propagated in this way are not so large as those of seedling plants.

*Scorzonera.*

327. *Scorzonera*, or garden viper's grass, (*Scorzonera Hispanica*, L.; *Syngenesia Polygamia Æqualis*; *Cichoraceæ*, Juss.) is a native of Spain, the south of France, and Italy. The stem rises two or three feet high, with a few embracing leaves, and is branched at top; the lower leaves are eight or nine inches long, and end in a sharp point; the flowers are yellow. It was cultivated in gardens in this country in the end of the 16th century. The tap root is the part used; it is carrot-shaped, about the thickness of one's finger; tapering gradually to a fine point, and thus bearing some resemblance to the body of a viper: it has a dark brown skin, but is white within, and abounds with a milky juice. The outer rind being scraped off, the root is steeped in water, in order to abstract a part of its bitter flavour. The plant is not, in the present day, much cultivated.

The seeds are sown in any cool deep soil, generally in drills, about a foot separate, where they are to remain, after being thinned out to four inches apart. The plant is perennial; but the roots are fit for use only the first autumn and winter after sowing, while as yet no flower-stem has risen; the roots, like all others, becoming tough when the flowers are produced. To avoid the risk of the plants running to flower the first season, the seed is not sown till the middle of April. If a few strong plants be left, they yield seeds freely the following year; or the plant may be propagated by slips in the manner of skirrets; but the roots thus procured are not so good or tender as those from seed. In some gardens, the roots are lifted in November, and stored in the manner of carrots; in others, they are left in the ground, and taken up during winter as wanted.

*Salsify.*

328. *Salsify*, or purple goat's-beard, (*Tragopogon porrifolius*, L.; *Syngenesia Polygamia Æqualis*; *Cichoraceæ*, Juss.) is a biennial plant, a native of some parts of England, but not common; figured in *English Botany*, t. 638. It is the *salsifis* or *cercifis* of the French. The root is long and tapering, of a fleshy white substance; the herb smooth, glaucous, and rising three or four feet high; the leaves resembling those of the leek, as intimated in the trivial name; the flowers of a dull purple colour, closing soon after midday; the seed, as in other species of goat's-beard, remarkable for having attached to it a broad feathery crown. It has been cultivated for a century past in our gardens, but Gerarde and Parkinson do not mention it; while they recommend the yellow goat's-beard, *Tragopogon pratensis*, which is now neglected. Salsify roots, boiled or stewed like carrots, have a mild sweetish flavour. The stalks of year-old plants are sometimes cut in the spring, when about four or five inches high, and dressed like asparagus. Salsify is at present, however, but little attended to.

It is sown in April, and thinned, like similar crops, to six or eight inches apart. A mellow and deep soil affords the best plants. They may remain in the ground all winter, and be taken up as wanted. If two or three roots be left, or be transplanted in the autumn, they will afford abundance of seed the following year.

*Radish.*

329. The *Radish* (*Raphanus sativus*, L.; *Tetradynamia Siliquosa*; nat. ord. *Cruciferæ*) is an annual plant, originally from China. It is mentioned by Gerarde; and was probably known in England long before his time. The leaves are rough, lyrate, or divided transversely into segments, of which the inferior less ones are more remote; the root fleshy, fusiform in some varieties, in others subglobular; white within, but black, purple, or white on the outside; the flowers, pale violet, with large dark veins; pods long, with a sharp beak.

There are two principal varieties, distinguished by the shapes of the roots already mentioned: 1. With fusiform roots, the long-rooted or spindle-rooted radish, the *rave* of the French; 2. With subglobular roots, the turnip-rooted radish, the *radis* of the French. The roots of both are used principally in the way of salad, in winter and the early part of spring. Formerly the leaves were often boiled and eaten; but now the roots only are employed; and as they are always used raw, the plant might, without impropriety, have been ranked under the title of *Salads*.

330. Of the spindle-rooted kind, the subvarieties much in cultivation are, the small-topped or short-topped purple, the leaves of which occupy little room; and the pink or rose-coloured, or, as it is frequently called, the salmon radish. There is also an early dwarfish short-topped red, and an early short-topped salmon radish, sown for the first crops, and used for forcing. Of the turnip-rooted kind, there are several subvarieties. The small turnip-rooted white or Naples radishes, when they appear in the green market in spring, are not unfrequently mistaken for young turnips: they should be eaten young, when crisp and mild, being, when full grown, rather hot and harsh. There is also a small turnip-rooted red radish, and the queen radish, both red and white. The black turnip-rooted or Spanish

radish (*raifort* of the French) has a dark coloured skin, but is white within; though rather coarser than the others, it is much esteemed for autumn and winter use.

Radishes are sown for the earliest crop in the beginning of November, in a sheltered border, or in front of a pinery or green-house; and they are ready for drawing early in March. More seed is sown in December or January: and sowings are continued once a fortnight till April, so as to secure a succession of young roots as they may be wanted.

Any sort of light soil answers, but it should be of sufficient depth to allow the long roots to penetrate easily. A slight covering of fern (*pteris*) is found very useful in the early spring months, when sharp frosts occur: this covering may be raked off in the day-time, and restored at night, without much injury to the leaves of the young radishes. When very dry weather occurs in the end of March, the crops are regularly watered. They who wish to have large radishes are sometimes at the pains to prick a number of holes with the finger, and to drop a seed into each hole. Only a little earth is then tumbled into it, the greater part of the hole being left vacant. The root is thus induced to swell, and long and semi-transparent radishes are procured, Some gardeners mix spinach seed with their later sowings of radishes; so that when the radishes are drawn, the other soon covers the ground. Others sow lettuce and onions along with radishes. If radishes are to be drawn when small, they are allowed to stand at two inches only apart; otherwise they have twice that space or more allowed them. When crowded, they are apt to become stringy in the root.

331. The turnip-radish is sown in February or March, and the plants are thinned out to about six inches with a small hoe. The red and the white queen radish, and the black Spanish radish, are sown from the middle of July to the middle of September, and thinned out in the same manner. They are fit for use in the beginning of September; and before hard frost comes on, they are generally taken up, and stored among sand like carrots, the tops being cut close off: in this way they are ready for use throughout the winter.

The dwarf early short-topped red, and early short-topped salmon radishes, are easily forced on a hot-bed: if the seed be sown by the middle of November, the radishes will be fit for drawing by the end of December, and will afford a supply for a month. Care must be taken to have a sufficiently thick layer of earth, to hinder them from penetrating into the dung.

The seed of any of the sorts is easily procured by transplanting a few of the best and most characteristic plants of the respective kinds: the sorts should be placed as far from each other as possible, to prevent commixture of pollen.

It may be noticed, that the young and green seed-pods are sometimes used for pickling; and are perhaps scarcely inferior to nasturtiums.

It may also be mentioned, that Delaunay, in his *Bon Jardinier*, 1815, describes a new sort of turnip-radish, introduced of late years into France from Egypt; it is remarkable for being of a yellow colour. It has more poignancy than any of the kinds, except the black; and experience has shewn that it may be produced, in the Paris gardens, at almost any season of the year.

## *Alliaceous Tribe.*

### *Onion.*

332. The *Onion* (*Allium Cepa*, L. *Hexandria Monogynia*; *Asphodeli*, Juss.) is a biennial plant, well marked by its fistular leaves, swelling stalk, and bulbous root. Neither the native country of the plant, nor the date of its introduction into this island, are known. There are several varieties in cultivation. One of the chief of these is the Strasburgh, which is of an oval shape, attains a considerable size, and keeps very long. The Deptford onion may be considered as a subvariety of the Strasburgh. The white Spanish onion grows to a large size, and is of a flat shape. Allied to this is the large silver-skinned onion, the most beautiful of all the varieties: the small silver-skinned is preferred for pickling. The globe onion is likewise much cultivated, being a good keeper; and the Reading and the Portugal are frequently sown.

333. For the principal crop, the seed is sown in February or the beginning of March, according to the state of the weather, and the dryness of the ground. The onion delights to grow on light but rich ground, which has not been recently manured: it should be well delved, broken fine, and exactly levelled. In heavy land, it is thought better to sow in the end of March or beginning of April. The seed is either sown at broad-cast or in shallow drills; a very slight covering of earth is given, and the bed is merely smoothed with the rake; the more that onions grow on the surface, the better they prove. The usual proportion of seed is about an ounce to a pole of land. Market gardeners sometimes sow thicker, with the view of drawing young onions, which are called cullings, or in Scotland *sybies* (from *ciboules*.) A small quantity of lettuce seed is frequently sown along with onions; and very fine lettuce plants are thus procured, without materially injuring the onion crop. A first hoeing is given when the plants have advanced three or four inches in growth, and they are then thinned out with the hand to about four inches apart. Another hoeing is given, generally about a month or six weeks afterwards, according to the kind of season; and the broad-cast plants are then singled out to about six inches square, and those in drills to about four or five inches in line. After the onions have begun to swell, the hoe cannot be used, and any large weeds are drawn out with the hand. If the weather be dry at the time of thinning, a plentiful watering is necessary for settling the earth to the roots of the remaining plants. About the end of August the crop is ripe, which is known by the leaves falling down. The onions are then drawn, and laid out on a dry spot of ground, such as a gravel walk, and occasionally turned. In a fortnight they are generally found sufficiently firm and dry for keeping; and they are then stored in a garret or loft, (never in a cellar,) and excluded as much as may be from the air. They are still very apt to grow; and to prevent this, some are at the pains to select the finest bulbs, and singe the radicles with a hot iron. In many places they are strung in bunches, and suspended from the roof of the loft.

334. The secondary crop of onions is sown in August or the beginning of September, and called the Michaelmas or winter crop. They are thinned in the usual way; and weeds must be carefully kept down, as they spring up very rapidly at this season of the year. In the spring months, when the keeping onions fail, part of these autumn sown onions are drawn for use: the remainder form bulbs, which are ready in the early part of summer. In the course of May, however, some bulbs will be observed pushing a flower-stem: these are cast out; and to check this tendency, and divert the growth to the bulb, the crop is *laid over*, as it is called. This operation is described by Nicol in his "Kalendar." Two people, with a rod or rake-handle, walk along the alleys, holding the rod so as to strike the stems an inch or two above the bulb, and bend them flat down. Winter onions, thus managed, may be

taken up about the end of June, and are generally firm and keep long.

In order to procure firm diminutive bulbs, proper for pickling, some seed should be sown late in the spring, perhaps about the middle of April, in light and very poor land. It should be sown pretty thick; and the seedlings need scarcely be thinned, unless where they rise absolutely in clusters. The bulbs thus treated are generally of a proper size for pickling in August. The small silver-skinned variety, it has been already mentioned, is well adapted for this purpose.

It may here be noticed, that such of the keeping onions as have sprouted in the loft are sometimes planted in a bed early in the spring, especially by market-gardeners. In a short time they appear fresh, throwing out long green leaves. They are then sent to market, tied in small bunches, and sold as a substitute for *scallions*, and under that name.

335. It has long been known, that young seedling onions might be transplanted with success. Even Worlidge, in his little treatise on gardening,* published in the end of the 17th century, praises this mode. The practice has of late years been revived, and recommended in England by Thomas Andrew Knight, Esq. and in Scotland by Mr James Macdonald, gardener to the Duke of Buccleuch at Dalkeith. Mr Knight's plan is, to sow the onion seed, at the ordinary autumn season, thick under the shade of a tree, and to transplant the bulbs the following spring: he thus procures onions equal in size and other qualities to those imported from Spain. Mr Macdonald, again, transplants the young spring sown onions. He sows in February, sometimes on a slight hot-bed, or merely under a glass frame; and between the beginning of April and the middle of the month, according to the state of the weather, he transplants the young seedlings, in drills about eight inches asunder, and at the distance of four or five inches from eath other in the row. It is evident, that, hy thus having the crop in regular rows, hoeing may not only supersede hand-weeding, but may be more effectually performed. The bulbs, thus enjoying the great and well-known advantages of having the surface-earth frequently stirred, swell to a much larger size than those not transplanted; while in firmness and flavour they are certainly not inferior to foreign onions. At the same time the transplanted onions remain free from wire-worm or rot, while those left in the original seed-bed are frequently much injured by both. The beds destined for these onions, having probably been under a winter crop, are deeply delved over in the beginning of April, and thus rendered clean at the most critical season of the year for the larvæ that infest the soil. Besides, the plants grow with superior vigour, in consequence of the repeated hoeings, and are thus better able to resist injuries. Mr Macdonald, indeed, sometimes practises the dipping of the roots of seedlings in a puddle prepared with one part of soot and three parts of earth; but this may probably be dispensed with, as it seems likely that the exemption from the attacks of the worm, or the power of resisting them, depend rather on the other circumstances mentioned. It may be added, that all the varieties of onion seem to answer equally well for transplanting.

Various means have been suggested of guarding against the attack of the maggot alluded to. One of the most simple and most important consists in selecting a fresh soil and an airy situation, never sowing on recently manured land. It is proper to avoid having very tender plants at the season when the maggot is known commonly to make its appearance: by sowing a fortnight or three weeks later or earlier, crops might often be saved. It is frequently remarked, that while spring sown onions are cut off, the autumn sown crop escapes. Mr Machray at Errol has suggested the propriety of sowing onions only after crops known not to be subject to the attacks of the maggot, such as strawberries and artichokes. This plan, he informs us, (*Scottish Hort. Mem.* i. 274.) he has practised for a number of years, and has found effectual in preserving his onions; while it is attended with no inconveniency, as nothing can be more easy than to keep up a succession of strawberry and artichoke plants.

336. The procuring of fresh seed is a matter of importance; for if it be kept over a year, a great part will not germinate. Onion seed can be ripened in our climate; but some how or other it is very apt to degenerate. A good deal, however, is yearly saved in the neighbourhood of Deptford. Imported seed is always *proved* by attentive gardeners, and also by seedsmen: a small sample being sown in a flower-plot, and placed in a hot-house, the quality, as far as capability of germination is concerned, is soon determined. When it is intended to collect home seed, some of the firmest, largest, and best shaped bulbs are selected, and planted out in February or March, in good ground, near a south wall or hedge. When the heads are formed, they are supported by lines of small cord passed between stakes. In September, if the season be favourable, the seed ripens, turning to a brown colour, and beginning to burst the cells which contain it. The heads are then gathered; and, when dried, the seeds are beat out, and kept in paper bags.

337. A bulbiferous variety is cultivated in some gardens, under the name of *Tree onion.* Its culture has been recommended by Mr George Nicol of Edinburgh, in the Memoirs of the Caledonian Horticultural Society, (vol. i. p. 350.) under the title of *Allium Canadense*, a species for which it has very generally been mistaken. The stems from two-year old plants rise more than two feet high. Several bulbs of different sizes are produced at the top of the stem, and these, as well as the root-bulbs, may be used for kitchen purposes, like common onions. They are of good flavour, though rather stronger in taste than common onions. They are well adapted for keeping, and especially for pickling. Mr Nicol observes, that they are very seldom infested by maggots; and he recommends, therefore, that a few stock-bulbs should be preserved in gardens, to provide against the contingency of the crop of common onions failing.

This bulb-bearing or tree-onion is figured in the "Botanical Magazine," plate 1469, and described by Dr Sims as merely a variety of the *Allium cepa.* It is certainly not the *Allium Canadense* of Willdenow or Pursh, (for which, as already noticed, it has been generally mistaken.) the Canadian plant having flat linear leaves, and a slender uninflated stem, with top-bulbs resembling those of garlic. But, on the other hand, it differs from the common onion, not only in producing bulbs at top, but in having a stronger alliaceous flavour, and in being perennial. Possibly therefore it might constitute a distinct species.

338. The *Egyptian onion*, or *Ground onion*, has been considered as another variety of *Allium cepa*, but seems to be more nearly allied to *A. fistulosum.* Instead of producing bulbs at the top of the stem like the former, this plant produces clusters at the surface of the ground in the manner of potatoes. It was brought from Egypt, it is believed, during the occupation of that country by the British army, and was first cultivated in the neighbourhood of Edinburgh in 1811, by Lieutenant Burn of the Royal

* *Systema Horticulturæ*, by J. W. gent.—2d edit. 1683.

Navy. The bulbs are planted in April, at a foot or sixteen inches asunder, and covered with earth only about half an inch deep. In the course of the season, a number of bulbs form in clusters around the parent bulb, as already described; those nearest the surface grow largest; those toward the centre are soonest ripe, and may be removed, to give room to the others. If intended for keeping, they should be taken up before they attain maturity. If allowed to remain long in the ground, they sometimes become of a very large size. The bulb seems quite hardy, having been observed to brave the severity of frosty weather, at least equally well as the common onion. Flower stems rise sparingly, and only from strong bulbs. In quality the ground onion seems not inferior to the common onion. It more speedily reaches maturity, being planted in April, and reaped in August and September. Maggots have not been observed to infest it; but it has not been ascertained that they will not attack it. From our own experience, we suspect that it will speedily degenerate in this country.

339. The *scallion* seems to be a third variety of the Allium Cepa, distinguished by the circumstance of its never forming a bulb at the root. Miller states, that the scallion is propagated by parting the roots in autumn; that it grows in almost any soil or situation, and resists our severest winters. He adds, that, being green and fit for use very early in the spring, it is worthy of a place in all good kitchen gardens. It was, indeed, formerly much in use; but the true scallion is now very little known, and is said to exist only in a few gardens, where it is preserved by way of curiosity. Some derive the name *scallion*, or *escallion*, from *ascalonicum*, and without more ado identify it with the rocambole, (*A. ascalonicum*); others consider it as synonymous with the Welch onion, (*A. fistulosum*); but both these species were well known to Miller, and accurately distinguished by him, and yet he describes the scallion as something different. In popular language, scallion means sometimes a thick-necked seedling onion, drawn for use in the green state; and sometimes, as already mentioned, a winter kept onion which has sprouted, and is planted for some weeks in the spring till it acquire green leaves.

*Leek.*

340. The *Leek* (*Allium Porrum*, L; *Poireau* of the French) is a native of Switzerland, and a biennial plant. The stem rises three feet, and is leafy at bottom, the leaves an inch wide. The flowers appear in May, in close very large balls, on purplish peduncles. The whole plant is used for culinary purposes; but the blanched stem is most esteemed. It is in season in winter and spring, and is chiefly used in soups, and for stewing. It is mentioned by Tusser in 1562, but was no doubt known in this country long before that date. The Welch are proverbially fond of leeks.

"Leek to the Welch, to Dutchmen butter's dear!"

sings Gay; and the description of a plain prose writer justifies the remark: "I have seen the greater part of a garden there stored with leeks," says Worlidge, speaking of Wales, "and part of the remainder with onions and garlic." Leeks formerly constituted an ingredient in the dish called *porrage*,—a name, indeed, which may be supposed to be derived from *porrum*.

There are three varieties: the narrow-leaved or Flanders leek; the Scotch, or flag leek, sometimes called the Musselburgh leek; and the broad-leaved or tall London leek. The latter variety is often cultivated; but for exposed situations, the Scotch leek is by much the more hardy.

Leeks are raised from seeds sown in the spring, much in the same way as onions, and occasionally along with these. They are at first sown closely in beds; and in June or July, when early cabbage or an early crop is removed, the leeks are planted out in rows, about a foot apart, and six inches asunder in the rows. The tips of the leaves, and the points of the fibrous roots, are commonly trimmed off before planting. A good rule is, to make a deep hole with the dibble, and merely to lay in the leek-plant up to the leaves, without closing the earth about it. In this way the stem of the leek is encouraged to swell and lengthen, and is at the same time blanched. This plan, however, must either be adopted only in moist weather, or the plants must be well watered, so as to ensure their taking root. It is remarked, that if the leaves be topped two or three times during the summer, the leeks grow to a larger size; as new heart leaves are pushed forth, and the stalks, or useful part, are thus increased. They are ready for use in the autumn and winter. When there is a prospect of severe frost, part of the leek crop is sometimes lifted, and laid, with the roots in sand, in a cellar.

In good seasons, the seed ripens perfectly well in this country. For producing seed, the largest plants are selected, and in February are transplanted to the south side of a wall or hedge. As the flower-stems advance, they are supported by strings passed along and fixed to stakes, being apt to be kroken by the wind, especially when the heads get large and heavy. When ripe, which is generally in September, the heads become brown; they are cut off along with part of the stalk, and hung up for some weeks, and the seed is then rubbed out.

*Cibol.*

341. The *Cibol*, or Welch Onion, (*Allium fistulosum*, L.; *La Ciboule de St Jacques* of the French), is a perennial plant, a native of Siberia. It appears, from Parkinson, that it was cultivated in 1629, but it was known long previously. Although called Welch *onion*, it produces no bulb; but the fistular leaves, and the lower part of the stems, are much used in salads in the spring months. They have rather more of the garlic than of the onion flavour. Sometimes they are planted as scallions; indeed, some consider this plant as the true scallion, but without sufficient evidence.

Cibols are chiefly raised from seeds, which are sown in July. The seedling plants soon appear; but, in the course of October, the leaves go off, and the ground seems quite bare. As early as January, however, they again begin to shoot, and by March they are fit for use, being then very green and tender. As might be expected of a Siberian plant, it withstands our severest winters. The wide-swelling fistular leaves give it rather a curious appearance; a few plants may therefore be suffered to stand on a south border of the garden, where they will in general ripen their seed.

Dr Johnson (*Dict. in loco*) remarks, that the name *cibol* is frequently used in the Scotch dialect, but that the *l* is not pronounced. By the term *cibo* or *sybie*, however, the Scots mean a young seedling onion of the common kind, gathered for use before the swelling of the bulb: the true cibol is very little cultivated in Scotland, and is not distinguished by the common people.

*Chives.*

342. The *Chive* or Cive, (*Allium Schœnoprasum*, L.) is

a perennial plant, of more humble growth than any of its congeners in the garden. It is a native of Britain, but not common: it occurs, among other places, in the south of Scotland, on low hills near Hawick; it is figured in "English Botany," plate 2441. The bulbs are very small and flat, and grow connected together in clusters. When gathered for use, they are cut or shorn like cresses, and on this account are generally spoken of in the plural. The young leaves are employed principally as a salad ingredient in the spring, being accounted milder than scallions. Occasionally the leaves and small bulbs are used together, slipped to the bottom, and thus forming, as it were, separate little cibols. Sometimes they are added as a seasoning to omelets; and they are useful for other culinary purposes.

Chives are readily propagated by parting the roots either in autumn or spring, and they will grow in any soil or situation. They should be repeatedly cut during the summer season, the successive leaves produced in this way being more tender. A small bed or border thus managed, will afford a sufficient supply: it will continue productive for three or four years, when a new plantation should be made. Chives are sometimes planted as an edging; and if they be allowed to grow up, they make a pretty enough appearance with their pale purple flowers in June.

*Garlic.*

343. *Garlic* (*Allium sativum*, L.; *Ail* of the French) is a perennial plant, growing naturally in Sicily, and in the south of France. The leaves are linear, long, and narrow. It has a bulbous root, made up of a dozen or fifteen subordinate bulbs, called cloves. It was cultivated in England in 1548; but had probably been known long before that period. When an entire bulb is planted, it does not fail to throw up a flower-stem in the summer; but this is not wished. Garlic is therefore propagated by detaching the cloves, and planting them; and in this way the tendency to flower is less. It may be propagated also by the seed; but this mode is tedious, three years elapsing before a tolerable crop is produced. The soil should be light and dry, well delved, and broken fine. The sets are placed four inches distant from each other in every direction, and between two and three inches deep. The smaller the cloves, the more healthy and productive are the plants. They are put in in February or March. About the middle of June the leaves are tied in knots, to prevent the stronger plants from spindling or running to flower, and to promote the swelling of the bulbs. The crop is taken up in August, when the leaves begin to wither. The roots are tied in bunches, and hung in a dry room for use. Garlic is used in seasoning various kinds of dishes, being in general introduced only for a short time into the dish while cooking, and withdrawn when a sufficient degree of flavour has been communicated. It is much more employed in French cookery than in ours. An ordinary sized bed commonly furnishes a sufficient supply for the use of a large family in this country.

*Shallot.*

344. The *Shallot* (*Allium ascalonicum*, L.) is a perennial plant, a native of the Holy Land, where it was observed by Hasselquist. *Eschalot* (or *Eschalotte*, F.) is the more correct denomination, the name being derived from Ascalon, a town in Palestine. In some old books it is styled *barren onion*, from the circumstance of its seldom sending up a flower-stalk. In size and general growth the plant resembles the chive; but it produces bulbous roots, composed of cloves like garlic. These are used for culinary purposes in the manner of garlic; but they are milder, and do not communicate to the breath the offensive flavour which garlic or even raw onions impart.

The culture of shallots is greatly similar to that of garlic; only the offsets or cloves are planted more early, and the crop is somewhat sooner taken up. The smallest and longest cloves form the best sets, being least subject to grow mouldy. A good soil is desirable for them; but one that has been manured for a former crop is to be preferred; for in soil newly dunged the plants are much more apt to be infested with maggots. Mr Marshall very properly recommends planting in autumn where the soil is dry, and in spring where it is naturally damp. The severest frosts seem to have no effect in injuring the roots. The crop is taken up, in the end of summer, when the leaves become discoloured; and the bulbs are hung up in nets in a cool airy place, for use.

Mr Machray at Errol mentions (*Scottish Hort. Mem.* i. 275), that he has found soot mixed with the manure given to shallot beds effectual in preventing the appearance of maggots, while the shallots were improved in size. But Mr Henderson, gardener at Delvine in Scotland, has recommended the planting of shallots in autumn, as the surest way of enabling them to escape or withstand the attacks of these vermin, (*Scottish Hort. Mem.* i. 200.) He plants his shallots about the middle of October, the ground being previously manured with old well-rotted dung mixed with house ashes. He mentions, that he had, on one occasion, a parcel of spring planted shallots only seven feet distant from those planted in autumn; and that the former were totally destroyed by the maggot, while the latter proved productive and good.

*Rocambole.*

345. The *Rocambole* (*Allium Scorodoprasum*, L.; *Ail d'Espagne* of the French) is a perennial plant, indigenous to Sweden and Denmark. It has compound bulbs like garlic, but the cloves are smaller; it sends up a stem two feet high, which is bulbiferous. We know that the rocambole was cultivated by Gerarde in 1596, but it was probably introduced long before. The cloves are used in the manner of garlic or shallot, and nearly for the same purposes. At the top of the stem, along with the flower, in July and August, small bulbs (which have sometimes been called *seeds*) are produced; these may likewise be used, and indeed they are, strictly speaking, the proper rocamboles.

The plant may be propagated by means of either sort of bulbs; but those of the root are most speedily productive. They are commonly planted in the spring; but in dry ground they are put in in the autumn, the produce being in this way of a larger size. Those plants which do not push up a flower-stem naturally produce the strongest root-bulbs; and if it is not wished that the plants should fruit, the smaller the offsets planted the better. The culture is otherwise the same as that of garlic. A few rows of rocambole are sufficient.

## *Spinach Plants.*

*Spinach.*

346. *Spinach* (*Spinacia oleracea*, L.; *Diœcia Pentandria; Atriplices*, Juss. *Epinard*, F.) is an annual plant, with the leaves large, the stems hollow, branching, and, when allowed to produce flowers, rising two feet high. It is diœ-

cious, or the male and the female flowers are produced on different plants; the former come in long spikes; the latter appear in clusters, close to the stalk, at every joint. Spinach is the only diœcious plant cultivated for culinary use. Western Asia is the country of which our garden spinach is considered as originally a native. It has been cultivated in Britain, from the earliest times of which we possess any horticultural record, for the sake of the leaves, which are used in soups, or boiled and mashed, and served up with butter, and eggs hard done.

There are two principal varieties, the prickly-seeded, with triangular, oblong, or sagittate leaves; and the smooth-seeded, with round or blunt leaves. The former is the more hardy, and is employed for winter culture; the latter has more succulent leaves, and is preferred for summer crops.

For the winter crop, therefore, the seed of the prickly kind is sown in the beginning of August, when rains may soon be expected. A light dry but rich soil is preferred; and a sheltered situation is desirable. When the plants shew four leaves, the ground is hoed, and the spinach moderately thinned; and the hoeing is repeated, as the growth of weeds may require. In October and November, the outer leaves of the spinach are generally fit for use; and in mild weather, during the winter and early spring, successive gatherings may thus be procured. In February, some fine dry days generally occur, and at this time the surface of the ground around the winter spinach is stirred, the plants cleaned, and finally thinned out. With due attention, the prickly spinach thus proves productive till April or May.

The first sowing of smooth-seeded or round-leaved spinach is commonly made in the end of January, on a sheltered border. This early crop, if sown broad-cast, is at first thinned out to three inches apart, and, at subsequent hoeings, to eight or ten inches. Successive sowings are made in February, March, and April, in the ordinary garden compartments, and these are at once thinned out to six or eight inches apart. In some places these crops are placed between wide rows of cabbages, as they afford a crop before the cabbages advance much in growth. Sometimes radish seed is sown along with them, the radishes, on the other hand, being drawn off in time to give room to the spinach. If spinach be sown late in the season, it is done only on moist clayey grounds, the quality of which, while it promotes the production of leaves, rather retards the inclination to flower; and the sowings are repeated every fortnight. Spinach is often sown in shallow drills, about a foot asunder: this mode is more troublesome at first; but this is compensated by the facility with which the thinning, cleaning, and gathering, are afterwards accomplished: indeed, less thinning is necessary, as drilled spinach is generally cut straight over like cresses. When spinach is sown in drills, between rows of other vegetables, the prickly-seeded should be preferred, even in spring, as it does not grow so large, nor spread so wide.

When spinach seed is wanted, the plants are thinned out to at least a foot separate. A very few plants with staminiferous spikes are sufficient for fertilizing a considerable row of the female or seed-bearing plants. The seed ripens in August; it should be covered with a net, small birds being very fond of it.

*White Beet.*

347. The *White Beet* (*Beta Cicla*, L.; *Pentandria Digynia; Atriplices*, Juss.) is a biennial plant, a native of Portugal and Spain. This has been known and cultivated in gardens since the days of Gerarde and Parkinson; not for the sake of the roots, which are generally small, seldom larger than a person's thumb, but for the lower leaves and their footstalks: the leaves are thick and succulent, and are boiled as a spinach, or put into soups. There is a larger variety, called the great white or sweet beet, of which the stalks and midribs of the leaves are stewed and eaten as asparagus, under the name of *chard*.

White beet is sown in the beginning of March, on an open spot of ground. When the plants have put out four leaves, they are hoed and thinned out to at least four inches asunder. A month afterwards, a second hoeing is given, and the plants are left perhaps eight inches separate. The outer leaves being first picked for use, a succession is afforded for the whole season. The plants endure for two years, but it is best to make a small sowing annually. When beet-chards are wanted, the plants are frequently watered during summer; they are kept protected with litter over winter, and have earth heaped against them. In this way the chards may be had till the approach of the following summer.

348. A variety, by some considered a hybrid, between the red and the white beet, having very large roots, as well as large leaves, was introduced into this country about the year 1786, chiefly by the exertions of the late distinguished Dr John Coakley Lettsom. It was called, in Germany, Mangold-Wurzel, or Beet-Root; but Abbé Commerell, in recommending it in France, having mistaken Mangold, *beet*, for Mangel, *want*, converted the name into Racine de Disette; and in this country we have sanctioned the blunder, by adopting the name, Root of Scarcity. Of this variety most of the roots weigh 10lb. or 12lb.; in rich and deep soil, often 20lb. Some which grew in the island of St Helena weighed above 50lb. each. The seed is sown in March; and the seedlings, when their roots are the size of goose-quills, are transplanted into rows a foot and a half distant, and nearly as much apart in the rows. In transplanting, the leaves are cut over at top, but the roots are not touched; and the tap root is not fully sunk in the soil, but only so deep as that half an inch may project above ground. The root is rather coarse for table use, but excellent for cattle. The mid-rib of the leaf, dressed like asparagus, is pretty good.

*Orache.*

349. *Garden Orache*, or Mountain Spinach, (*Atriplex hortensis*, L.; *Polygamia Monœcia; Atriplices*, Juss.) is an annual plant, a native of Tartary. The stem rises three feet high; the leaves are various in shape, thick, pale green, and glaucous, and of a slightly acid flavour. There are two varieties, the White or pale green, and the Red or purple. Orache was formerly much cultivated as a spinach; but now it is less frequently sown. Some, however, prefer it to common spinach, and it is much used in France. It is sown in drills, in autumn, soon after the seed is ripe; and the plants are thinned out, next spring, to four inches asunder. The stalks are good only while the plant is young; but the larger leaves may be picked off in succession throughout the season, leaving the stalks untouched, and the smaller leaves to increase in size; and still the spinach thus procured will be found very tender.

*Wild Spinach.*

350. *Wild Spinach*, or Good Henry, (*Chenopodium bonus Henricus*, L.; *Pentandria Digynia; Atriplices*, Juss.) is a perennial plant, indigenous to Britain, growing by road-sides in many places. It is figured in Sowerby's "English Botany," pl. 1033. The stem rises rather more than a foot

high; it is round and smooth at the base, but upwards it becomes somewhat grooved and angular; it is covered with minute transparent powdery globules. The leaves are large, alternate, triangular arrow-shaped, and entire on the the edges. While young and tender, it makes no despicable substitute for spinach. Curtis mentions, that in some parts of Lincolnshire it is greatly esteemed, and cultivated in gardens in preference to common spinach. Withering observes, that the young shoots, peeled and boiled, may be eaten as asparagus, which they resemble in flavour. The leaves are often boiled in broth, of which they form a very palatable ingredient.

The seed is sown in March or April, in a small bed. In the course of the following September, in showery weather, the seedlings are transplanted into another bed, which has been deeply dug, or rather trenched to the depth of a foot and a half, the roots being long and striking deep, while at the same time they are branched; so that each plant should have a foot or fifteen inches of space. Next season the young shoots, with their leaves and tops, are cut for use as they spring up, leaving perhaps one head to each plant, to keep it in vigour. The bed continues productive in this way for many successive years. The first spring cutting may be got somewhat earlier, by taking the precaution of covering the bed with any sort of litter during the severity of winter.

### *Herb Patience.*

351. *Garden Patience*, or Patience Dock, (*Rumex Patientia*, L.; *Hexandria Trigynia; Polygoneæ*, Juss.) is a perennial plant, a native of Germany. The leaves are broad, long and acute pointed, on reddish foot-stalks; the stems, when allowed to spring up, rise to the height of four or five feet. In old times, garden patience was much cultivated as a spinach. It is now very much neglected, partly perhaps on account of the proper mode of using it not being generally known. The leaves rise early in the spring; they are to be cut while tender, and about *a fourth part of common sorrel* is to be mixed with them. In this way patience dock is much used in Sweden, as we have been informed by the late Sir Alexander Seton of Preston, who had an estate in Sweden, and frequently resided there. This mixture may be safely recommended as forming an excellent spinach dish. Garden patience is easily raised from seeds, which may be sown in lines in the manner of common spinach, or white beet. If the plants be regularly cut over two or three times in the season, they continue in a healthy productive state for a good many years.

## *Boiled Salads.*

Under this title (not perhaps strictly correct, as *salad* may be considered as implying rawness in the vegetable) we include a few plants which cannot well be ranked as pot-herbs, and yet are generally boiled before being presented at table. One of the chief of these is

### *Asparagus.*

352. (*Asparagus officinalis*, L.; *Hexandria Monogynia; Asparagi*, Juss.; the Asperge of the French, and Spargel of the Germans.) This is a perennial plant, which occurs native in some parts of England, as near Bristol, and in the Isle of Portland; and it has been observed sparingly in one place in Scotland, Seaton Links, East Lothian. It is figured in "English Botany," t. 339. In its native state it is so dwarfish in appearance, even when in flower, that none but a botanist, attending to the minute structure, would consider it as the same species with our cultivated plant. The roots consist of many succulent round bulbs, forming together a kind of transverse tuber; numerous stems arise, with alternate branches, subdivided into alternate twigs; the leaves are very small, linear and bristle-shaped; the flowers yellowish-green, the berries red. The whole plant, with its fruit, is very elegant in appearance, and is often placed in chimneys as an ornament in the autumn months. The early shoots, when about three or four inches high, are greatly esteemed for the table. For the sake of these, the plant has been cultivated in gardens for ages.

There are two varieties, the Red-topped and the Green-topped; the former commonly rising with a larger shoot, but not reckoned so delicate in flavour as the green sort.

353. Asparagus is propagated either by seeds, or by year-old plants purchased from nurserymen or market-gardeners. It is best to raise the plant from seed; and it is of considerable importance to procure the seed from an experienced and attentive gardener: for seed gathered from the strongest and most compact shoots, is found, as might naturally be expected, to yield by much the better plants. It is sown as broad-cast on a seed-bed in March, not very thickly, and the bed is slightly trodden, and raked smooth; or it is sometimes sown in shallow drills, six inches asunder, and earthed in, from half an inch to an inch deep. The young plants are kept as free of weeds as possible during the summer; and in the end of October following, some rotten dung or other litter is spread over the surface of the ground, to protect the buds during winter. In the following March or April, according to the dryness of the season, these year-old plants are transferred from the seed-bed into a quarter prepared for them.

Asparagus ground should be light, yet rich; a sandy loam, well mixed with rotten dung or sea-weed, is accounted preferable to any. The soil should not be less than two feet and a half deep; and before planting a bed, it is considered good practice to trench it over to that depth, burying plenty of dung in the bottom, as no more can be applied there for eight or ten years. It can scarcely therefore be too well dunged: besides, although the plant naturally grows in poor sandy soil, it is found that the sweetness and tenderness of the shoots depend very much on the rapidity of the growth, and this is promoted by the richness of the soil. Damp ground or a wet subsoil are not fit for asparagus: indeed the French consider wetness as so prejudicial to this plant, that they raise their asparagus beds about a foot above the alleys, in order to throw off the rain.

The plants are generally raised with a narrow-pronged fork, to avoid cutting the roots; and when they are taken up, the roots are kept in a little earth, or covered with a mat, till replanted, being very apt to sustain injury from drying, or being too much exposed to the air. A trench about six inches deep being prepared, the roots are carefully laid in, a foot distant from each other, the buds or crowns being kept upright, and about two inches below the surface. A foot between each ordinary trench is reckoned sufficient; but between every four rows a double distance is left for an alley. Some plant in single rows, at two feet and a half, or perhaps three feet apart; and this is by many experienced asparagus farmers considered as better than the bed form.

It is a general rule, that, in dry weather, the new planted beds or rows should be carefully watered. With attention to this rule, asparagus may be transplanted at a later period of the season than March or April. From the Scots Horticultural Memoirs, (Vol. i. p. 71.) we learn that this operation has been very successfully performed at midsummer. The plants were at that time fourteen months old, and from twelve to fifteen inches high. Being removed with care, and well watered, none of them failed; on the contrary, they gained considerably on those left in the seed-bed. Next spring the remainder of the seedlings were planted out, but many of them failed, while the midsummer plantation continued to grow vigorously, and far surpassed those that survived of the spring planting.

354. Another mode of propagating asparagus is followed by some cultivators. They sow the seeds in the spot where the roots are to remain, either by dibbling holes about half an inch deep, and at a foot distant, and dropping two seeds into each hole, for fear of one failing; or making drills an inch deep, and three feet asunder, and sowing rather thickly, so as to insure a crop, and afterwards thinning out, at first to five or six inches, and ultimately to nine or ten. In this way, it is thought, stronger plants are produced.

It is a common practice to take a crop of onions along with the drilled seedling asparagus; and likewise to plant rows of cauliflower, or sow drills of carrot or turnip, between the lines of transplanted asparagus the first year.

Several hoeings are given in the course of the summer, generally three. In the end of September, or beginning of October, the haulm decays, and is cut over; all the refuse is dug into the alleys, and the superfluous earth thus acquired is often spread over the beds to the depth of an inch or more, which is called *landing up*. Frequently small dung, or perhaps sea-weed, is spread on the beds, and this is accounted the better practice; the surface being previously stirred with a fork, so as to allow the juices of the manure washed down by the rains to be readily imbibed.

In the spring dressing of the beds, the intervals are slightly delved over. For this purpose, the narrow pronged fork, already mentioned, is generally employed, being much less apt to injure the roots. This dressing is given just before the buds begin to appear, and the raking requires some delicacy of hand.

The same practice, both for the autumn and spring, is observed for the second year; it being only in the third year after planting out, or the fourth from the seed, that cutting for use is begun. In April, a few shoots may generally be cut; in May and June they come rapidly and copiously. In the first productive season, only the large buds or shoots are taken, the smaller being left to spring up and draw strength to the plants. In subsequent years all the shoots are gathered as they advance, till the end of June or beginning of July. A common rule is, to cease to cut, or to let asparagus *spin*, (grow up,) when green peas come in. With due attention, an asparagus quarter may be kept in a productive state for ten years or more. In cutting the shoots for use, some of the earth is removed, in order to enable the gatherer to avoid the succeeding buds below. Some use a common gardener's knife, and others employ a narrow-pointed knife, with its blade notched like a saw. Shoots two inches under the ground, and three or four above, make the best dishes of asparagus. The crop, if judiciously cut, may last nearly three months; from the middle of April to the middle of July. An asparagus quarter should not contain less than a pole of ground, as it often needs this quantity to furnish a good dish at one time. For a large family about sixteen roods are kept in a productive state, which are calculated to furnish, on an average, between 200 and 300 shoots every day in the height of the season. Several of the market gardeners in the neighbourhood of London have many acres of asparagus ground, as mentioned in a former part of this article, § 38.

355. The *forcing* of asparagus was practised in England in the middle of the 17th century. Meager mentions, that the London market was, at that period, supplied with forced asparagus early in the year: "Some having old beds of asparagus which they are minded to destroy, and having convenience of new or warm dung, lay their old plants in order on the dung, and the heat doth force forward a farewell crop," (p. 188.) The forcing of this article is now carried to a considerable extent in the neighbourhood of London. It is likewise very generally practised in private gardens.

A common hot-bed, prepared with horse dung, is formed according to the size of the frame or frames. A layer of turfs is sometimes placed on the dung, to prevent the access of the vapour from it, which is apt to hurt the flavour of the crop. About four inches of good light soil or old tan-bark are placed on the turf. In this plants six or eight years old are closely deposited. These plants are sometimes got from nurserymen, to whom such stock is no longer useful; or one of the oldest beds in the garden is for this purpose sacrificed, care being taken to have succession beds coming forward. But where the demand for the market, or for a private family, is regular, the best way is to have several successive beds in progress. Those plants intended for forcing may be transplanted as usual when one year old, but in much closer order, and so kept till the fourth year. A three-light garden frame will hold from 600 to 800 three-year-old plants. The roots are placed as close together as possible (as already hinted,) with the buds standing upright, and covered with three or four inches of soil. The temperature of the dung is generally regulated merely by guessing the heat imparted to sticks plunged into it: if it becomes too weak, a *lining* of weeds or dung is heaped around the sides: if it prove too strong, some air holes are formed, by pushing large sticks into the sides and withdrawing them, leaving empty spaces, or by removing the glass covers for some time. The proper temperature is about 55° Fahrenheit. Air is occasionally admitted, by raising the glasses a little; and sometimes a slight watering is necessary. At other times, in severe weather, mats are laid over the frames. A little fine light earth is sometimes added, once or twice, as the buds rise. In five or six weeks some of the shoots are generally fit for gathering. In France they often cut in a fortnight; but shoots produced in this rapid way are in a great measure colourless and tasteless, having been forced nearly without access of light and air. In gathering the shoots from a hot-bed, it is thought better to avoid cutting with a knife, and to employ only the finger and thumb; by a gentle twist the shoot is detached, and with less risk of injuring the tender buds below. Each light or frame yields on an average 300 shoots, which come in succession during about three weeks. Where a regular winter supply of this article is desired, beds are made up in succession accordingly, from November to March. After being forced, the plants are cast on the dunghill as useless.

M. Nicol describes a mode of forcing asparagus in flued pits, such as are used for young pine-apple plants. A layer of old half rotten bark, placed over well fermented dung, forms the bed, the plants being placed in light dry earth. Very little fire-heat is found to be necessary; generally a slight fire at night is sufficient. Watering, and the regular admission of air, are to be attended to. He remarks, that by means of very simple expedients, one half of a flued pit may be forced, and the other kept back, and thus a succession of shoots secured.

356. Asparagus, it may be remarked, was a favourite of the Romans; and they seem to have possessed a very strong growing variety, as Pliny mentions that, about Ra-

venna, three shoots would weigh a pound; with us, six of the largest would be required. It is much praised by Cato; and as he enlarges on the mode of culture, it seems probable that the plant had but newly come into use. In this country, Dutch asparagus was preferred in the end of the 17th century; and this variety is still distinguished for affording the thickest shoots. In a garden formed at Dunbar in the very beginning of the 18th century, by Provost Fall, (a name well known in the mercantile world,) asparagus was for many years cultivated with uncommon success. The variety used was the red topped, and it was brought from Holland. The soil of the garden is little better than sea sand. This was trenched two feet deep, and a thick layer of sea-weed was put in the bottom of the trench, and well pressed together and beat down. This was the only manure used either at the first planting, or at subsequent dressings. There was an inexhaustible supply of the article generally at hand, as the back-door of the garden opens to the sea-shore.

*Sea-Cale.*

357. *Sea-Cale*, (*Crambe maritima*, L.; *Tetradynamia-Siliquosa*; nat. ord. *Cruciferæ*), is a perennial plant, growing naturally on many of the sandy and gravelly beaches of the west of England, and also among cliffs on the sea coast of Essex and Sussex. It is not mentioned by Lightfoot in his Flora of Scotland; but it grows on the shore of the Frith of Forth at Caroline Park, near Edinburgh. It is figured in English Botany, t. 924. The roots are spreading (rather than creeping, as they are commonly described); the whole plant is smooth, glaucous, or covered with a fine bloom; the lower leaves large and waved; the stalks rise near two feet high, producing white flowers, followed by spherical seed-pods, resembling peas, each containing only a single seed.

358. The common people, particularly on the western shores of England, have for time immemorial been in the practice of watching when the shoots begin to push up the sand or gravel, in March and April, and cutting off the young shoots, which are thus blanched and tender, and using them as a pot-herb. It was toward the middle of the 18th century, however, before sea-cale was introduced into the kitchen-garden. About the year 1767, it was first brought into general notice in the neighbourhood of London by the late distinguished Dr Lettsom, who cultivated it in his garden at Grove Hill. In the "*Gardener's Dictionary*," published in 1774, by James Gordon at Fountainbridge, are contained directions for the cultivation of this vegetable, and for blanching it by covering the beds four inches deep with sand or gravel. A good many years afterwards, a detailed account of its culture was given by the Rev. Mr Laurent, in the third volume of Young's *Annals of Agriculture*. The late Mr Curtis, well known for his botanical writings, next published a tract recommending it; and in the first volume of the *Transactions of the Horticultural Society of London*, there is a very good paper on its cultivation, by Mr John Maher, gardener at Edmonton. It is now become a pretty common vegetable in Covent Garden market, and has even begun to appear on the green stalls of the Scottish metropolis.

359. The bed or quarter intended for sea-cale is trenched deep, at least two feet. The soil should be sandy and light, but at the same time mixed with fine rich mould; and it may here be noticed, that of all manures for this crop, *drift ware* or sea-weed is the best. The plant may be propagated either by offsets or pieces of the roots having two or three eyes or buds attached to them, or by seeds. The latter mode is generally preferred. The seeds are sown in March, perhaps about two inches deep. Three seeds are sometimes set in a triangular form, six inches apart, leaving a space of two feet between the triangles. If the quality of the seed is any wise doubtful, two or more are commonly put in each hole, to make sure of a crop, any superfluous plants being afterwards thinned out. During the first summer, the only culture necessary is hoeing, to keep the plants clear of weeds. In November, some gardeners cover the whole bed with rotten dung, in the way that is often practised with asparagus. This is raked off in the spring, and the surface of the earth stirred with the asparagus fork. During the second year, the same plan is followed. In the third year, most of the plants will be strong enough to be blanched for use.

360. The blanching is accomplished in different ways. For a long time the only provision for this purpose was, to make the shoots pass through several inches of soil before reaching the surface, and afterwards drawing up the earth to them as they advanced. It was an improvement to use sifted coal-ashes for the earthing up, and a farther improvement to use old tree-leaves for that purpose. Some cultivators placed hoops over the beds, and covered them close with mats. Large flower pots, such as are denominated No. 1, inverted over the plants, were found very useful in forwarding the etiolation, and in keeping the plant crisp and clean. Blanching pots with handles were afterwards used; and a figure of one of these is given in the *London Horticultural Transactions*, vol. i. plate 1. A very great improvement in the constructing of blanching pots was suggested by Mr R. A. Salisbury, Secretary to the London Horticultural Society,—the making them in two pieces, or with moveable tops or lids. Such are now used in the neighbourhood of Edinburgh, and are found exceedingly convenient; a figure of one of them may be seen Plate CCCXII. Fig. 5. These pots should be nearly as wide at top as below, in order to give room for the cutting of such shoots as are ready, without breaking the others; and the covers should fit very nicely, so as to exclude light and air as completely as possible; the pot in this way serving not only for blanching, but to a certain extent for forcing. It is necessary to have from thirty to fifty such covers; each affording only as much as will form a dish, during the season. Sir George Mackenzie, Bart. whose name has more than once been mentioned as a horticultural improver, has described (*Scottish Hort. Mem.* i. 313) a simple and easy mode of blanching practised in his garden at Coul. This consists in covering the beds with clean dry straw, which is changed when it becomes wet or heavy. Oat straw, when it is broken in the thrashing-mill, is found to be well suited for this purpose.

361. It is justly remarked by Nicol, that vegetables are seldom improved by forcing; but that sea-cale is perhaps an exception; the forced shoots produced at midsummer being more crisp and delicate in flavour than those procured in the natural way, in April or May. Certainly no vegetable is more easily or more cheaply forced. It is done in two ways; either in the beds in the open air, or in hot-bed frames or flued pits. In the open air beds, the operation consists merely in placing blanching covers over the plants as soon as the leaves are decayed in the end of autumn; and then covering up the whole bed with stable-dung, packing it closely between the pots, and heaping it over the tops of them to the depth of six inches or more. In the course of December the sea-cale vegetates, and advances in proportion to the heat generated by the fermentation of the covering of dung. In general, it is fit for cutting in January and February. If the heat of the litter at any time decline, a portion of new stable dung is mixed with it. The advantages of having blanching pots with

moveable lids, are, in this kind of forcing, very great: the temperature may more easily be ascertained, by lifting a lid in one or two parts of the bed, and introducing a thermometer: in the same way, it is easy to examine whether the shoots be ready for cutting, and to select the most forward from several stools, without materially disturbing the dung and dissipating the heat. The method of forcing sea-cale on the open ground was described by Mr Maher, in 1805, in the paper above alluded to; but he was not acquainted with blanching-pots having moveable tops. It is also described by Nicol, in his "Kalendar," 1810, with the improved blanching-pots. It is curious, therefore, that Abercrombie, in his "Practical Gardener," 1813, should take no notice of it, while he recommends planting sea-cale in hot-beds under frames and glasses.

362. Mr Barton, gardener at Bothwell Castle in Scotland, covers the sea-cale beds to the depth of a foot and a half, with leaves, as they fall from the trees, and are raked from the shrubberies and walks in the end of autumn, adding over all a very slight layer of long dung, sufficient only to keep the leaves from being blown about. The shoots rise sweet and tender among the leaves, early in the spring, being in some measure forced, and very perfect etiolation is at the same time accomplished.

In a hot-bed frame, or in flued pits, sea-cale is forced nearly in the same manner as asparagus. The plants should be strong and healthy, and at least three years old: they are by this mode of forcing exhausted, and not worth preserving. The best way therefore is, to sow a bed of sea-cale annually: in this way a regular succession of plants will always be ready, either for forcing in the open ground or in hot-bed frames.

By the various improvements, therefore, of late years made in the culture of sea-cale, this desirable vegetable may be commanded for table, with very little trouble or expence, at any time from November till May; a period including all the dead months of the year. It may be affirmed that sea-cale shoots, when duly blanched, are not inferior to asparagus when prepared like it; and farther, that they form an excellent ingredient for soups. Not only the head or shoot (sometimes also called the crown) is fit for use, but the blanched stalks of the unfolding leaves, four or five of which are attached to each head. Before boiling, these are detached, and tied in small bundles like asparagus. It is a vegetable which (as remarked by Sir George Mackenzie, in the paper already mentioned) cannot easily be overdone in cooking; it should be thoroughly drained, and then suffered to remain a few minutes before the fire, that a farther portion of moisture may be exhaled. From four to six heads, according to the size, make a tolerable dish.

363. It is somewhat strange, that in France the use of sea-cale as a delicate culinary vegetable should be nearly unknown. Bastien, in an edition of his popular *Manuel du Jardinier*, published in 1807, describes the *chou marin d'Angleterre* correctly enough; but he appears to have tried to make use of the full grown leaves, instead of the blanched shoots, in early spring: a coarser mess can hardly be imagined; and it is no wonder therefore that he should deny the merits of sea-cale, and resign the plant, as he does, with a sneer, to colder climates!—*mais elle convient mieux que d'autres dans des climats froids.* When the French gardeners learn how to cultivate it, and particularly when they are able to force and to blanch it at mid-winter, by the simple means above described, there can be no doubt that sea-cale will become a favourite with the Parisians.

When seed is wanted, if two or three strong plants be left to flower, they will not fail to produce it in plenty. The flower is of a rich white colour, and gives the plant an ornamental appearance; when fully expanded, the flowers smell strongly of honey.

### *Artichoke.*

364. The *Artichoke* (*Cynara Scolymus*, L.; *Syngenesia Polygamia Æqualis; Cinarocephalæ*, Juss.) is a perennial plant. It is a native of Italy, according to Linnæus, and of the south of France, according to Garidel: but Beckmann, (*History of Inventions and Discoveries*, translated by Johnston, vol. i. p. 339, et seq.) has given reasons for thinking, that its native country is uncertain, the Italian and French specimens being probably only the outcasts of gardens, and that the plant mentioned by ancient Greek and Roman writers, is not to be considered as our artichoke, but as a similar plant, the true artichoke having been brought to Italy from the Levant only in the 15th century. It is not known to have been cultivated in English gardens till near the middle of the 16th century.

It is a remarkable and a well known plant in gardens. From the root spring many large pinnatifid leaves, three or four feet long, covered with an ash-coloured down; the midrib deeply channelled and furrowed. The appearance of the flower-heads is familiar. These, in an immature state, contain the part used, which is the fleshy receptacle, commonly called the *bottom*, freed from the bristles and seed-down, vulgarly called the *choke*. In the usual way of cooking, the entire heads are boiled. In eating, the portions of the receptacle adhering to the base of the calyx-leaves or scales are also used. The bottoms are sometimes fried in paste, and they form a desirable ingredient in ragouts. They are occasionally used for pickling; and sometimes they are slowly dried, and kept in paper bags for winter use. In France the bottoms of young artichokes are frequently used in the raw state as a salad; thin slices are cut from the bottom, with a scale or calyx-leaf attached, by which the slice is lifted, and dipped in oil and vinegar before eating.

365. There are two varieties cultivated; the French conical, or green artichoke; and the Globe or red artichoke. The head of the former is rather of an oval shape; the scales are open, and not turned in at top, as in the globe artichoke. The latter is distinguished not only by the shape, and by the position of the scales, but by being chiefly of a dusky purple colour. The receptable of the globe artichoke is more succulent than that of the French, but the latter is generally considered as possessing more flavour.

Artichokes are increased by rooted slips or suckers taken off at the time of the spring dressing, in the beginning of April. They delight in a light loam, cool but dry, and which is at the same time rich and deep. In preparing for this crop, the soil should be trenched to the depth of three feet, or at least two feet and a half, and manure should be liberally placed in the bottom of the trench. In dry weather, the young plants require regular watering for some time. Artichokes will grow pretty well in a situation somewhat shaded, but they should not be under the drip of trees. In a free and airy situation, however, the heads are of better quality.

Nicol mentions, that the strongest crops he ever saw, grew in rather a mossy earth that had been trenched fully a yard in depth, and had been well enriched with dung, and limed; and that the plants were generally covered before winter with a mixture of stable litter and sea-weed. This last article, we believe, is one of the very best manures for artichokes. In no place is the plant to be seen in greater perfection than in gardens in the Orkney

Islands; and we know that the luxuriance of the plants in these is to be ascribed to the liberal supply of sea-weed dug into the ground every autumn. It was long ago remarked by a horticultural writer, that "water drawn from ashes, or improved by any fixed salt, is very good for artichokes." *Systema Agriculturæ*, 1682.

366. The plants are often placed four feet apart every way: sometimes they are planted three feet apart in rows, and the rows are kept six feet asunder. In many of the market-gardens near London, the rows are eight or ten feet from each other; intermediate low growing crops are sown or planted, the artichokes being always allowed five feet free. Some gardeners plant two offsets together; and if both survive and prove strong, they afterwards remove one. Others plant three offsets in a triangular patch or stock, each offset being ten or twelve inches from the other; and these stocks are afterwards treated as if they were single plants. A crop of spinach or turnip is generally taken, for the first year, even between the closest rows. At the end of the first season after planting, a small and late crop of artichoke-heads is procured, generally in October. In the second year, the leaves of the plants will almost meet in the rows.

To encourage the production of large main heads, some detach all the lateral heads in a young state. These are commonly in a fit state for eating raw, having attained about one third of their proper size; and they are for this purpose frequently sold in Covent Garden market, chiefly to foreigners. Another thing, practised with the same view, is the shortening the ends of the large leaves. When all the heads are gathered, the whole stalks are broken down close to the ground, in order to save the useless expenditure of sap, and to promote the setting out of young shoots at the root.

In November the plants are earthed up, or, in other words, a portion of earth is drawn around each plant. It was formerly a custom to make a trench between the rows, and to fill this trench "with dung which would not freeze;" the earth thrown out, forming a ridge around the plants. Some modern writers recommended the making of the trench, but omitted to speak of filling it with dung; so that the roots of the plants were thus more exposed than if the ground had been left untouched. In this way the forming of any trench came into disrepute; and, as already noticed, the best practical gardeners now only draw the earth from the surrounding surface towards the plants. Long dung, peas haulm, old tanners' bark, or such stuff, are then laid around, but kept at some distance from the stems and leaves of the plants.

367. The spring dressing is equally important. The litter and earth being removed, in March or April, according to the kind of season, the stocks are examined; and two or three of the strongest or best shoots being selected for growing up, the rest are removed: this is often done merely by pressure with the thumb, but sometimes a knife or chisel is employed. It was formerly mentioned that this is the proper time for procuring young plants. It is remarked by gardeners, that the shoots from the under part of the stock, which are soft and crisp, are preferable to those from the crown of the roots, which have hard and rather woody stems. If the shoot be six or eight inches long, it is enough; and if it be furnished with two or three small fibres, they are sufficient to ensure its growth.

Artichoke plants continue productive for several years; but, every season, some well-rotted dung, or fresh sea-weed, should be delved into the ground at the winter dressing. It is certain, however, that after a few years, the plants begin to degenerate, the heads becoming smaller and less succulent. It is therefore a general rule, not to keep an artichoke plantation beyond four or at most six years. Scarcely any kind of grub or wire-worm ever touches the roots of artichokes: they form, therefore, an excellent preparative for a crop of onions, shallot, or garlic. In many gardens a small new plantation is formed every year; and in this way the artichoke season, which begins in June, is prolonged till November; those from the old stocks continuing till August, when those from the new stocks come in. If the last gathered be cut with the stems at full length, and if these be stuck among moist sand, the heads may be preserved a month longer.

If some of the large heads on the old stocks be suffered to remain, the calyx-leaves expand, and the centre of the head becomes covered with jagged purple florets, producing a fine appearance. The flowers possess the quality of coagulating milk, and have sometimes been used in place of runnet. In general the seed is not perfected in our climate. When ripe seed is wanted, it is found useful to bend down the heads after flowering, in such a way that the autumnal rains may be cast off by the calyx-scales; and the heads are retained in this posture by being tied to stakes.

368. The *chard* of artichokes, or the tender central leaf-stalk blanched, is by some thought preferable to that of the cardoon. When the artichoke quarter is to be shifted, and the old stocks are at any rate to be destroyed, the plants may be prepared, after midsummer, when the best crop of heads is over, for yielding chards against winter. The leaves are to be cut over within half a foot of the ground; the stems as low as possible. In September or October, when the new shoots or leaves are about two feet high, they are bound close with a wreath of hay or straw, and earth or litter is drawn round the stems of the plants. The blanching is perfected in a month or six weeks. If the chards are wished late in winter, the whole plants may be dug up, before frost sets in, and laid in sand in their blanched state; in this way they may be kept for several weeks.

*Cardoon.*

369. The *Cardoon*, (*Cynara Cardunculus*, L.) or, as it is sometimes written, *Chardon*, is known by nearly the same name in all the European languages. It is a perennial plant, and is considered as indigenous to the south of France and to Spain. It so greatly resembles the artichoke as to require no other description. It rises to a greater height than that plant, and becomes sometimes really a gigantic vegetable. It was cultivated in 1683, by Sutherland, in the Botanic Garden at Holyroodhouse, Edinburgh; but its use as a culinary plant was known in England previous to that period. The leaf-stalks of the inner leaves, which are fleshy and crisp, afford the eatable part, or chard. They are rendered white and tender by blanching, to the extent of two or even three feet. Cardoons are in season in winter; they are employed in soups and stews, and sometimes as a salad, eaten either raw or boiled. In this country they are not much in demand, and the crop is to be seen only in some private gardens, and in a few of the principal market grounds near London.

The best soil for cardoons is one that is light, and not over rich; but it ought to be deep. Although the cardoon is a perennial plant, it is sown for use every year. Formerly the plants were raised on hot-beds, and transplanted in May or June; but now the seed is generally sown where the plants are to remain. This is not done sooner than the middle or the end of May, lest the plants should be inclined to throw up flower-stems. Some gardeners sow in small hollows, perhaps three inches deep, and four feet distant from each other every way. Two or three seeds are placed in each hollow, for security; but only the strongest plant is ultimately retained. Others sow in trenches, prepared as for celery, and keep the plants much closer in line, not allowing more than nine or ten inches to each plant; it is better, however, that they should have more space. The cardoon requires a good deal of water; and in very dry weather this should be copiously afforded, as it tends both to make the leaves succulent, and to prevent the inclination to flowering. The young plants that are rejected in either way, may be transplanted, if wished; but in this case it is useful to preserve a small ball of earth with each plant, and liberal watering is proper.

370. In September, when the leaves are large, they are tied up for blanching, leaving only the top free. This is generally done with hay or straw bands, and a dry day must be selected for the purpose. At the same time a hillock of earth is formed around each plant, to the height perhaps of a foot or eighteen inches; and this is smoothed on the surface, that the rain may run off, and not fall into the centre of the plants. In proportion as they advance in growth, additional bands are added, and the earth is raised higher. When the plants are in trenches, they are gradually earthed up like celery, without using bands: the earthing is of course begun in July. In either way, the blanching is completed in about two months. If severe frost come on, the tops are covered with haulm or long litter. If cardoons be wanted more early, the tying and earthing may be begun sooner; but the leaf-stalk will not probably be found so broad and thick as it ought to be.

A few of the strongest plants are sometimes left, to produce their flowers and seeds the following year; but ripe seed is to be procured only in very favourable seasons in this country. It is therefore generally imported from Holland or France; and it keeps for several years.

In France, the native prickly plant is sometimes cultivated, under the name of Cardoon of Tours, and is accounted preferable to the common garden variety. So formidable are its spines, that great care is necessary in working about it, to avoid personal injury; a strong leather dress, and thick gloves, are therefore worn. This prickly sort has not yet been introduced into Britain.

*Rampion.*

370. The *Rampion* (*Campanula Rapunculus*, L.; *Pentandria Monogynia; Campanulaceæ*, Juss.) is a biennial plant; a native of England, but rare; figured in English Botany, t. 283. The lower leaves are oval-lanceolate, and waved. The whole plant abounds with a milky juice. The part used is the root, which is of the size and shape of a small radish, but of a white colour, and mild taste, or with only a slight degree of pungency and bitterness. It is eaten either raw, in fresh salads, or more commonly boiled like asparagus. It is much more esteemed in France, under the name of *raiponce*, than in this country. There the roots and the young leaves are used together in the spring months. So little is it cultivated here, that Nicol does not speak of it in his "Gardener's Kalendar."

The seed is sown in the end of May, in a quarter somewhat shady. If sown earlier, or in a warm sunny situation, the flower-stems would be apt to spring up the first year, when, as repeatedly mentioned in similar cases, the roots would become hard and unfit for use. The seed is very minute, insomuch that, to enable the gardener to sow it equally and thin enough, it should be mixed with sawings of timber. A thimble-full of the seed is sufficient to sow a large bed. When the plants are about an inch high, they are hoed, and thinned out to the distance of three or four inches from each other. They are afterwards to be kept free of weeds, and the surface is occasionally stirred. The roots are ready for use at the approach of winter, and continue good till the spring growth commences. If a few plants be left, a flower-stalk rises, and the pale purple bell-flowers appear in the end of July, followed by plenty of seed in the autumn.

## *Fresh Salad and Soup Herbs; Garnishes, &c.*

Several of the principal plants which are used raw in salads, are likewise employed in making soups; such are lettuce, endive, and parsley. Others are merely salad plants; such are cresses and radishes.

*Lettuce.*

371. *Lettuce* (*Lactuca sativa*, L.; *Syngenesia Polygamia Æqualis; Chicoraceæ*, Juss.; *Laitue*, F.; *Gartensalat*, G.) is an annual plant, the original country of which is unknown. Some authors indeed seem inclined to consider it as merely an accidental variety, sprung from some of the other species of Lactuca. It was cultivated in England in the middle of the 16th century, and probably much earlier. The leaves are large, milky, frequently wrinkled, usually pale green, but varying much in form and colour in the different varieties. The use of lettuce as a cooling and agreeable salad is well known; it is also a useful ingredient in soups. It contains, like the other species of this genus, a quantity of milky juice of an opiate nature, from which of late years a medicine has been prepared by Dr Duncan, senior, of Edinburgh, under the title of *lactucarium*, and which he finds can be administered with effect in cases where opium is inadmissible.

372 Many varieties are cultivated; but these are generally considered as belonging to one or other of two kinds, the Coss (also called Roman and ice) and the Cabbage lettuce; the former with long upright leaves, the latter with the leaves round, rather flaccid, and growing squat upon the ground. The sorts at present most approved are, of the coss lettuces, the Egyptian green, and the white coss or Versailles; of the cabbage lettuces, the imperial, and the grand admiral, or admirable. The large Roman and the Cilicia lettuce, brown and green, are the kinds chiefly used in soups, or for stewing.

By means of successive sowings, and by care during winter, fresh lettuce is now produced almost the whole year round. The plants are used either when quite young and open, or when at full growth and cabbaged. A small sowing is often made in January, the seedlings being transplanted in March. A considerable crop is sown in the end of February; the main sowing is in March and April; and sometimes a portion of lettuce seed is sprinkled in along with onions or carrots, the lettuces being drawn before they can hurt the other crop. Lettuce seed is sown at broadcast, and is merely raked into the ground. The plants bear transplanting very well, particularly in showery weather; and a part of each crop should be regularly transplanted, to come in season immediately after those left in the seed-beds. They may be transplanted very young; when they have four or six leaves, they are fittest for this purpose. They are placed from ten to fifteen inches apart, according to the size they are likely to attain. When it is wished to forward the cabbaging of coss lettuce, the leaves are sometimes tied together, in the manner practised with endive. If the winter do not prove very severe, lettuces will stand without much injury close by the foot of a south wall, and be fit for use in January, February, and March. In some places they are protected by hoops and mats; in others, by means of glass-frames; and sometimes a few cabbage lettuces are kept on a slight hot-bed.

When it is wished to save seed, the best plants of the approved kinds are selected, and planted at a distance from all others, so as to avoid any intermixture of pollen. If the plants have stood over winter, they produce their flowers more abundantly, the stem becoming thick, and rising between two and three feet high; and such plants also ripen their seed more certainly and early.

*Endive.*

373. *Endive* (*Cichorium Endivia*, L.; *Syngenesia Polygamia Æqualis; Cinarocephalæ*, Juss.) is an annual, or at most a biennial plant, a native of China and Japan. The root-leaves are numerous, large, sinuate, toothed, smooth; the stem rises about two feet high, is branched, and produces pale blue flowers. It was introduced into this country about the middle of the 16th century.

There are three varieties; Broad-leaved Batavian, Green curled leaved, and White curled leaved. The curled varieties, having less of the bitter quality, are now generally preferred; and the green curled, being the hardiest sort, is adopted for the late or winter crops. Endive is one of the principal ingredients in autumn and winter salads, and is frequently used for stewing, and for putting in soups.

The seed is not sown till after the middle of May, often not till near the middle of June; because, if sown earlier, the plants would be apt to run to flower. Another sowing is made in July. The seeds are scattered thinly, so that the plants may not rise in clusters, and become weak. When they are about three or four inches high, they are transplanted into a well prepared bed of rich soil, in rows a foot asunder, and at the distance of ten inches from each other in the row; or in large drills, at the same distances, the blanching being in this way facilitated. In dry weather, watering is necessary.

374. The blanching is the next operation; and on this being well done, the tenderness, crispness, and mild flavour of the endive depend. It is accomplished by tying up the heads with strands of bass-mat or small willow twigs: this must be done when the plant is dry, that is, when neither rain nor dew rests on it; and some nicety is requisite in gathering the leaves together in regular order, so as not to cross each other, and in rejecting such leaves as are unhealthy. The plants are at first tied two inches below the top; afterwards about the middle of the plant. In three weeks or a month they are found to be blanched; and they continue fit for use in this state for about a fortnight. A few plants are therefore tied up every week, when the weather permits, in order to their being ready for use in succession.

The plants from later sowing are placed in sheltered borders near a wall or hedge; and when very severe weather comes on, the rows are protected with dry fern or any other light covering. After October, indeed, the mode adopted is, to make some trenches or small oblong mounds of earth, and to sink the plants nearly to the head in these: here they become sufficiently blanched in four or five weeks; and if additional plants be sunk in the trenches every fortnight, when the weather happens to be so mild and dry as to permit it, the endive season may be continued for a long time. Endive thus blanched in the earth must be dug out with the spade, and it requires to be very thoroughly washed.

A few of the strongest and most early plants are selected for producing seed. These are planted in the beginning of March, in a sheltered situation, if possible, near a paling, to which the flower-stems may be tied, so as to prevent accidents from the wind. The flowers come out in June, and are succeeded by ripe seeds about the middle of July. The seeds are gathered at different times, as they are observed to become ripe.

*Parsley.*

375. *Parsley* (*Apium Petroselinum*, L.; *Pentandria Digynia; Umbelliferæ*) is a biennial plant, considered as a native of Sardinia, but naturalized in several places of England and Scotland.

Three varieties are cultivated; Common parsley, and Curled parsley, for the leaves; and Large-rooted or Hamburgh parsley, for the roots.

The common and the curled parsley are raised in drills, generally on the edges of a border in the kitchen-garden. They are sown in February, or early in March, as the seeds lie from a month to six weeks in the ground before springing. Parsley bears transplanting, so that blanks in the edging may easily be filled up in rainy weather.

In order to have fresh parsley leaves through the winter, it is worth while to lay some larch or beech branches, or long broom, over the parsley border, and above these, in hard weather, a little dry bean haulm, *braken* fronds, bents or reeds, preferring the two latter articles on account of their durability. Mr Nicol remarks, that in this way fine young parsley may be had all winter, and may be gathered even from under the snow.

If a few strong plants be allowed to run to flower in May or June, plenty of seed will be produced in August.

It may be right to notice, that the poisonous plant called fool's parsley, (*Æthusa Cynapium*,) a common weed in rich garden soils, has sometimes been mistaken for common parsley. They are very easily distinguished: the leaves of fool's-parsley are of a darker green, of a different shape, and, instead of the peculiar parsley smell, have, when bruised, a disagreeable odour. When the flower-stem of the fool's-parsley appears, the plant is at once distinguished by what is vulgarly called its *beard*, three long pendent leaflets of the involucrum. The timid may shun all risk of mistake, by cultivating only the curled variety. This last, it may be remarked, makes the prettiest garnish.

*Hamburgh Parsley.*

376. *Hamburgh parsley*, although considered only as a large-rooted variety of the common kind, is somewhat different in its whole appearance. The leaves have longer foot-stalks, and their subdivisions are not so numerous; the leaflets at the same time, are much broader, and of a darker green. The roots are at least six times larger than those of common parsley. For the sake of these it is cultivated; and this variety might therefore without impropriety be ranked among the esculent roots.

It was introduced by Philip Miller, from Holland, in 1727. He could not for some years persuade the market-gardeners of London to cultivate it: Now, however, it is regularly brought to Covent Garden; but in many parts of the country it still remains nearly unknown. The roots, which are the size of ordinary carrots or parsnips, are of a white colour, sweet and tender: they are frequently boiled and eaten like carrots, and are excellent in soups and stews.

The culture of this variety of parsley necessarily differs from that of the other two, the object being here to produce large roots. In March or April it is sown in beds, the soil of which has been deeply delved, or perhaps trenched, and at the same time made fine. The plants are afterwards thinned out with the hoe to six or eight inches asunder; and this is all the culture they require. They are ready for drawing in the end of August. In October the roots are commonly raised, and placed in sand till wanted. They have more flavour, however, when newly taken from the ground; and if a bed be sown about midsummer, the roots continue young and good through the winter, being raised when the weather permits.

*Celery.*

377. *Celery* (var. of *Apium graveolens*, L. or smallage) is a biennial plant. Smallage grows in many places in England and Scotland, frequently by the sides of ditches near the sea. It is figured in *English Botany*, t. 1210. The effects of cultivation in producing upright, mild, and sweetish stems of celery from an original stock, of a rank coarse taste and abounding with suckers, are very remarkable. The blanched leaf-stalks are used raw as a salad, from August till March; and also in soups or for stewing.

378. Two very distinct kinds of celery are cultivated; the Upright or Italian, and the Celeriac or turnip-rooted celery. Of the former there are two subvarieties, with hollow and with solid stalks. The hollow is much cultivated for eating as salad; the solid is considered as preferable for soups and stews, and indeed is by many accounted the best for all purposes; but it is less able to endure the severity of winter, and is very brittle, and therefore troublesome to the market-gardener. There is a large upright variety with red stalks, much used for kitchen purposes. Celeriac differs chiefly in the roots swelling out like turnips: these are cut into slices, and either eaten raw in salads, or used as an ingredient in stewed dishes and soups. The leaves, at the same time, are shorter than in the other varieties, and spread open horizontally. Celeriac is not often brought to market.

Celery is sown at several different times, in order to ensure a succession of plants fit for transplanting at various seasons. The first sowing is commonly about the beginning of March, on a gentle hot-bed; the second, perhaps three weeks afterwards on a sheltered border; the third, about the beginning of May, on a moist shady border. The strongest plants of the first sowing are generally ready, from the middle to the end of April, for pricking into nursery beds of rich earth, in which they may stand separate three or four inches every way, in order to gather strength. Water is given, and the plants are shaded from the sun for a few days. A quantity of every successive sowing should thus be pricked out. Some gardeners, however, content themselves with sowing very thin, and take the plants directly from the seed-bed to be placed in the trenches; but it is not a good plan. If any plants be inclined to run to flower, it is better they should shew this tendency in the nursery-bed.

379. An improvement on the formation of the seedling-bed has been adopted at Mr Walker's of Longford, near Manchester. It is made entirely of very old hot-bed dung, laid thinly on a piece of well trodden soil, or ground beat hard with the back of the spade, so as to be impervious to the roots. The young celery plants, therefore, form bushy fibrous roots, as they cannot send down tap-roots: and in consequence of this, they shew no inclination to throw up a flower-stem till the following spring.

Towards the end of May, the most forward plants may be transplanted into the trenches for blanching. In dry weather, at this season, water is given freely, both to the transplanted plants, and to those left in the seed-bed. The usual modes of transplanting and blanching are the following: Trenches are formed, at the distance of three or four feet from each other, a foot and a half wide, and about a foot in depth. The soil in the bottom of this trench is delved and worked fine; and, if thought necessary, a little rotten dung or rich compost is mixed with it. The soil for celery should be deep and rich, somewhat moist, yet of a light nature: in mossy earth, if moderately dry, it succeeds remarkably well; the natural plant, smallage, as has been remarked, delights in growing by the sides of ditches. The earth taken from the trench is laid in ridges on each side, ready to be drawn in as wanted. The plants being trimmed, or having the tops of the long leaves cut off, and any side shoots removed, are placed in the bottom of the trenches, at the distance of four or five inches from each other. As they advance in growth, the earth is drawn in towards them, perhaps once in ten days, taking care to perform this operation only in dry weather, and not to cover the heart or centre of the plants with soil. When the plants rise considerably above the surface of the ground, all the earth laid in ridges will be exhausted; a new trench, therefore, is now opened between each row, for a supply of soil to continue the earthing up till the celery be fit for use, or till the leaf-stalks be blanched from eight to fourteen inches in length. The management of all the sowings is similar. The last is destined to stand over winter; and although the seedlings were directed to be raised on a moist shady border, the soil into which they are finally transplanted, should be as dry as possible. In severe weather, peas-haulm or other loose litter is thrown over the beds. It is a common complaint, that very fine looking celery is often found to be rotten at the base of the leaf-stalks: the fact is, that after the blanching is completed, celery will not keep good in the ground for more than a month at most. The necessity of successive crops is therefore evident. In lifting the plants for use, it is proper to dig deep, and to loosen the roots with the spade, so that the entire celery plant may be drawn, without risk of breaking the leaf-stalks or injuring the main roots, the fleshy tender part of which is relished by many.

380. Celeriac, after being raised in a seed-bed, is planted out on level ground, or in very shallow drills, as it requires but one earthing up, and that a slight one.

Attentive gardeners generally save celery seed for their own use. All that is necessary is, to select several strong healthy plants of the winter stock, and plant them out in rich soil early in the spring. When the stems run up to flower, they are apt to be broken by high winds, and should therefore be secured by stakes. The seed is ready in the end of August, and is dried in the usual way. It may be mentioned, that the seed, when bruised, communicates the celery flavour to soups, and may be thus employed when stalks or roots cannot be procured.

*Garden-Cress.*

381. The *Garden-Cress* (*Lepidium sativum*, L.; *Tetradynamia Siliculosa; Cruciferæ*, Juss.) is an annual plant, the native country of which is not known. Besides the common or plain sort, which is the kind principally used for salads, there are two varieties, with curled leaves and with broad leaves. The plant partakes strongly of the smell and taste which distinguish the Cruciferæ. Like mustard, it is very easily raised during winter on a slight hot bed; and in the spring months, in close patches, under hand glasses, in the open border, or in drills near a south wall, or in front of a hot-house. It is therefore a favourite article in winter and early spring salads. Where it is wanted through the summer, it must be sown once a fortnight,

as it is only fit for use when young and tender. The plain cress is sown thick, and remains so; but the curled and the broad-leaved require to be thinned out to half an inch asunder. The curled variety makes a pretty garnish; it is rather the hardiest of the kinds, and may therefore be sown late in the season. If a row of cress plants of each of the different sorts be allowed to spring up, plenty of seed will be produced in the autumn. During winter, cresses are often raised on porous earthen-ware vessels, of a pyramidal shape, having small gutters on the sides, for retaining the seeds. These are called pyramids; they are somewhat ornamental, and they afford repeated cuttings.

### *American Cress.*

382. The *American Cress*, (*Erysimum præcox*, Smith; *Tetradynamia Siliquosa; Cruciferæ*, Juss.), although its name might lead us to expect a transatlantic origin, is a native plant of this country. It was formerly considered as a variety of the common winter-cress, (*E. barbarea*); it was described as such by Ray and Petiver: Miller made it a distinct species, by the name of *E. vernum;* and Sir J. E. Smith has figured and described it, under the name of *E. præcox*, *Eng. Bot.* t. 1129. It is only biennial; while the common winter-cress is perennial. It has smaller leaves, more frequently sinuated; the pods thicker, and the seeds larger. It is often called Black American cress, and sometimes French cress.

It is either sown at broad-cast, on a small bed of light earth, or thinly in drills a foot asunder. Three or four sowings are usually made, at intervals of about five weeks, from March to July; and in this way young leaves are always to be had. A late sowing is made in August or September on some sheltered border; the plants stand the winter without injury, and are fit for use in February and March. The plants being cut over, or the outside leaves gathered, new leaves are produced, fit for use in succession.

### *White and Black Mustard.*

*Mustard*, (*Sinapis*, L.; *Tetradynamia Siliquosa; Cruciferæ*, Juss), is of two kinds, white and black. Both are annual plants, and both natives of this country.

383. *White Mustard* (*S. alba*), grows naturally in our fields, though not so common as some of its congeners. It is figured in *English Botany*, t. 1677. It is cultivated only as a small salad, and is used while in the seed-leaf, along with cresses. It may be raised at all seasons; during winter, in boxes in a hot-house or on a hot-bed. When it is wished to save the seeds, a spot of ground somewhat remote from other similar plants should be chosen.

384. The *Common* or *Black mustard*, (*S. nigra*) is a more common native than the white. It is figured in *English Botany*, t. 969. The French call the plant *senevé*, and confine the term *moutarde* to prepared table mustard. The tender leaves are sometimes used as greens in the spring, and the seed-leaves occasionally as a salad ingredient; but the plant is chiefly cultivated for the seed, which, when ground, affords the well known condiment. If the seeds taken fresh from the plant be ground, the powder has little pungency, but is very bitter; by steeping in vinegar, however, the essential oil is evolved, and the powder becomes extremely pungent. In moistening mustard powder for the table, it may be remarked, that it makes the best appearance when rich milk is used; but this mixture does not keep good for more than two days. The seeds in an entire state, are often used medicinally.

The black and the white mustard plants may be distinguished by observing, that the black is a larger plant than the white; that it has much darker leaves than the white, and the divisions of the leaves blunter; the whole upper part of the plant smooth, and the upper narrow leaves hanging downwards; the flowers small, the pods generally quite smooth, and lying close to the stem; while in the white, the flowers are large, the pods rough or hairy, and standing out from the stalk. The names white and black are given in consequence of the colour of the respective seeds.

Black mustard is principally cultivated in fields; but a small bed of it in the garden is often found convenient. The plants require considerable space, and repeated hoeings. The seed ripens in August.

### *Chervil.*

385. *Chervil*, (*Scandix Cerefolium*, L.; *Pentandria Digynia; Umbelliferæ*), is an annual plant, a native of various parts of the continent of Europe, and sometimes observed naturalized near gardens in England, but not admitted into our Flora by Sir J. E. Smith. The leaves are of a very delicate texture, three times divided. The plant rises from a foot to near two feet high, when in flower; but it is the foliage only when in a young state that is used. It was formerly much more cultivated in gardens than it is at present. The young leaves, however, are still sometimes put in soups, and frequently form an ingredient in salad.

It may be right to mention, that care should be taken to distinguish between this and the rough chervil, (*Scandix Anthriscus*,) which is a common denizen of our way sides, and not a wholesome plant. The seeds of the wild species are rough or prickly, while those of garden chervil are smooth. While the plants are only in leaf, they may be distinguished by those who are no botanists by the smell; the leaves of garden chervil, when rubbed, emitting a pleasant scent; while the smell of the wild kind is disagreeable. Chervil is much relished in Holland; and it is said, that some of the Dutch soldiers brought into this country to repress the rising in favour of the Stuarts, perished by using our wild species.

The seeds of garden chervil are sown in autumn, soon after they have ripened, commonly in shallow drills, about eight inches apart. They quickly come up, remain during winter, and are fit for use very early in the spring. Chervil may be repeatedly cut like parsley. It may also be sown in spring or summer; but at these seasons it almost immediately runs to flower. If a few plants be left uncut, they will afford plenty of seed in the end of July. There is a very beautiful variety cultivated in the Paris gardens, with finely frizzled leaves.

### *Purslane.*

386. *Purslane* (*Portulaca oleracea; Dodecandria Monogynia; Portulaceæ*, Juss.; *Pourpier* of the French) is an annual plant, a native of the East. It has a round smooth rather procumbent stem, and diffused branches; the leaves somewhat wedge-shaped and fleshy; the flowers yellow, and sessile. Purslane was well known in England at least as early as the middle of the 16th century. The young shoots and succulent leaves are the parts used. They were formerly much more in request for salads and pickles, and as pot-herbs, than they are at present.

There are two varieties, the Green and the Golden, the principal difference consisting in the colour, but the former being rather the more hardy. Purslane requires a warm situation, and a rich light soil. It is sown any time from May to July. Nicol, in his "Kalendar," speaks of sowing it in the open border in the end of March; but this may be considered as an oversight, the time being much too early. The seed is very small, and attention is necessary to the sowing of it thinly. In dry weather, it is proper to water the young plants at night, two or three times a week. With this care they will be three or four inches high, and ready for cutting, in the space of six weeks. Purslane, when cut over, springs again, and it may be repeatedly cut. When thus taken young, it is of a cold and tender nature, and forms a pleasant salad. If it be wanted earlier than June, it must be raised on a hot-bed, and planted out toward the end of April. If a few of the earliest and strongest plants be left, they soon run to flower, and in warm seasons they ripen their seeds; but imported seed is always to be had in the shops, and it keeps good for several years.

*Fennel.*

387. *Fennel* (*Anethum Fœniculum*, L.; *Pentandria Digynia*; nat. ord. *Umbelliferæ*) is a perennial plant, which, though not an original native, is now so completely naturalized in several parts of England, that it has been admitted into the British Flora by Sir J. E. Smith, and figured in "English Botany," t. 1208. Fennel, or finckle, has long been an inmate of our gardens. Its finely cut leaves and capillary leaflets make it an ornamental plant, especially when strong, rising perhaps to the height of five or six feet. Three varieties are cultivated; the dark-green leaved, the sweet fennel, and finochio, or Azorian fennel. The tender stalks of common fennel are used in salads; and the leaves boiled enter into many fish sauces. The blanched stalks of finochio are eaten with oil, vinegar, and pepper, as a cold salad; and they are likewise sometimes put into soups.

Common fennel will grow in any soil or situation. It may be propagated either by parting the roots, or by seeds. The seeds should be sown in autumn, soon after they are ripe. A few plants are sufficient for a family, and they endure for many successive years.

Finochio is a dwarfish variety, characterized by a tendency in the stalk to swell to a considerable thickness. This thickened part is blanched by heaping earth against it, and is then very tender. As the plant grows rapidly, and the swoln stem is best when young and tender, several successive sowings are requisite, at least where the article is much in request. Owing to the peculiar nature of this variety, it is more tender than the common fennel, and often perishes in the course of the winter. Misled by this circumstance, several horticultural writers describe it as an annual species.

*Dill.*

388. *Dill* (*Anethum graveolens*, L.) is a biennial plant, a native of the corn fields in Spain and Portugal. It has long been cultivated in our gardens as an aromatic and carminative, and the leaves were formerly used in soups and sauces; but the plant is now scarcely employed, unless that the seeds are sometimes added to cucumber pickles. In order to ensure a crop, the seeds should be sown when they ripen in autumn. If some plants be allowed to scatter their seeds, plenty of seedlings will rise in the spring.

*French and Common Sorrel.*

*Sorrel* (*Rumex; Hexandria Trigynia; Polygoneæ*, Juss.; *Oseille* of the French) is of different kinds.

389. *French sorrel* (*R. scutatus*, L.) is a perennial plant, a native of France and Italy; it was cultivated in England before the middle of the 17th century, and it is now common. The leaves are somewhat cordate or hastate, but blunt or rounded, and entire; glaucous, smooth, soft, and fleshy; the stems rise from a foot to a foot and a half high. It is sometimes called Roman sorrel; and, from the breadth and bluntness of the leaves, gardeners often distinguish it by the name of Round-leaved sorrel; our native species being their Long-leaved sorrel. The acid is considered as more grateful than that of common sorrel, and the leaves are more succulent; it is therefore preferred for kitchen use. The plant runs at the root, and is in this way easily propagated. It grows best in a light sandy soil; and the plants are placed about a foot apart. The only attention it requires is the cutting off of the flower-stems and branches in July, so that new leaves may push out for autumn use. In three or four years, however, the plants generally give indications of decay; and new ones must be raised from seed, or offsets procured from young and vigorous plants. If a few stems be allowed to remain in the summer, plenty of seeds may be procured in autumn.

390. *Common Sorrel* (*R. Acetosa*, L.) is a well-known perennial native, growing in meadows and by the sides of rivers, and is figured in "English Botany," t. 1270. The lower leaves have long foot-stalks; they are arrow-shaped, blunt, and marked with two or three large teeth at the base: the upper leaves are sessile, and acute. It is easily raised from seeds sown early in the spring. It thrives best in a shady border. The leaves are used, like those of French sorrel, in various soups, sauces, and especially in salads. As formerly mentioned, they give an excellent flavour to herb patience, used as a substitute for spinach. This species, it may be remarked, is used in France nearly as much as the other, which we generally call French sorrel.

There is a third species of sorrel, reckoned by the Parisians more delicate than either of the others. It is the *Rumex arifolius* of the *Flore Française*. Its leaves are larger and less acid; and it very rarely throws up a flower-stem.

391. *Wood-sorrel* is an entirely different kind of plant, (*Oxalis Acetosella*, L.; *Decandria Pentagynia*; belonging to the *Gerania* of Jussieu.) Having a very grateful acid taste, the leaves form a desirable addition to salads, particularly when young, in the months of March and April. It is to be found in almost every wood; but if the roots be transplanted, in tufts, into the more shady parts of the shrubbery, they will there establish themselves, and be at hand when wanted.

*Corn-Salad.*

392. *Corn-salad*, or *Lamb's Lettuce* (*Valeriana olitoria*, Willd.; *V. Locusta*, Lin.; *Tetrandria Monogynia; Dipsaceæ*, Juss.) is a small annual plant, growing on the margins of our fields, (*Eng. Bot.* t. 811.) and only 2 or 3 inches high. Cultivated in gardens, it rises, when in flower, a foot or more in height. The leaves have a pale glaucous hue; they are long and narrow, the lower ones rather succulent. The flowers are very small, pale bluish, and collected into a close little corymb. In the fields, lamb's-lettuce may be gathered in March, and it flowers in April. In gardens it may be had still more early in the spring: indeed during the greater part of a mild winter. The tender leaves are little inferior to those of young lettuce, having a slight agreeable flavour; they form an excellent ingredient in winter and early spring salads. It has very long been a favourite spring salad-plant in France, under the various denominations of *mâche*, *doucette*, *salade de chanoine*, and *poule-grasse*. Gerarde tells us, that

foreigners using it when in England led to its being cultivated in our gardens. The seeds are sown in autumn, generally about the end of August. They are either sown at broad-cast or in drills, on a small bed or border. The plants soon rise, with a low tuft of oblong narrow leaves; they are then thinned out to two or three inches asunder; and in February they are fit for use. The entire plant is drawn, in the manner of lettuce. The younger the plants are when used, the better: in warm dry weather, the leaves soon acquire rather a strong taste, disagreeable to many persons. Sometimes a small sowing is made in February, which affords plants with fine tender leaves in April and May. A few plants may be allowed to spring up to flower, and they perfect their seeds in July and August. The culture of lamb's lettuce, as a salad plant, has for some time past been declining, but without any good reason.

*Milk-Thistle.*

393. The *Milk-Thistle*, or *Our Lady's Thistle* (*Carduus Marianus*, L.; *Syngenesia Polygamia æqualis; Cinarocephalæ*, Juss.) is a biennial plant, a native of Britain, (*Eng. Bot.* t. 976.) It is at once distinguished by the beautiful milky veins which form an irregular network on the leaves. Some readers may be surprized to find a native thistle ranked among our esculent plants; but it is certainly not more unpromising at first aspect than the artichoke or the cardoon. When very young, it is eaten as a salad; the tender leaves, stripped of their spines, are sometimes boiled and used as greens; the young stalks peeled, and soaked in water to extract a part of the bitterness, are said to be excellent; early in the spring of the second year, the root is pretty good, prepared like salsify or skirret; the receptacle is pulpy, and eats like that of the artichoke. The young plants are sometimes blanched like endive, and used in winter salads: for this purpose the seeds are sown in spring, and the plants are allowed to remain about a foot and a half distant from each other; in autumn, the leaves are tied together, and the earth drawn up close to them, till they be whitened. The plant, however, is but rarely cultivated for any culinary purpose.

It grows naturally, or has been naturalized, near all the old castles or strongholds of Scotland, such as the castles of Edinburgh, Stirling, and Dunbarton. From this circumstance, and the formidable spines of the calyx, many consider it as the "true Scots thistle," the national badge. But the way-thistle (*Carduus lanceolatus*) is incomparably more common in that country. The Gardeners' Lodge of Edinburgh, it may be remarked, generally adopts the cotton-thistle (*Onopordum acanthium*) as its emblem; but apparently without any good reason, that plant existing only in one or two parts of the country. It may be added, that the representations of the Scots thistle, whether carved on ancient buildings, impressed on the coins of the realm, or emblazoned on armorial bearings, as seen in seals or in old engravings, bear equal resemblance to all of these, or, to speak more correctly, are equally unlike any thistle described by Linnæus, as they are dissimilar to each other.

*Burnet.*

394. Burnet (*Poterium Sanguisorba*, L.; *Monœcia Polyandria; Rosaceæ*, Juss.; *petite pimprenelle* of the French,) is a perennial plant, growing naturally in some parts of England, in dry upland pastures. It is figured in "English Botany," t. 860. The leaves are pinnated; they form a tuft next to the root, but are alternate on the stem; the leaflets are partly round-shaped, partly pointed, and much serrated on the edges. The stem rises fifteen inches high, and the flowers form small greenish or purplish heads.

Burnet leaves are sometimes put into salads, and occasionally into soups; and they form a favourite ingredient for cool tankards. When slightly bruised, they smell like cucumber, and they have a somewhat warm taste. They continue green through the winter, when many other salad plants are cut off, or in a state unfit for use. The plant is easily raised by sowing the seeds in autumn, soon after they are ripe; or it may be increased by parting the roots. A few plants are sufficient, as it is not much in use. To promote the production of young leaves and shoots, the stems are two or three times cut over during the summer.

*Rape.*

395. *Rape*, or *Coleseed*, (*Brassica Napus*,) is sown thick as a salad herb, to be cut while in the seed-leaf, in the same way as mustard. A variety of this plant affords the small French turnip or navew, already treated of, § 318. Some consider rape leaves as a good stomachic, and take them boiled.

In the same way, radish seed (*Raphanus sativus*, § 329.) is sometimes sown thick, and cut in the seed-leaf for use.

*Horse radish.*

396. *Horse-radish* (*Cochlearia Armoracia*, L.; *Tetradynamia Siliculosa; Cruciferæ*, Juss.) is a perennial plant, growing naturally in marshy places and by the sides of ditches, in some parts of England, and figured in "English Botany," t. 2223. The leaves are very large, and vary considerably in appearance, being sometimes entire, or only crenated, sometimes deeply pinnatifid; the flowers are white, and come in loose panicles. It has long been cultivated in gardens; the root scraped into shreds being a well known accompaniment of the roast beef of old England, and also used to give a zest to winter salads. The soil should be rich and deep, in order to induce the plants to strike their roots freely. Crowns, having about two or three inches only of root attached to them, make very good plants; but cuttings of the knotty parts of the roots, provided always they be furnished with one or two buds or eyes, are often preferred, as they are to be planted entirely under the soil. They are generally planted, in February or March, in lines, leaving a foot and a half between each line; and for the first season, therefore, a slight crop of spinach or lettuce may be taken between the lines. The sets are placed at the depth of at least a foot; if the soil be light, fifteen inches is not too deep. The roots are not dug for use till the second year; and they are raised only when wanted, the pungent quality escaping rapidly as the root dries. The bed lasts for four or five years; care being taken, in digging the roots, to leave the stock plant, or original set, untouched, removing for use only the upright straight root of twelve or fifteen inches in length, produced by planting at that depth.

*Indian Cress.*

397. *Indian Cress*, or *Nasturtium*, (*Tropæolum majus*, L.; *Octandria Monogynia; Gerania*, Juss.) is a native of Peru: it was introduced into England near the close of the 17th century. It is the *capucine* of the French. The stalks, if supported, will rise six or eight feet high; the leaves are peltate, or have their petiole fixed to the centre of the leaf; the flowers are very showy, of a brilliant

orange colour, and continue in succession from July till destroyed by frost. In its native country it endures several seasons; but here, being unable to sustain our winter, it is treated as an annual plant, and sown every year. The flowers and young leaves are frequently eaten in salads; they have a warm taste like cresses, and from this circumstance the name of *nasturtium* has been bestowed. The flowers are also used as a garnish to dishes, and form a beautiful contrast with the flowers of borage. The seeds, when green, form a favourite pickle; they are often called capers, and substituted for them.

If the seeds be sown in April, in drills about two inches deep, in places where the stalks can have support, no other care is necessary. A fresh but poor soil is better than a rich one, which last makes them too rampant and less fruitful. The plant is often employed as a temporary hedge or screen, to hide any disagreeable object, stakes being fixed, which it soon completely covers. Although destitute of proper tendrils, the petioles or leaf-stalks make a peculiar bend, by which they attach themselves to any small body coming in the way, and support the plant. The seeds ripen freely in September, and may then be gathered for pickling, keeping some of the largest and ripest for next year's sowing.

There is a variety with double flowers, which is continued by cuttings, and sheltered in a hot-house, or the warmer part of a green-house, all winter. It is both highly ornamental as a flower, and forms a still more beautiful garnish than the single.

398. *Dwarf Indian Cress* (*Tropæolum minus*, L.) is also a Peruvian plant, and an annual; it is cultivated in the same way, and for the same purposes, as the other. It is generally sown on borders, and allowed to spread on the ground. There is likewise a double variety of this, which forms a very pretty green-house ornament.

*Marigold.*

399. *Marigold*, or *pot marigold*, (*Calendula officinalis*, L.; *Syngenesia Polygamia necessaria; Corymbiferæ*, Juss.) is an annual plant, a native of France and Spain; but one of the oldest and best known inhabitants of our gardens, its flowers having formerly been much in repute, as "comforters of the heart." Though little faith is now placed in its virtues, it still keeps its place; it is to be found in most cottage gardens both in England and Scotland; and Mr Marshall observes, that "the flower is a valuable ingredient in broths and soups, however it may have got into disuse." The flowers are dried in autumn, and kept in paper bags for use. The single-flowered orange marigold is most aromatic, and the most proper for keeping. There is a pale flowered variety, called the Lemon-coloured marigold; and there are double-flowered varieties both of the orange and lemon colour. The most curious variety is the childing or proliferous, which sends out small flowers from the margins of the calyx of the large central flowers; but this sort is very apt to degenerate; to give a fair chance of preserving it, seed should be saved only from the large central flowers. The common marigold sows itself abundantly, and the seedlings may be transplanted in May; so that, when the plant has once established itself, there is seldom any need for sowing.

*Borage.*

400. *Borage* (*Borago officinalis*, L.; *Pentandria Monogynia*; nat. ord. *Asperifoliæ*) is an annual plant, either a native, or completely naturalized in many parts of Britain; (*Eng. Bot.* t. 36) The lower leaves are oblong and spread on the ground; the flower-stems rise near two feet high; both they and the leaves are rough with white bristly hairs; the bright blue flowers make a beautiful appearance, and are produced for several months in succession. Borage was formerly high in estimation as a cordial plant, for driving away sorrow; but "very light, surely, (says Sir J. E. Smith,) were those sorrows that could be so driven away." It is still sometimes used when young as a pot-herb, and in salads; the spikes of flowers form an ingredient in cool tankards, and the blossoms are occasionally employed as a garnish. The juice of the plant affords nitre, and the withered stalks have been observed to burn like match-paper. Borage will sow itself, and come every year. There is a variety with white flowers, and another with flowers of a pale red or flesh colour; but neither is common.

*Angelica.*

401. This is the *Angelica Archangelica* of Linnæus, (*Pentandria Digynia; Umbelliferæ*): it is a biennial plant, with very large pinnate leaves, the extreme leaflet three-lobed. The roots are long and thick; and they, as well as the whole plant, are powerfully aromatic. It is truly a northern plant, being common in Lapland and Iceland. It was cultivated in Britain in 1568, and probably more early. The stalks of it were formerly blanched, and eaten as celery. Now they are used only when candied; and the young and tender stalks are for this purpose collected in May. Though the plant is only a biennial, it may be made to continue for several years, by cutting over the flower-stem before it ripen seed; in which case it immediately sets out below. It is easily raised from seed, which should be sown soon after being gathered. It grows best in a moist soil, and thrives exceedingly by the side of a ditch.

*Love-apple.*

402. *Love-apple*, or *Tomato*, (*Solanum Lycopersicum*, L.) is an annual plant, a native of South America; it was cultivated by Gerarde in 1596. The stem, if supported, will rise to the height of six feet or more. The leaves are pinnate, and have a rank disagreeable smell. The flowers are yellow, appearing in bunches in July and August, and followed by the fruit in September and October. The fruit is smooth, compressed at both ends, and furrowed over the sides; it varies in size, but seldom exceeds that of an ordinary golden-pippin. The common colour is yellow; but there is a red-fruited variety, which is now the sort principally cultivated; and there is also a small variety called the cherry-shaped. When ripe, it is put into soups and sauces, to which it imparts an agreeable acid flavour. The green fruit is frequently pickled; and sometimes also the ripe. A preserve is likewise made of the fruit.

The seed is sown on a hot-bed in March; when the seedlings are two inches high, they are transplanted into a slight hot-bed till they acquire a little strength. They are then placed near a wall, paling, or reed hedge, to which they can be trained, in a sheltered place, with a full south exposure. The fruit, after all, ripens only in favourable seasons. In dry weather the plants require regular watering. Two or three of the ripest and best of the berries are selected for seed, the pulp being taken out, and the seeds separated by washing.

Love-apples have by many been considered as the *Aurea mala* spoken of by Virgil: but the plant scarcely deserves the title of "arbor silvestris," and would hardly receive it from a poet who was a naturalist; and on this account, probably, Dr Duncan, sen. has suggested, that Virgil's plant might really be an apple-tree, such as the oslin or original pippin, the fruit of which is of a fine yellow colour. In this view, the Doctor is supported by the authority of Sir William Temple. (*Miscell.* vol. ii.)

403. Allied to the love-apple is the *Egg-plant*, (*Solanum melongena*, L.) It is a tender annual, rising about two feet high, with reclining branches. The flowers are of a pale violet colour; they are followed by a very large berry, generally of an oval shape, and white colour, much resembling a hen's egg, or, in large specimens, a swan's egg. There is likewise, however, a variety with globular berries; and the fruit is sometimes of a violet colour. In southern countries the fruit is eaten; here the plant is often cultivated as an ornament for the hot-house and the green-house; but the fruit is seldom made use of. It is sometimes transplanted to successive hot-beds, and planted out in June in a warm border; where, if the autumn prove fine, the fruit makes a beautiful appearance.

*Capsicum.*

404. *Capsicum*, or Guinea pepper, (*Capsicum annuum*, L.; *Pentandria Monogynia; Solanaceæ*, Juss.) is an annual plant, rising about two feet high; a native of both the Indies. It has been long known, being mentioned by Gerarde. It is raised principally for the sake of the young pods, or, to speak more correctly, inflated berries, which make a favourite pickle. They are sometimes also used in the ripe state, when they form a spice of the hottest quality. The seed is sown in the spring, on a gentle hotbed; and the seedlings are transplanted into another bed, where they are nursed till June, when they are planted out in a sheltered border. The berries vary much in shape, producing many subvarieties of the plant. They are long or short, heart-shaped or bell-shaped, and angular. They vary likewise in colour; being generally red, but sometimes yellow. In Scotland, capsicum plants are often potted and kept under glass, the climate being seldom sufficient to ripen the berries in the open border.

A small-fruited annual species, called Cherry-pepper, (*Capsicum cerasiforme*, Hort. Kew.) is sometimes raised; and occasionally the true Bell-pepper (*C. grossum*, L.) is cultivated. This last is a biennial species, of humble growth, but producing large berries. These are better for pickling than the others, the skin being pulpy and tender; while in the others it is thin and tough. This biennial species must of course have a place in the stove.

*Caper.*

405. The *Caper-bush* (*Capparis spinosa*, L.; *Polyandria Monogynia; Capparides*, Juss.), though common in the south of France, and growing in the open air even at Paris, seldom withstands our winters, even though placed in the most sheltered situation. Trained, however, against any spare piece of wall in a stove, it grows luxuriantly, and produces its flower-buds freely. Sometimes it effectually establishes itself in crevices of old hot-house walls, this sort of situation resembling its native one. The use of the flower-buds for pickling is familiar. Perhaps a hardier variety might be obtained by repeatedly raising it from the seed, at first in Guernsey or Jersey, and thus gradually inuring the progeny to cold. It may be mentioned, that in the garden at Campden House, Kensington, a caper-tree stood alive in the open air for near a century. It had a south-east aspect, and was well sheltered from the north. It had no covering, and was generally much injured by the frost during winter; but it made strong shoots, and produced flower-buds every year.

A species of spurge common in our gardens (*Euphorbia Lathyris*, L.) is vulgarly called Caper-bush, from the resemblance of its fruit to capers; but it is acrid, like the other spurges. The flower-buds of marsh-marigold (*Caltha Palustris*, L.) form a safe substitute for capers; and likewise the young seed-pods of the common radish.

*Rhubarb.*

406. Of *Rhubarb* (*Rheum*, L.; *Enneandria Trigynia; Polygoneæ*, Juss.) two species are commonly cultivated.

*Rheum rhaponticum*, L. with the leaves blunt and smooth, veins somewhat hairy underneath, petioles grooved above, and rounded at the edge. This is the species most commonly cultivated in the kitchen garden for the footstalks of the leaves, which are peeled, cut down, and formed into tarts, in the manner of apples. They are best when young and succulent, in April and the early part of May.

*Rheum palmatum*, L. with leaves palmate, acuminate, somewhat rugged, petioles obscurely grooved above, and rounded at the edge. This has by many been considered as the officinal species, and its cultivation has been greatly promoted by the Society for the Encouragement of Arts. In the Transactions of that Society may be found accounts of the different modes which have been followed in this country in cultivating the plant and drying its root for use; or a very distinct abstract of these accounts may be seen in the last edition of Miller's Dictionary, art. *Rheum.* There is still, however, a degree of uncertainty concerning the species which yields the true Turkey or Russian Rhubarb; and the Edinburgh Faculty, in their Pharmacopœia, therefore adopt the popular name of Rheum Russicum. The probability is, that the roots of several species are used. In many places the leaf-stalks of this species are employed in making tarts, and when young are scarcely inferior to the other. A few plants are commonly kept in gardens for curiosity. They are highly ornamental, and particularly remarkable for the rapidity of their growth, rising to the height of perhaps nine or ten feet in seven weeks, and sometimes growing five or six inches within twenty-four hours.

## *Sweet Herbs, and Medicinal Plants.*

*Thyme.*

407. *Thyme* (*Thymus vulgaris*, L.; *Didynamia Gymnospermia; Labiatæ* or *Verticillatæ*) is a perennial plant, indigenous to Spain. It has been cultivated in our gardens, from the earliest times. It is a larger and more woody plant than our native species, *T. Serpyllus*, but the flowers are smaller. Sprigs of thyme are used for giving flavour to soups. There are several varieties, particularly the broad-leaved or green thyme, and the narrow-leaved thyme. The plant is propagated either by parting the roots or planting slips in the spring, or by sowing the seed at the same season. It grows best on light dry soil, which has not been recently manured. A very small bed of the green thyme is enough for kitchen use. Sometimes it is planted as an edging to a border, in which case it must be cut close. It is often admitted to the flower-garden, and varieties with variegated leaves are to be met with. If the plants be allowed to ripen their seeds, numbers of seedlings will appear the following year, when they may be transplanted. In autumn, some of the bushes of thyme

are cut over, and hung up surrounded with paper, to dry for winter use.

The Lemon-scented thyme is a variety of our native species above mentioned. It is sometimes also cultivated, being in request for flavouring particular dishes.

*Sage.*

408. *Sage* (*Salvia officinalis*, L.; *Diandria Monogynia*; *Labiatæ*, Juss.) is a native of the south of Europe, which has very long been an inhabitant of our gardens. It is a branched shrub, about two feet high; the leaves are wrinkled, green, cinereous, white, or tinged with dusky purple; flowers terminal, in long spikes; of a blue colour. Several varieties are cultivated: Red or purple sage, and Green sage; and each of these with variegated leaves, forming ornamental plants in the flower-border. There is a small-leaved green variety, called Sage of Virtue; and there is a Broad-leaved balsamic sage. The red is the sort preferred for culinary purposes, but the green is also employed. The leaves are used in stuffings and sauces for many kinds of luscious and strong meats. Of sage of virtue the decoction called Sage-tea is usually made; but it is equally good from the broad-leaved or the common green. The plants do not endure in good condition for more than three or four years; but they are easily propagated by slips in the spring, or by cuttings when the summer is advanced. The cuttings should be five or six inches long, stripped of all the lower leaves, and plunged nearly to the top in the earth, being at the same time well watered. The lighter and poorer the soil, the better is the sage, and the more surely do the plants stand the winter. In July or August some parcels of sage twigs are commonly collected, and hung up in papers for winter use; but the leaves on the plants remain green through the winter, and a few may occasionally be gathered without doing injury.

*Clary.*

409. *Clary* (*Salvia sclarea*, L.) being of the same genus with sage, may here be noticed. It is a biennial plant, a native of Italy. The lower leaves are very large, the stem is about two feet high, clammy to the feel; the flowers are in loose terminating spikes, composing whorls, and of a pale blue colour. Clary was very early cultivated in English gardens, having been accounted medicinal. It is sometimes used in soups, but its very strong scent is not agreeable to many. A considerable bed of clary is seldom to be seen in gardens, excepting when it is intended to make clary wine. For this purpose, in dry weather, the flowers are gathered; some employ the whole spikes, and others carefully separate the blossom from the calyx. Most generally, clary flowers are used only for giving flavour to home-made wines, being thought to impart something of the frontignac zest. The plant is propagated by seeds sown in the spring, and transplanted in the summer months at fifteen inches apart. Next year they yield their flowers; and if a few plants be left, plenty of seed may be procured.

*Mints.*

Several species of *mint* (*Mentha*, L.; *Didynamia Gymnospermia*; nat. ord. *Labiatæ*) are cultivated in gardens; all of them indigenous to Britain, and hardy perennials. The principal kind is,

410. *Spearmint*, (*M. viridis*, L.) This is not a common native plant; it is figured in "English Botany," t. 2424. The young leaves and tops are a good deal used in spring salads in England; they also form an ingredient in soups, or, more frequently, are employed to give flavour, being boiled for a time and withdrawn. They are also shredded down, and mixed with sugar and vinegar as a sauce to roasted meat, particularly lamb. A narrow-leaved and a broad-leaved sort are cultivated in gardens; and some variegated kinds are considered as ornamental plants, particularly a reddish variety called Orange-mint.

411. *Peppermint*, (*M. piperita*, L.) is likewise a rare native, figured in *English Botany*, t. 687. A few plants are sufficient in a garden, it being scarcely used but for distilling.

412. *Pennyroyal*, (*M. pulegium*, L.) figured in *English Botany*, t. 1026, is sometimes cultivated; but a few plants are sufficient.

All of these mints delight in a moist soil. Spearmint and peppermint are readily propagated, by parting the roots in autumn, by making slips in spring, or by means of cuttings during summer. Pennyroyal is easily increased by its creeping and rooting stems. Stalks of spearmint are often dried in the latter end of summer, when the plant is coming in flower, and kept for winter use; but unless the drying be gradually accomplished, and in the shade, much of the flavour escapes. Young mint leaves, however, may be had at any time of the winter or early spring, by setting a few roots in flower-pots in the autumn, and removing some of these into the corner of a hot-bed, or of the stove, some short time before the leaves be wanted.

*Balm.*

413. *Balm* (*Melissa officinalis*, L.; *Didynamia Gymnospermia*; *Labiatæ*, Juss.) is a hardy perennial, with square stems, which rise two feet high or more; leaves large, growing by pairs at each joint; a native of Switzerland and the south of France, and very early cultivated in our gardens. It is readily propagated by parting the roots, preserving two or three buds to each piece, or by slips, either in autumn or spring. The roots or slips being placed about a foot and a half asunder, and watered, soon establish themselves; and the balm plantation does not require to be renewed oftener than every third or fourth year. In order to have young leaves and tops all the summer, it is proper to cut down some of the stalks every month, when new shoots immediately spring. As the remaining stalks approach the flowering state, they are cut over at full length for drying. They should be cut as soon as the dew is off in the morning; for in the afternoon, at least in bright sunshine, the odour of the plant is found to be much diminished. The stalks and leaves are carefully dried in the shade, and afterwards kept in small bundles, pressed down, and covered with paper. The *primum ens melissæ*, by which Paracelsus was to renovate man, is now quite forgotten, and the plant is used only for making a simple balm tea, which affords a grateful diluent drink in fevers, and for forming a light and agreeable beverage under the name of Balm Wine.

*Marjoram.*

*Marjoram*, (*Origanum*, L.; *Didynamia Gymnospermia*; *Labiatæ*, Juss.) Of this, three species are cultivated.

414 *Pot Marjoram* (*O. Onites*, L.) is a perennial plant, a native of Sicily. The stem is somewhat woody; it rises more than a foot high, and is covered with spreading hairs; the leaves are small and acute, almost sessile, and tomentose on both sides. Though it seldom ripens its seeds in this country, it is sufficiently hardy to withstand our win-

ters. It is easily propagated by cuttings or slips. It is now little used by the cook.

415. *Sweet Marjoram* (*O. Marjorana*, L.) is a native of Portugal. It resembles pot marjoram, but the leaves have distinct petioles, and the flowers are collected in small close heads; from which last circumstance it is often called Knotted Marjoram. Being only a biennial, a little of the seed should be sown every year. The seed seldom ripens in this country, and is therefore commonly imported from France. It flowers in July, and is then gathered and dried for winter use.

416. *Winter sweet marjoram* (*O. heracleoticum*, L.) is a perennial species, a native of Greece, and which requires a sheltered border and a dry soil. The leayes resemble those of common sweet marjoram, but the flowers come in spikes. The plant is propagated by parting the roots in autumn.

Both the kinds of sweet marjoram are a good deal employed to give relish to soups, broths, stuffings, &c. They are used fresh in summer; and, for winter use, are drawn by the roots, and dried slowly in the shade, being afterwards kept hung up in a dry place.

*Savory.*

*Savory* (*Satureja*, L.; *Didynamia Gymnospermia*; *Labiatæ*, Juss.) Two species are cultivated, the winter and the summer savory.

417. *Winter savory* (*S. montana*, L) is a native of the south of France and of Italy, which has been very long cultivated in gardens. It is a small shrubby evergreen perennial plant, with two narrow stiff leaves, an inch long, opposite at each joint, and from the base of these a few small leaves in clusters. It is propagated by slips, or by cuttings of the young roots, and also by seeds. It is hardy, and continues good for several years, especially on poor soils. Some plants having established themselves on an old wall, have been observed to continue for many years.

418. *Summer savory* (*S. hortensis*, L) is an annual plant, a native of the south of Europe, with slender erect branches about a foot high; leaves opposite about an inch in length. This is propagated only by seed, which is sown in the spring time, thinly, in shallow drills, eight or nine inches apart. When it is to be stored for winter use, it should be drawn up by the root, as in this way it retains its flavour better.

*Basil.*

*Basil* (*Ocimum*, L.; *Didynamia Gymnospermia; Labiatæ*, Juss.) Two species are cultivated, both natives of the East, and both annual plants.

419. *Sweet Basil* (*O. basilicum*, L.) is generally sown on a hot-bed in the end of March, and planted out in May, at eight or ten inches square. If raised from the hot-bed in small tufts, with a ball of earth attached, it is sure to succeed. In dry weather, liberal watering is proper. In a sheltered situation, sweet basil, thus treated, rises to about a foot in height. If sown at once in the open border, the plants are late and small. The leaves and small leafy tops are the parts used. On account of its strong flavour of cloves, basil is often in demand where highly seasoned dishes are in use: a few leaves are sometimes introduced into a salad, and not unfrequently into soups.

420. *Bush Basil*, (*O. minimum*, L) is little more than half the size of the common basil. It forms a round orbicular bushy head. It is raised on a hot-bed in the same way as the other, but should be planted out in a richer soil, and in a warmer situation. The same parts of the plant are used, and for the same purposes.

In very favourable seasons, and in the south of England, both species sometimes ripen their seed; but in general, Italian seed may be depended on.

*Tarragon.*

421. *Tarragon* (*Artemisia Dracunculus*, L.; *Syngenesia Polygamia æqualis; Corymbiferæ*, Juss.) is a perennial plant, a native of Siberia, which was cultivated in gardens in the time of Gerarde. It rises a foot and a half high, is branched, and has narrow leaves, green on both sides. The leaves and tender tips are used as an ingredient of pickles, for the sake of their fragrant smell and warm aromatic taste. A simple infusion of them in vinegar makes a pleasant fish-sauce. In France, tarragon is often added to salads, that its agreeable pungency may correct the coldness of other herbs; and it is frequently put in soups.

In a dry loamy soil, tarragon proves quite a hardy plant; but it is apt to perish in a wet situation. It is easily propagated by parting the roots, or by planting in the spring young shoots with only two or three fibres. During the summer months, even cuttings will grow; but both the shoots and cuttings must be plentifully watered till they strike root. The plant is therefore seldom raised from the seed. The stems containing the leaves and tops are sometimes dried for winter use; and if fresh young tops be wanted at that season, they can soon be procured by keeping some roots in pots, and placing these in a hot-bed or stove.

422. *Common Wormwood*, which is another species of Artemisia, (*A. absinthium*, L.) was formerly kept in gardens, being much used as a vermifuge. It is a native plant, figured in "English Botany," t. 1230, and wild specimens are more powerful than cultivated ones. It is easily propagated by slips or cuttings. The growth of this plant, it may be remarked, should be encouraged in poultry walks, it being found beneficial to them. The distillers of great still whisky in Scotland sometimes employ it in place of hops, and for their use small fields of it are occasionally sown.

*Rosemary.*

423. *Rosemary* (*Rosmarinus officinalis*, L; *Diandria Monogynia; Labiatæ*, Juss.) is a native of the south of Europe, but if planted on a dry soil, in a sheltered garden, it withstands our ordinary winters. When its roots enter the crevices at the base of an old wall, the plant is not injured by the severest frosts. It is an evergreen shrubby plant, rising sometimes six or eight feet high; the leaves are sessile, linear, dark green above, greyish or whitish underneath; the blossoms of a pale blue colour. As it is a highly aromatic and a medicinal plant, a few bushss should be in every garden. An infusion of the leaves is grateful to many people. The flowers and calyces form a principal ingredient employed by the makers of what is called Hungary water. A rosemary sprig is the emblem of remembrance. "There's rosemary; that's for remembrance," says the distracted Ophelia, in Shakspeare. In some parts of the west of England, the sprigs are still distributed to the company at funerals, and often thrown into the grave upon the coffin of the deceased. Abercrombie, in his *Practical Gardener*, alludes to this practice, but supposes the motive to be the "preventing of contagion." There are varieties, with white-striped and with yellow-striped leaves; the former rather tender.

The plant is easily propagated by slips or cuttings in the spring.

*Lavender.*

424. *Lavender*, or *Spike Lavender*, (*Lavandula Spica*, L.; *Didynamia Gymnospermia; Labiatæ*, Juss.) is a native of the south of Europe, and has been cultivated in our gardens since the middle of the 16th century. The plant is shrubby, rising from two to four feet high; the leaves linear, hoary, slightly rolled back at the edges; the flowers forming terminating spikes. There is a narrow-leaved and a broad-leaved variety. Lavender is rather a medicinal plant than one used by the cook. In every garden, however, a few plants are kept. The spikes of flowers being very fragrant, the ladies often make imitation scent-bottles of them. Frequently they are put in paper bags, and placed among linens to perfume them. In physic gardens, the plant is extensively cultivated for the sake of the flowers, from which lavender water is distilled. It is propagated by cuttings, or young slips, any time in the spring months. In large gardens it is sometimes used as an edging, but it is too bulky. If lavender be planted in a dry, gravelly or poor soil, its flowers have a powerful odour, and the severity of our winters has little effect on it; while, in a rich garden soil, although it grows strongly, it is apt to be killed, and the flowers have less perfume. In common garden soil, new plantations should be made every four or five years.

*Coriander.*

425. *Coriander* (*Coriandrum sativum*, L.; *Pentandria Digynia; Umbelliferæ*, Juss.) is a native of the East, but has naturalized itself in Essex, near places where it has long been cultivated for druggists and confectioners, and is therefore figured in *English Botany*, t. 67. It rises about a foot high, with doubly pinnated leaves. It is not often raised in private gardens. Formerly the young leaves were used in salads, and in soups; but they have a strong and scarcely agreeable scent. The seeds are now chiefly in request for medicinal purposes. If these be wanted, the seed should be sown in autumn, and the plants afterwards thinned out to five or six inches asunder.

*Caraway.*

426. *Caraway* (*Carum carui*, L.; *Pentandria Digynia; Umbelliferæ*) is a biennial plant, a native of some parts of England, and figured in *English Botany*, t. 1503. The plant rises a foot and a half high, with spreading branches; the leaves are decompound; the leaflets in sixes. In former times, the tapering fusiform roots were eaten like parsnips, to which Parkinson gives them the preference. In the spring time, the under leaves are sometimes put in soups, But the plant is now principally cultivated for the seeds; these are used in making cakes, and are incrusted with sugar for comfits; they are likewise distilled with spirituous liquors, and for this purpose large quantities are raised in fields in Essex. Nicol and others direct its being sown in the spring; but it is much better to sow in autumn, soon after the seed is ripe; the seedlings quickly rise, and, the plant being biennial, a season is thus gained. A moist rich soil answers best. The seed is generally sown in rows; and in the spring, the plants are thinned out to four or six inches apart. In the end of summer, when the seeds appear to be nearly ripe, the plants are pulled up, and set upright to dry, the seed being then more easily beat out.

*Tansy.*

427. *Tansy* (*Tanacetum vulgare*, L; *Syngenesia Polygamia superflua; Corymbiferæ*, Juss.) is a well known perennial plant, a native of most parts of Britain, generally growing on the banks of rivers; it is figured in *English Botany*, t. 1229. In a cultivated state, it rises to the height of three or four feet; the stem leafy, the leaves alternate, deep green, finely divided; the flowers appear in terminating corymbs, and are yellow. It has long had a place in the garden, partly on account of its medicinal virtues, being in high estimation as a vermifuge, and partly for the sake of its young leaves, which are shredded down, and employed to give colour and flavour to puddings. There is a variety with curled leaves, which is rather ornamental; this is often called Double tansy. There is likewise a sort with variegated leaves, which is sometimes admitted into shrubberies. Tansy is extremely hardy, and will grow in any soil or situation. A few plants are sufficient; and it is very easily propagated at any time by parting the roots. Tansy leaves may be procured very early in the spring, by laying two or three tufted roots of the plant upon a slight hot-bed about mid-winter, arched with hoops and covered with mats in severe weather. The young leaves may also be had throughout the summer, by cutting down the flower-stems close, so as to encourage a new growth.

*Costmary.*

428. *Costmary*, or *Ale-cost*, (*Balsamita vulgaris*, Hort. Kew.: *Tanacetum Balsamita*, L.; *Syngenesia Polygamia æqualis; Corymbiferæ*, Juss.) is a native of Spain, Italy, and the south of France: it is however a hardy perennial, and has been cultivated in our gardens from the earliest times. The lower leaves are large, ovate, of a greyish colour, and on long footstalks; the stems rise two or three feet high; they are furnished with leaves of the same shape, but smaller and sessile. The flowers are of a deep yellow colour, and appear in loose corymbs in August and September; in indifferent seasons or in cold situations, they scarcely expand, and the seeds very seldom come to maturity in this country. The whole plant has a pleasant odour. Costmary was formerly more used in the kitchen than it is at present. In France it is an ingredient in salads. It was also put into ale, and hence the name Ale-cost. The other name, cost-Mary, intimates that it is the *costus* or aromatic plant of the Virgin. A few plants are enough in a garden. They do best in a dry soil, and will remain good for several years. It is readily propagated by parting the roots in autumn. There is a variety with deeply cut and very hoary leaves, but this sort is less fragrant.

*Hyssop.*

429. *Hyssop* (*Hyssopus officinalis*, L.; *Didynamia Gymnospermia; Labiatæ*, Juss.) is a perennial evergreen undershrub, a native of the south of Europe, and has been long cultivated in our gardens. The stems rise a foot and a half high; the leaves are lanceolate, narrow like those of lavender, but shorter. There are several varieties, blue, red, and white flowered, and hairy leaved; but the first is the most commonly cultivated. The whole plant has a strong aromatic scent. The leaves and young shoots are sometimes used for culinary purposes, in the way of a pot-herb; and the leafy tops and flower-spikes are cut, dried, and preserved for medicinal uses. It is sometimes planted as an edging in the kitchen garden, the plants being set

only about ten inches distant from each other: in a separate bed, they should be two feet asunder. It may be propagated by seeds, by roooted slips, or by cuttings, in the spring months. In a poor dry soil it is not only more hardy, but more aromatic, than in a rich soil. It often grows on old walls; but the "hyssop that springeth out of the wall" of Solomon, is supposed by Hasselquist to have been a small moss, which he observed covering the ruins of Jerusalem.

*Rue.*

430. *Rue* (*Ruta graveolens*, L.; *Decandria Monogynia; Rutaceæ*, Juss.) is a perennial evergreen undershrub, a native of the south of Europe. It was early cultivated in our gardens, and was in former days called Herb of Grace, from the circumstance of small bunches of it having been used by the priests for the sprinkling of holy water among the people. There is a tall growing and a small kind; the latter is now chiefly cultivated. Formerly border edgings were frequently made with it; but it is now seldom employed for that purpose. It ought, however, to be occasionally pruned down, and kept from flowering too much; in this way it continues in a fresh bushy state for a number of years. It is easily propagated by slips or cuttings in the spring; and a few plants are generally thought sufficient in a garden. Like rosemary, lavender, hyssop, and other similar aromatics, it does best in poor dry soils. The leaves are sometimes used as a medicine, and often given to poultry afflicted with croup.

*Chamomile.*

431. *Chamomile* (*Anthemis nobilis*, L.; *Syngenesia Polygamia superflua; Corymbiferæ*, Juss.) is a well known perennial plant, which grows naturally in Surrey, Cornwall, and some other parts of Britain, and is figured in *English Botany*, t. 980. Few gardens are without a chamomile bed: it is certainly a highly aromatic plant, and an infusion of the dried flowers makes a safe bitter and stomachic, much used under the name of Chamomile-tea. The double-flowering variety is ornamental, and is generally kept in gardens; but the single-flowered sort is preferable for use; the useful principle not residing in the floscules of the ray, which are multiplied in the double flower. The flowers are gathered when in their prime, dried slowly in the shade, and preserved in paper bags till wanted. The plant is easily propagated by slips or rooted shoots in the spring months. It delights in a poor soil: the plants may be placed ten inches or a foot apart, and should be watered in dry weather till they be established. It is sometimes employed to form rustic green seats, and it answers very well, if the seats be not very much used.

*Scurvy-grass.*

432. *Scurvy-grass* belongs to the same Linnean genus as the horse-radish, § 396, although in general habit the plants have no resemblance. It is the *Cochlearia officinalis*, L. an annual or at most a biennial plant, indigenous to most of our sea-shores, and, like the plant called thrift or sea-pink, growing also on many of our mountains, particularly in Scotland. It is figured in "English Botany," t. 551. A thick-leaved variety, called Dutch Scurvy-grass, is sometimes cultivated in gardens for medicinal purposes. The smaller leaves are occasionally eaten between slices of bread and butter. It is sown in July, or as soon as ripe seeds can be gathered; it requires little attention, needing only to be thinned and kept clear of weeds. If the seeds be not wanted, the flower stems may be cut over, and the plants will thus continue for two or more years. Common scurvy-grass thrives uncommonly well on the top of an old wall, where it will sow itself, and remain many years.

*Elecampane.*

433. *Elecampane* (*Inula Helenium*, L.; *Syngenesia Polygamia superflua; Corymbiferæ*, Juss.) is a native of different parts of the south and west of England, and figured by Sowerby in "English Botany," t. 1546. It is a perennial plant, with a thick fusiform aromatic root; it rises from three to five feet high, being one of our largest herbaceous plants; the lower leaves are a foot long, and perhaps four inches broad in the middle; the yellow flowers appear in large heads in July and August. In former days the root had many virtues ascribed to it; the plant was therefore cultivated in village-gardens throughout Europe: now, it is much less in repute, but it still keeps its place in the physic-herb corner. As a few plants only are wanted, they are generally procured by offsets in the autumn. The root is fit for use the second year: and roots of this age, it may be noticed, are better than those of old plants.

*Anise.*

434. *Anise* (*Pimpinella Anisum*, L.; *Pentandria Digynia*; nat. ord. *Umbelliferæ*) is an annual plant, a native of Egypt, but cultivated in Malta and Spain, for the seeds, which are medicinal, and a good deal in demand. In this country the plant requires a warm border. The seed is sown in April, where the plants are to remain; and they are thinned as they come up. It is only in very favourable seasons that the seeds are perfected. Mr Lysons mentions it as one of the plants raised by the physic gardeners near London, probably by mistake: for it is certainly too tender to be cultivated in this country for profit.

*Blessed Thistle.*

435. *Blessed Thistle* (*Centaurea benedicta*, L.; *Carduus benedictus* of the old writers; *Syngenesia Polygamia frustranea; Cinarocephalæ*, Juss.) is an annual plant, growing naturally in the Levant. It was formerly cultivated with care in our gardens for its supposed extraordinary virtues. An infusion of it is still sometimes used; and a few plants are therefore raised from the seed, which is generally sown in autumn.

It seems unnecessary to swell the list of these simples, or medicinal plants; but it may be proper slightly to mention a few esculents or herbs, principally native, the cultivation of which is either seldom attended to in this country, or has fallen into disuse.

436. *Garden Rocket* (*Brassica Eruca*, L.) is an annual plant, a native of Switzerland, which was in former times used as a salad herb, but is now seldom to be met with, unless in botanic gardens. When in flower it has a strong peculiar smell, which some would not hesitate to call fetid; but in a young state the flavour is just perceptible, and the leaves then form a very tolerable salad ingredient. It is still cultivated in some parts of the continent.

437. *Wild-rocket*, or Hedge-mustard, (*Sisymbrium officinale*, Hort. Kew.; *Erysimum officinale*, L; English Botany, t. 725.) has been sometimes sown and used as a spring pot-herb. When young, it has a warm and not disagreeable taste.

438. *Winter-Cress* (*Barbarea vulgaris*, Hort. Kew.; *Erysimum Barbarea*, L.; English Botany, t. 443.) is a well known perennial plant, which has long been occasionally used as an early spring salad. Some still consider the American cress of gardeners as merely a variety of this: but after cultivating both for several years, we have found those to be right who regard them as distinct. (See § 382.) It may be remarked, that a double flowered variety of Barbarea vulgaris is admitted to the flower-border, under the name of Yellow rocket.

439. *Sauce alone*, or Jack by the hedge, (*Erysimum Alliaria*, L.; English Botany, t. 796) is sometimes used, either in sauce, as a salad, or boiled as a pot-herb. When gathered as it approaches the flowering state, boiled separately, and then eaten to boiled mutton, it certainly forms a desirable pot-herb. To any kind of salted meat it will be found an excellent green. Being not unfrequent by the sides of hedges, in a natural state, it has seldom been raised in gardens.

440. *Samphire* (*Crithmum maritimum*, L.; English Botany, t. 819.) is well known as forming a very good pickle, and also a piquant addition to a salad. It grows among rocks on the precipitous shores of some parts of England, particularly Kent and Cornwall, and of Galloway in Scotland. It is the plant alluded to by Shakespeare in his celebrated description of Dover cliffs:

> ——"Half way down
> Hangs one that gathers samphire; dreadful trade!"

It is a perennial plant, and is propagated by parting the roots, or by seed sown in the spring. It is not easily cultivated. It seems to succeed best on a rich light soil, having sand and gravel mixed with it. It must be in a well sheltered situation, and requires to be freely watered in dry weather, till the roots have struck deep among the soil and gravel. Mr Marshall mentions, that it has been found to do well in pots, set for the morning sun only. If a few plants can be got to take deep root in an old wall, or on an artificial rock-work, they will have a much better chance to remain. The name samphire is a corruption of *sampier*, and this again is derived from the French name of the plant *Saint Pierre*. It may be observed, that what is called *golden samphire* in Covent Garden market, is the Inula crithmifolia, Eng. Bot. t. 68; and that the *Marsh samphire* of the same market, is the Salicornia herbacea, Eng. Bot. t. 415.

441. *Buck's-horn Plantain* (*Plantago coronopus*, L.) was formerly cultivated as a salad herb, but is now neglected, the smell being to many rank and disagreeable. It is still, however, regularly sown in French gardens as a salad herb, under the name of *Corne de Cerf*.

442. The young leaves of the *Ox-eye Daisy* (*Chrysanthemum leucanthemum*, L.) are noticed by Dr Withering as fit to be eaten in salads; and John Bauhin mentions that they were much used for that purpose in Italy.

443. The *Cotton Thistle* (*Onopordum acanthium*, L.; English Botany, t. 977.) is a biennial, growing naturally in different places, and remarkable for its large downy leaves and lofty stem. It was formerly cultivated and used like the artichoke and cardoon; the receptacle, and the tender blanched stalks, peeled and boiled, being the parts used.

444. *Alexanders* (*Smyrnium Olusatrum*, L.; English Botany, t. 230.) is a biennial plant, rising about two feet high, and flowering in the spring; the leaves of a pale green colour, and the flowers yellowish. It grows naturally near the sea in several places, and may often be observed to be naturalized near old buildings. It was formerly much cultivated, having been used as a port-herb and salad. In flavour it has some resemblance to celery; by which it has been entirely supplanted.

445 *Water Cress* (*Nasturtium officinale*, Hort. Kew.; *Sisymbrium Nasturtium*, L.; English Botany, t. 855.) is a well known perennial inhabitant of our ditches and slow running streams. It forms an excellent spring salad; and it is easily cultivated in any marshy spot, or by the side of a garden pond, by introducing a few plants from ditches where it grows wild. The popular remedy called *spring juices* consists of its juices, with those of Brooklime, scurvy-grass, and Seville oranges: it is therefore cultivated by a few market gardeners for the supply of Covent Garden. In France, the sprigs are used as a garnish to roast fowl.

446 *Brooklime* (*Veronica beccabunga*. L.; English Botany, t. 655.) is a perennial plant, growing in wet places near springs, and in slow running streams or ditches, very generally associated with the water-cress. The leaves are mild, or have only a slightly bitterish taste, and form a very tolerable salad ingredient in March and April. In Scotland the plant is called *water purpie*, and the sprigs are gathered for sale along with *wall-cresses* (well or water cresses.)

447 The young tops and leaves of the *Great Nettle* (*Urtica dioica*, L.; English Botany, t. 1750) are gathered in early spring, about February, as a pot-herb, and form a tolerably good one. *Nettle-kail* is an old Scottish dish, now known only by name. If nettle-tops be wanted, they can readily be had without cultivating the plant.

448. *Sow-thistle* (*Sonchus oleraceus*, L.; English Botany, t. 843.) is a common annual weed in our gardens. There is a prickly and a smooth variety. The latter is in some countries boiled and eaten as greens; hence the Linnean trivial name *oleraceus*. The tender shoots boiled in the manner of spinach are very good, superior perhaps to any greens not in common use.

449. *Dandelion* (*Leontodon taraxacum*, L.; English Botany, t. 510) is a well known perennial, generally despised as a troublesome weed: yet the leaves, in early spring, when they are just unfolding, afford a very good ingredient in salads. The French sometimes eat the young roots, and the etiolated leaves, with thin slices of bread and butter. Blanched dandelion loses its disagreeable flavour, and considerably resembles endive in taste.

450. *Bladder Campion*, or Spatling Poppy (*Silene inflata*, Hort. Kew.; English Botany, t. 164.; *Cucubalus behen*, L.) is a hardy perennial, growing naturally by the sides of our corn-fields and pastures. Its young tender shoots, when about two inches long, are excellent when boiled, having something of the flavour of peas. The plant sends forth a great number of sprouts, and when these are nipped off they are succeeded by fresh ones.

451. The *Hop* (*Humulus Lupulus*, L.; Eng. Bot. t. 427.) is well known as being cultivated for the sake of its flowers for preserving beer; but for use as a kitchen-herb it is little regarded. The young shoots, however, which, early in the spring, rise abundantly from old stocks, are not much inferior to asparagus. They are sometimes, but not often, sent to market, and sold by the name of *hop-tops*.

For further particulars regarding esculent plants which have fallen into neglect, the reader may be referred to the "Flora Diætetica" of Bryant.

### *Fungous Plants.*

Of the tribe of Fungi several esculent species occur in this country, belonging to the genera Agaricus, Tuber, and Phallus. Only one is cultivated, the Common Mushroom, *Agaricus campestris* of Linnæus, *A. edulis* of Bulliard and others.

*Common Mushroom.*

452. This is well known. It is most readily distinguished, when of middle size, by its fine pink or flesh-coloured gills, and pleasant smell: in a more advanced stage the gills become of a chocolate colour, and it is then more apt to be confounded with other kinds, of dubious quality; but the species which most nearly resembles it, is slimy to the touch, and destitute of the fine odour, having rather a disagreeable smell: further, the noxious kind grows in woods or on the margins of woods, while the true mushroom springs up chiefly in open pastures, and should be gathered only in such places.

The uses of the mushroom are familiar; it is eaten fresh, either stewed or broiled; and preserved, either as a pickle, or in powder. The sauce commonly called *ketchup* (supposed from the Japanese *kit-jap*) is, or ought to be, made from its juice, with salt and spices. Wild mushrooms from old pastures are generally considered as more delicate in flavour and more tender in flesh, than those raised in artificial beds. But the young or button mushrooms of the cultivated sort are firmer and better for pickling; and in using cultivated mushrooms, there is evidently much less risk of deleterious kinds being employed.

Mushrooms are most speedily and certainly propagated, by placing the germinating seeds,—or rather the white fibrous radicles, which produce tubercles in the manner of potatoes, called the *spawn*,—in a situation proper for the developement of the plants. Without at all abetting the doctrine of equivocal generation, we may assert our power to produce this spawn at pleasure. Some long stable dung, which has not lain in a heap, or undergone any degree of fermentation, is mixed with strong earth, and put under cover from rain: the more the air is excluded, the sooner does the spawn appear: a layer of old thatch, or any kind of litter that has lain long abroad, and so is not apt to ferment, is proper for excluding the air. In about two months the white threads of the spawn will be found penetrating the dung and earth. When spawn is once procured, it may be extended or propagated, as spawn, without producing mushrooms. A mode of doing this, practised by Mr John Hay, may here be mentioned. A quantity of cow droppings is to be gathered from the pastures; some rotten wood, or spray from the bottom of a hedge, is to be collected, with a little strong loam. These are mixed, and formed into a moist ductile sort of mortar or paste, of such consistence, that it can be cut into pieces like bricks. When these are so far dried that they can conveniently be lifted, a row is laid in some dry place, under cover, perhaps in a shade at the back of a hot-house; a little spawn is placed upon the layer; then another layer of the spawn bricks, and so on. In a few weeks the whole mass is penetrated by the spawn. The spawn bricks may then be laid aside for use; they will keep many months; and the drier they are kept, the more certainly do they afford a crop of mushrooms, when placed in favourable circumstances for doing so.

The usual mode of raising mushrooms, in beds prepared with layers of horse-droppings and fine mould, is generally understood, and has been fully described in a preceding part of this work, (art. FUNGI.) It may be proper, however, in addition to what is there said, to give an account of what is called Oldacre's plan, this being generally considered as an improvement on the culture of mushrooms.

453. Mr Isaac Oldacre is an Englishman, who for many years held the office of chief gardener to the Emperor of Russia at St Petersburgh. In 1814, he visited his native country; and on that occasion, at the desire of Sir Joseph Banks, put in practice at Spring Grove his improved mode of raising mushrooms. In forming the compost for the beds, he prefers fresh short dung, from a stable or the path of a horse-mill. The dung must neither have been exposed to wet nor to fermentation. About a fourth or a sixth part of cow or sheep's droppings is added, and the whole ingredients are well mixed and incorporated. The beds, if they may be so called, are formed on shelves, or in drawers or boxes, in the mushroom-house, or in any outhouse, where a slight increase of temperature can be commanded. A stratum of the prepared mixture, about three inches thick, being deposited, is beat together with a flat wooden mallet. Another similar layer is added, and beat together as before; and this is repeated, till the beds be six inches thick, and very compact. A degree of fermentation soon takes place in this mass; but if the heat arising from this process be not quickly perceptible, another layer must still be added, till sufficient action be excited. When the beds are milk warm, (or between 80° and 90° Fahr.) some holes are dibbled about nine inches apart, for receiving the spawn. These are left open for some time; and when the heat is on the decline, but before it be quite gone, a lump of spawn is inserted into each opening, and the holes are then filled up with the compost. Ten days afterwards, the beds are covered with a coating of rich mould, mixed with a fourth or sixth part of droppings, to the depth of an inch and a half. This is beat down with the back of a spade, and the bed may then be accounted ready for producing. The mushroom-house is now kept as nearly and equally at 55° Fahr. as circumstances will allow. When the beds become very dry, it is occasionally found requisite to sprinkle over them a little water, taken from a pond or river; but this must be done with great circumspection.

Beds thus prepared, we are assured, yield abundant crops of mushrooms. If a number of shelves or drawers be at first prepared, a few only, at a time, may be covered with mould, and brought into bearing; the rest of the shelves or drawers being cropped in succession, as mushrooms may happen to be in demand. It is evident that they may thus be procured at all seasons. The more that free air can be admitted into the mushroom-house, the flavour of the mushrooms will be found to be improved.

In what particulars the advantage of Mr Oldacre's plan over former modes chiefly consists, does not very clearly appear. Beds made up in the usual way are much less compact, and are more damp: compactness and dryness may therefore be considered as important. Indeed, the beneficial effects of keeping the spawn dry were long ago noticed by Miller, in his Dictionary, who found, that spawn which had lain for four months near the furnace of a stove, yielded a crop in less time and in greater profusion than any other.

In some old authors, a very sage advice is given for promoting the fecundity of mushroom beds constructed on the ordinary plan, viz. to take a few full grown mushrooms from pastures, and, breaking them down in the watering-pot, to water the beds with the infusion. This is plainly nothing else than sowing mushroom seed, the minute seeds lodged in the gills being thus suspended in the water, and introduced along with it into the bed.

454. Although the Agaricus campestris is the only species cultivated, it is not the most delicate of the tribe as to flavour, nor perhaps the best deserving of culture. Some of the others should be tried, and there seems no reason to doubt of ultimate success. A. aurantiacus possesses ex-

cellent qualities; the flesh is tender, and the flavour delicate: it is in high repute on the Continent, where it is gathered in pine forests, about the end of summer. It is the *oronge* of the French, and is distinguished from another species, called the false oronge, by having a complete volva. A. solitarius is remarkable for its fine flavour. A. procerus is a great favourite in France, where it is known by the name of *grisette*. A. deliciosus is much used in Germany and Italy; but though it is not uncommon in our fir plantations, it is scarcely ever eaten in this country. The Champignon (*A. pratensis*) is used in soups, and is therefore occasionally brought to market; but, as remarked by Mr Sowerby, in "English Fungi," it is apt to be confounded, by the common mushroom gatherers, with A. virosus, one of the most to be avoided. A. violaceus is sometimes sold in Covent Garden, under the name of Bluets: it is a harmless kind, but has no other merit. The species which most commonly forms the circles and semicircles on downs near the sea-shore, called *fairy-rings*, is A. oreades. This Mr Lightfoot, in his *Flora Scotica*, considers as the *mousseron* of the French; but their mousseron is A. virgineus of Persoon, a fleshy species, nearly of a pure white colour, while our plant is coriaceous and buff-coloured.

### *Truffles and Morels.*

These have already been described under the article Fungi, and are figured in Plate LXXV. of this work.

455. The *Truffle*, or subterraneous puff-ball, (*Tuber cibarium*,) is one of the best of the esculent fungi. It grows naturally in different parts of Britain, but is most common in the downs of Wiltshire, Hampshire, and Kent, where dogs are trained to scent it out; the plant growing and coming to perfection some inches below the surface. The dogs point out the spot by scraping and barking, and the truffles (for several generally grow together) are dug up with a spade. They are principally sent to Covent Garden market. No attempt, it is believed, has hitherto been made to cultivate truffles; but of the practicability of the thing, there seems no reason to doubt. In their habits of growth, indeed, they differ essentially from the mushroom; but it is certainly possible to accommodate the soil and other circumstances to the peculiar nature of the fungus. It has been said, that the tubercles on the surface of truffles are analogous to the eyes or buds of potatoes, and that they have been propagated, like potatoes, by means of cuts furnished with tubercles: it may however be suspected, that the pieces thus planted contained ripe seeds. Truffles, we may add, seem to delight in a mixture of clay and sand; and a moderate degree of bottom heat, such as is afforded by a spent hot-bed, might probably forward their vegetation.

456. The *Morel* (*Phallus esculentus*, L.; *Helvella esculenta* of Sowerby, and *Morchella esculenta* of Persoon) rises, in the spring months, generally in woods, but sometimes on commons. It frequently appears for sale in Covent Garden market in May and June; but it has never been cultivated. The cultivation of morels, however, would probably be more easily accomplished than that of truffles. Morels are used either fresh or dried, commonly as an ingredient to heighten the flavour of gravies or ragouts. If intended for keeping, they should not be collected when wet with dew, nor soon after rain; if gathered in a dry state, they may be kept for many months.

Having treated at great length of the Kitchen Garden, and of culinary plants suited to our climate, we now turn to the Flower Garden; and here we shall study brevity as much as possible.

## FLOWER GARDEN.

457. The flower garden, it has been already observed, § 55. has a separate situation, generally at some distance from the fruit and kitchen garden. It should indeed form an ornamental appendage to the mansion, and be easily accessible in all kinds of weather. There is no objection to the flower garden being seen from the windows of the house: on the contrary, this is sometimes considered as desirable. In some places, the flower garden consists of parterres of various shapes, generally curved, separated from each other by little grass lawns. Such insulated parterres look very well from the windows of the house; the turf, in our moist climate, being always of a lively green, and forming a fine contrast with the dressed ground, and with the gay hues of the flowers. But for many days in the year these grass-girt parterres are inaccessible to the proprietors, more especially to ladies, it being impossible to pass along the turf without getting wet, at times when well made gravel walks are comfortably dry. Wherever, therefore, this kind of flower garden amidst turf is formed, there should be another, which may be considered as the winter garden, and which may contain one or more of the glazed houses for preserving plants.

In many cases the flower garden is defended by low walls or by close pales, covered by shrubs. If there be little room, they may be concealed by a single row of some evergreen, such as phillyrea, alaternus, pyracantha, laurustinus, or tree-box. The wall on the north side of the garden, however, is in some places used for a double purpose; the more tender kind of shrubs being trained against it on the south aspect. In situations where a wall would be unsuitable, an "invisible fence" of wire is employed, this proving sufficient to exclude hares and rabbits, while it nowise offends the eye, and scarcely interrupts the view. Evergreen hedges, of laurel, yew, or holly, make excellent fences, especially if united with a sunk fence.

458. The shape and size of the flower garden can be regulated only by the taste and the means of the owner. If the eye embrace the whole at once, the garden should evidently be of some regular figure. But if the size be considerable, it is advantageous that the ground should be unequal in surface, and irregular in shape. In general, a green-house, conservatory, and stove, should form prominent objects in different parts of it: it should abound with evergreen trees and shrubs, so as to maintain its verdure even at midwinter; the principal borders should be destined for mingled perennial flowers, of the most ornamental kinds; a few may be devoted to showy annuals; and particular beds should be appropriated for the different kinds of flowering bulbs, as well as for pinks, polyanthuses, and auriculas. These borders and beds, it may be remarked, should be so placed, that from the windows of the house, or from the principal entrance of the garden, they may be seen across or laterally, so that the colours of the flowers may appear in mass, without being broken by the alleys.

A rock-work is generally formed; and if the situation admit of it, or if curiosity in plants be indulged in, a small piece of water for aquatics is proper. A circular or oval plat is commonly devoted to a collection of roses; and a damp border with peat soil is set apart as an "American ground." One of the walks is often arched over with strong wire, or with slight spars, on which climbing shrubs may be trained, so as to form a berceau. Covered seats of various kinds are constructed, under the names of heath and moss houses, arbours, and grottoes. If, however, the garden be regular in surface, bowers of light lattice-work, covered with climbing plants, are to be preferred. In very few places do fountains or statues now enter into the composition of the flower garden; and urns, busts, or inscriptions, are not to be introduced without caution.

Taking it for granted that the flower garden should have a ready communication with the principal gravel-walks near the house, and also with those leading to the shrubberies, and likewise that it is extremely desirable to have the walks at all times dry, we shall first make some remarks on the formation of such walks in general, and shall then consider some of the principal constituent parts of the garden more in detail.

*Garden Walks.*

459. Formerly grass walks were common in gardens; but the inconveniences attending them, especially dampness, and liability to wear bare in the middle, have caused them to be in a great measure relinquished; and they are now to be seen only in a few old gardens. Walks, at the present day, are principally made with gravel. If gravel walks be properly formed at first, much future labour is saved. If judged necessary, a drain should be made to pass below them; but at all events a quantity of lime-rubbish or very coarse gravel should form the foundation. In the flower-garden it is not necessary to have a fine permeable bottom of earth, such as is proper under gravel-walks next to fruit-tree borders. Lime-rubbish prevents the lodging of earth worms, which are so apt to disfigure walks, and also tends to drain the walks and keep them dry. Over the rubbish is laid screened gravel. In some places *gingle* from the sea-shore is used; but this does not bind without the addition of a little clayey matter. Good gravel may often be got from some inland pit, where there is naturally a slight mixture of clay. The gravel pits of Kensington and of Blackheath have long been celebrated. If gravel be liberally laid on at first, the face of the walk may afterwards be more easily refreshed, by turning over the surface gravel, and then using the roller.

If the walk be five or six feet broad, it should rise about an inch and a half in the centre. It is often made to rise considerably more; but the appearance is thereby impaired, and the walker is annoyed. If the walk be of large dimensions, the height in the centre may increase in proportion: so that in ten feet of breadth, a rise of two or three inches is quite allowable. The walks of the flower garden should scarcely be less than five or six feet wide; nor can there in general be any good reason for their exceeding eight feet. They should be two or three inches lower in level than the flower-borders, otherwise these last would look flat and mean.

The rollers used for levelling and smoothing the walks, are formed sometimes of wood, sometimes of stone; but the largest and best are of cast iron. Rolling immediately after rain is practised, the gravel binding readily at that time.

460. In many places only the principal walks are covered with gravel; all the subordinate ones, and the paths through woods or large shrubberies, being merely laid with sand. Gravel walks are much injured by the drip of trees in rainy weather, and are not easily repaired; while sand walks require only to have their surface stirred with a Dutch hoe, and to be raked smooth again. It is, however, of importance to have a foundation of very coarse gravel, broken field stones, or lime rubbish, below the sand. Sand from an inland pit, having commonly a tendency to bind, is preferable to pure sea or river sand. In places near the sea, and where banks of shells occur on the beach, sea-shells, when broken, will be found to form a very neat walk, also susceptible of binding to a certain degree. The utility of the binding quality is manifold; it gives the walk a neat appearance; it renders it more pleasant for walking on; and it permits of sweeping, without deranging the surface.

461. If the flower garden is to consist of parterres separated by grass-turf, the first formation of these little lawns requires particular attention. When the ground is delved over and levelled, a stratum of sand or very poor sandy earth, perhaps three inches thick, is laid on, and over this an equal depth of good earth, on which to sow the grass seeds. The use of the poor soil below is to prevent the grass from getting rank. This is particularly necessary, where a mixture of rye-grass and brome grasses (particularly *Bromus squarrosus* and *multiflorus*) is sown; and all the grass seed, it may be observed, sold in this country, consists of such a mixture. Were only fescue grasses sown (*Festuca duriuscula* and *ovina*,) with perhaps crested dog's tail (*Cynosurus cristatus*), there would be much less danger of over-luxuriant patches appearing, while their fine wiry leaves and slightly glaucous hue, would render the turf highly beautiful. The selection of grasses for lawns is too little attended to. The same kind of seed is sown indiscriminately in exposed and in shady situations. If white clover and rye-grass be sown under trees, it is little wonder that the ground should remain bare: if the seeds of *Poa nemoralis* were scattered in such situations, the bare spaces would soon be covered with a lively green sward. A judicious little essay on the employment of the gramina, and particularly of the species last mentioned, presented to the Highland Society by the late Mr George Don of Forfar, may be seen in the third volume of the Transactions of that Society, p. 194, *et seq.*

*Soil.*

462. The *soil* of the flower-garden should of course be various. For the general borders a loamy soil is preferable. The surface earth from old pastures, taken along with the turf, is accounted excellent. There may be mixed with it a quantity of old hot-bed dung, or other rotten manure; a third or a fourth, according as the earth is naturally rich or poor. If the compost seem apt to bind, a small proportion of sea-sand is the remedy. If a poor soil be wished for, which at the same time is open, then half-rotten tan from the bark stove is substituted for dung.

It may here be remarked, that various composts should always be in readiness, and others in a state of preparation; and for this purpose a convenient spot, as much hid from view as possible, but near to the garden, should be set apart as a compost yard.

Peat-soil is very useful in the flower-garden. It is of two sorts, boggy peat, and sandy or surface peat; the former adapted only to the larger and more hardy kinds of American plants; the latter, to other American plants, to alpine plants, to Cape heaths, and to many green-house plants. The best sort of peat-turf is frequently to be found constituting a mere skin over a bed of sand. The turf or sod should be taken with what peat-soil adheres to it, and should be allowed to moulder in the compost yard. Spots where wild heath grows luxuriantly, or where it closely covers the surface, are likely to afford excellent light or sandy peat. It may be added, that at the points where mountain rivulets enter the flat country, accumulations of peat earth and sand may often be found, the peat being freed, by the washing of the rivulet, from the chief part of the salts and other principles likely to prove hurtful to vegetation. A mixture of nearly equal parts of peat soil and loam is suitable for very many kinds of plants. For the succulent tribe Miller recommends a compost prepared of one-half earth from the surface of a common, where the soil is light; and the other half drift sea sand and old lime rubbish screened, in equal parts. Decayed leaves of trees have long been considered as forming the most suitable ingredient in composts, where it is wished to imitate a vegetable soil. Large pits are dug in convenient parts of the woods, and into these the heaps of leaves and small spray are raked during winter, as light sprinkling of the surface soil being thrown over all, to prevent the leaves from being blown about. After the lapse of a year, a very light vegetable soil is thus procured; while the half rotten spray forms an appropriate soil for some kinds of epidendrum, cultivated in the stove.

In the first forming of composts, considerable attention should be paid to the thorough mixing together of the ingredients. The heaps should not be round and of great bulk, but should rather be formed into long and narrow ridges, the sides of which may more effectually be exposed to the influences of the atmosphere. The compost should remain for at least a year before being used, and should be several times turned over and mixed in the course both of summer and winter.

The best kind of rich manure for the flower-garden is found in old hot-beds which have been formed of stable dung and litter; but even this should not be delved into the borders without being mixed with a portion of good loam; for there are few *flowers* to which very rich manures do not prove detrimental.

A quantity of pit sand should always be in readiness for mixing with other soils, or for *striking* cuttings of different plants. The purest and finest pit sand is preferred. However pure to appearance, it still contains a portion of very fine vegetable matter; sea-sand being destitute of this, is not nearly so proper.

To enlarge further on soils for the flower-garden seems unnecessary. In Cushing's *Exotic Gardener* may be seen a table of genera, shewing the peculiar soil most suitable, in a general way, to each genus; and the same little book contains some very useful remarks on the preparation and use of composts.

It may here be observed, that for all border plants, as well as for tulips, ranunculuses, and other flowers kept in beds, the earth or the compost should not be screened fine. It is enough, if stones which the spade sensibly strikes against be cast out, and if clods be broken small at the time of delving. Screened earth is apt to bind after heavy and continued rains, and thus to impede the progress of the roots which it was meant to facilitate. For plants kept in pots, and particularly for seedlings and cuttings, the matter is quite otherwise; the soil for most of these should be made fine by passing it through a sieve.

## *Edgings.*

463 In the formal style of gardening which prevailed in the 17th and the early part of the 18th century, *edgings* of various kinds were much more needed and more attended to than they now are. The compartments of parterres were generally divided by box, and on the margins of the walks were frequently small hedges of lavender, or rue. Thyme, savory and hyssop, were also in those days employed as ornamental edgings.

464. For the general gravel-walks in gardens, the best edging is without doubt the *dwarfish Dutch box* (*Buxus sempervirens* var.) A compact low hedge of this effectually keeps the walks clean, by preventing the earth of the border from falling down into them, or being washed into them by heavy rains. If the box be kept low and regularly clipped, it endures in good repair and beauty for several years. It is commonly clipped twice in the year, in April and July. It should be kept about three inches broad at the base, and tapering upwards to a sharp ridge. A linear and continuous edging of this kind pleases every eye. Box is planted either in the beginning of autumn, or in the spring about the month of April. If slips having few or no roots be used, watering is proper till the plants be fairly established.

Next to box, the plant which forms the best retaining edging is perhaps *thrift* or *sea-pink* (*Statice armeria.*) In June and July, when in flower, it makes a showy edging; and it answers the purpose during the rest of the year with its dense tufts of leaves. It should be replanted every year, or at farthest every second year.

The double-flowered *daisy* (*Bellis perennis*, var. fl. pl.) has very long been used in this way. When kept in repair, it forms an edging very pleasing to the eye. The plants should be separated and transplanted every season, in the beginning of September, and only one strong stem or bud left to each bunch of roots.

Double *catchfly* (*Lychnis viscaria*, fl. pl.) is sometimes employed; but it seldom makes a neat edging: the flowers are ornamental, but the stems are too tall. *Dwarf gentian* (*Gentiana acaulis*) of all other plants forms the most brilliant edging, while in flower in the spring; but it is necessary that a continuous azure line be kept up, and for this purpose the verge must be of some breadth: It is applicable therefore only to large or broad borders, and it succeeds best in a strong or clayey soil. *London-pride* (*Saxifraga umbrosa*) forms a loose and straggling verge, but is very pretty while the plants are in flower: It is fittest for a shrubbery walk. *Lady's cushion*, or Indian moss as it is sometimes called, (*Saxifraga hypnoides*) is occasionally planted as an edging, and makes a pretty enough appearance. Some other similar species of Saxifraga, such as *palmata* and *cæspitosa*, may be used in the same way.

For gay parterres, the large blue-flowered *pansy violet* (*Viola tricolor* var.) makes a beautiful slight edging. Although strictly speaking, an annual plant, if it be parted every season, it endures for several years. It is very commonly used for adorning the margins of elegant flower-borders in the neighbourhood of Dublin.

*Dwarf bell-flower* (*Campanula pumila*, or *C. rotundifolia* var.) makes a fine edging for little borders where nicety and beauty are studied. Sometimes a few feet of the edging are formed alternately of the blue and of the white variety. For small borders, also, a very ornamental edging may be formed of *Stone crop* (*Sedum acre*), preferring the variety which has the tops of the shoots of a yellowish colour; this, even during winter or very early in the spring, having the appearance of being in flower.

It may be remarked, that patches of several of the different edging plants which have been enumerated, perhaps a few yards alternately of each, have an agreeable effect, especially in a long or extensive border.

Most kinds of edgings may be planted early in the spring. In planting them, it is more proper to use the spade than the dibble. The ground being slightly beat, a drill is cut by the garden-line, perpendicular on the side next the border; the plants are then placed against the perpendicular side, their roots spread out, and the earth closed upon them.

For edgings to square or oblong beds intended for tulips, ranunculuses, or similar plants, thin boards painted of a lead colour, are perhaps better than any other. Edgings to endure only for one season are sometimes formed of annual plants, sown in the spring; such as the dwarfish stock (*Malcomia maritima*, H. K.), or candy-tuft, purple or white, (*Iberis umbellata*.)

465. A simple and elegant edging may be formed of sheep's-fescue (*Festuca ovina*,) the very fine foliage of the plant being highly ornamental. In the extensive nurseries at Gateside, Newcastle, this sort of verge has been adopted, F. duriuscula being mixed, however, in some places, with the true sheep's-fescue. If very carefully sown or planted in a narrow straight line, it has a slender linear appearance, and does not occupy more space than a small box edging. For a temporary edging, another kind of grass, the large cow-quakes, (*Briza maxima*,) is sometimes very happily employed, the loose racemes, with their nodding spikes, having a pleasing and uncommon effect. If sown in autumn, soon after the seeds ripen, the plants become larger and stronger than those sown in the spring. Common grass verges can scarcely be less than a foot in breadth, and are not therefore adapted for small borders: if formed of fine turf laid upon sand to keep the plants dwarfish, such simple verges are very proper for the margins of shrubbery borders.

*Evergreens.*

466. Near the house, and about the flower garden, evergreen shrubs should abound. There should be at least one evergreen for two deciduous shrubs. The transplanting of evergreens requires some attention. It is often desirable to have them at once of considerable size; and fine large specimens may sometimes be found in public nurseries, or in market gardens. A year before these are to be removed, the roots should be cut, by passing a sharp spade all around and below them; thus encouraging the setting out of new and tufted roots, and greatly facilitating the subsequent removal of the plant. The roots of any kind of evergreen should be as little as possible exposed to the air. Nicol, in his Calendar, makes some judicious observations on the best time for transplanting of evergreens: He prefers the middle or end of April, or rather the precise time when the plant begins to grow for the season, when the buds swell, and the new leaves are about to be unfolded: the roots are then also in an active state, and if the transplanting be speedily accomplished, no check is sustained. Next to this late period of the spring, the beginning of August is a good time; for a second growth then takes place, as careful observers must have remarked, occasioned perhaps by the showery weather which generally occurs at that season.—Only a very few of the principal hardy evergreens can here be noticed.

467. Of the Alaternus (*Rhamnus alaternus*) there are several varieties, particularly the jagged and the plain leaved, and the gold and the silver variegated. Resembling this is the *Phillyrea*; but the genera may at once be distinguished, without seeing the flowers, by observing, that in the former the leaves are alternate, while in the latter they are opposite. Of phillyrea there are three species, privet-leaved (*P. media*), narrow-leaved (*P. angustifolia*), broad-leaved (*P. latifolia*), and several varieties of each of these: these were, in former days, among the most favourite tonsile evergreens.

The Chinese Arbor vitæ (*Thuja orientalis*) and the American (*T. occidentalis*) are large, and rather suited for extensive shrubberies. The same may be said of the common laurel (*Prunus laurocerasus*), and the Portugal laurel (*P. lusitanica*.)

468. The Sweet Bay (*Laurus nobilis*), which is a considerable tree in the south of Europe, appears but as a shrub in this country, producing its flowers only in sheltered situations and good seasons. The common laurel above mentioned, we may remark, is often mistaken for the bay, and regarded as the plant which furnished crowns for the Roman heroes. The error is perhaps fortunate, our bays thus escaping mutilation on occasions of public rejoicing. There is no doubt, however, that it was the sweet bay which furnished the wreath worn on the brow of the victor, and of the priestess of Delphi. The mistake has arisen from the bay having formerly been called laurel, and the fruit of it only named *bayes*. The Alexandrian Laurel (*Ruscus racemosus*) has also been mistaken for the heroic plant; but although destitute of this honour, it is a most elegant shrub, worthy of a prominent station.

The different varieties of Laurustinus (*Viburnum tinus*) are very ornamental, as they not only enliven the winter scene with their green leaves, but delight us with their flowers at that dead season. These last, however, are produced only in sheltered situations.

469. The Strawberry-tree (*Arbutus unedo*) is an elegant plant at all times; but when at once covered with fruit and flowers, the appearance is not only beautiful, but curious. In Ireland, about the Lakes of Killarney, this species, which ranks as a shrub in Scotland and the north of England, attains the size of a lofty tree. In the Transactions of the Dublin Society for 1806, a gigantic specimen is described by Mr J. T. Mackay as growing in Rough Island, an islet in the lower lake, entirely composed of limestone. In 1805, this tree measured nine feet in circumference at two feet from the ground; at the height of five feet it branches off into four limbs, each of which then measured two feet and a half in circumference; from the base of the trunk to the extremity of the branches, the length was 36 feet; and the tree has a fine spreading head. The *andrachne* (*A. andrachne*) is a beautiful shrub or small tree, but liable to be injured by severe frosts, and suited only to the milder counties of England and Ireland.

The superb Yucca, or Adam's needle, (*Yucca gloriosa*) may here be mentioned, as it retains its leaves at all times. When in flower it makes a magnificent appearance. Young plants are at first rather tender; but when fairly established, they prove sufficiently hardy for the open border. A fine specimen has stood for about a century in the pleasure-grounds of Kilochan, belonging to Sir Andrew Cathcart in Ayrshire; and it flowers every second or third year.

The Aucuba, or gold plant, (*Aucuba Japonica*) was formerly kept in the green-house; but it now ornaments the flower-garden with its fine spotted yellow leaves; and in a sheltered situation it sustains no injury from our ordinary winters.

470. Rhododendrons of different species are highly ornamental, particularly R maximum, Ponticum, hirsutum, and ferrugineum. These grow well in any loamy soil, although they no doubt flourish more among sandy peat. If a rivulet pass the flower garden, the banks of it should be planted with them. *Kalmias* may also be introduced, particularly K. latifolia, angustifolia, and glauca; together with *Ledum* palustre and L. latifolium, or the Labrador tea plant; likewise different species of *Vaccinium*, and of *Andromeda*, particularly pulverulenta and cassinefolia; and *Gaultheria* procumbens.

471 Among low evergreens for the front of the borders, different species of Cistus or rock-rose are excellent; and several hardy exotic Heaths, which shew their flowers early in the spring, particularly Erica mediterranea and carnea. E. arborea, the flowers of which are fragrant, sometimes attains the size of a considerable shrub, and is very ornamental, but it succeeds only in the milder parts of England. Even our four native species deserve a place

The most common is E. vulgaris, of which there is a white-flowered variety, and one with double flowers. E. cinerea, fine-leaved heath or *bell-heather*, is the next in point of abundance; it is more showy than the former, and there is a variety with white flowers. E. tetralix, or cross-leaved heath, is the third species; it is an elegant plant, distinguished by the leaves growing in fours, and by the flowers coming in clusters on the tops of the stalks. E. vagans is a native of the south of England, found indeed scarcely any where but in Cornwall. These native heaths grow perfectly well in any poor soil; but the ground should not be delved close by them, as their roots are generally extended very near the surface. *Pittosporum tobira* is a beautiful glossy-leaved Chinese evergreen, which succeeds in a well sheltered border, but unless it be situated in a dry soil, is apt to be cut off by the damp at the surface of the earth. Several species of *Daphne* are very ornamental as evergreens, and produce their flowers in the spring months, particularly D. cneorum, collina and pontica; and although the mezereon (*D. mezereum*) is a deciduous shrub; yet as it displays its blossoms very early in the spring, generally in February, it deserves a place: there are three varieties, dark red, pale red, and white. The Periwinkles (*Vinca major* and *minor*), when regularly cut over every year, form neat evergreen bushes.

472. The Musk rose (*Rosa moschata*) may be considered as approaching to an evergreen; and there is an almost evergreen variety of the sweet-briar (*R. rubiginosa*). But of all others, *R. Indica* is the greatest acquisition to our gardens, being not only always in leaf, but flowering both late and early, in November and in March. The *Ayrshire Rose*, a species not well ascertained, deserves a place, especially for covering any wall, pale, or winter seat; it grows very rapidly, and always retains some of its leaves. It is said to be from America, and to have received the name of Ayrshire rose, from having been first cultivated at Fairfield, near Kilmarnock. A rampant native species (*R. arvensis*) has likewise obtained among nurserymen the name of Ayrshire rose, and is often sold instead of the other, to which it bears a considerable resemblance.

*Autumn, Winter, and Spring Gardens.*

473. It now very commonly happens, that the autumn and early part of winter are the only seasons in which families, swayed by the fashionable world, reside at their country mansions. The forming of an autumnal and a winter garden is therefore important. In the former, many late-flowering perennial plants, such as asters, solidagos, rudbeckias, hollyhocks, and many kinds of annual flowers, may render the borders gay till the frost prove too severe. The carnation shed may with propriety be situated in the autumn garden.

474. Addison, in one of his Spectators (No. 477.) sets forth the pleasures and beauties of a winter garden. "In the summer season," he observes, "the whole country blooms, and is a kind of garden, for which reason we are not so sensible of those beauties that at this time may be every where met with; but when nature is in her desolation, and presents us with nothing but bleak and barren prospects, there is something unspeakably cheerful in a spot of ground which is covered with trees that smile amidst all the rigour of winter, and give us a view of the most gay season in the midst of that which is most dead and melancholy. I have so far indulged myself in this thought, that I have set apart a whole acre of ground for the executing of it. The walls are covered with ivy instead of vines. The laurel, the hornbeam, and the holly, with many other trees and plants of the same nature, grow so thick in it, that you cannot imagine a more lively scene." A winter garden of much smaller dimensions than here suggested, would in general be found sufficient. The idea was taken up also by Lord Kames, in his "Elements of Criticism," (vol. ii. p. 448). "In a hot country," he remarks, "it is a capital object to have what may be termed a summer garden, that is, a space of ground disposed by art and by nature to exclude the sun, but to give free access to the air. In a cold country, the capital object should be a winter garden, open to the sun, sheltered from the wind, dry under foot, and having the appearance of summer by a variety of evergreens." All the evergreens which have already been mentioned would enter with propriety into the composition of such a garden. The *hornbeam*, it may be noticed, however, must have crept into the Spectator's list by inadvertency, it being a deciduous tree. Besides evergreen trees and shrubs, there are a good many humble herbaceous plants, which retain a greenness in their foliage over winter; such are, common daisies, thrift, pinks, none-so-pretty, burnet, and several others. These may also be admitted; and plants which flower in winter, or very early in the spring, may be scattered over the borders; such are Christmas rose and winter aconite (*Helleborus niger* and *hyemalis*); dog's-tooth violet, white and pink, (*Erythronium dens canis*); bulbous fumitory (*Fumaria bulbosa* and *solida*); and others. To the winter garden a Conservatory may be considered as an appropriate appendage.

475. A part of the winter garden may be appropriated as a spring garden, and planted chiefly with the early flowering shrubs, such as the common and the double dwarfish almond (*Amygdalus nana* and *pumila*), and the sweet almond (*A. communis.*) On the borders, the different species of narcissus, particularly the poetic, the daffodil, jonquil, and polyanthus-narcissus, may appear; these, even when rising through the ground, produce a lively appearance: And other early spring flowers might be added, such as the spring bitter-vetch (*Orobus vernus*); comfrey-leaved hound's tongue (*Cynoglossum omphalodes*); snowdrop, (*Galanthus nivalis*); the puccoon, (*Sanguinaria Canadensis*); and red, blue and white hepaticas (*Anemone hepatica.*) The *heathery* or heath-house might very properly form the principal object in the spring garden, many of the exotic ericæ flowering early in the year. The auricula frame might likewise be situate here.

*Border Flowers.*

476. The principal borders are of course dedicated to mingled perennial plants, sufficiently hardy to endure our ordinary winters. A very few only can here be specified: those mentioned shall be the most showy and desirable of their kinds. They are arranged in the borders partly according to size, and partly according to colour. The tallest are planted in shrubbery borders, or in the back part of broad flower-borders. Those of middling size occupy the centre; and those of humble growth are placed in front. The beauty of a flower-border when in bloom depends very much on the tasteful disposition of the plants, in regard to colour, or on mingling the reds, the purples, the blues, the yellows, and the whites, in due proportions. To increase the variety of colours, some biennial plants, and even a few annual kinds, are occasionally introduced. By intermixing plants which flower in succession, the beauty of the border may be prolonged for some weeks. In a botanic garden the same plant cannot with propriety be repeated in the same border; but in the common flower-garden, a plant, if deemed ornamental, may be often re-

peated with the best effect; nothing can be finer, for example, than to see many plants of double scarlet lychnis, double wallflower, double sweet William, or double purple jacobæa.

477. For the shrubbery border the following are a few of the fittest tall-growing herbaceous plants. Hollyhocks (*Althæa rosea*) of different varieties and colours; these shew their flowers in October, when other plants are fading, and they continue till the frosts cut them off; they are properly biennial plants, but if some of the stems be cut over, before flowering, the roots continue for several years. Herb Christopher (*Actæa spicata*) a native of the north of England, and *A. racemosa* from North America, with the goat's-beard Spiræa (*S. aruncus*), are plants which succeed in the shade, and are therefore very fit for the shrubbery, or for any shady situation. The white-flowered Fox-glove (var. of *Digitalis purpurea*) is ornamental; it is only biennial, but rises freely from seed sown by itself. Several species of Aconite or monk's-hood, with blue and with yellow flowers, may here be planted; but the most common kind (*Aconitum napellus*) it is to be remembered, is a poisonous plant. With the monk's-hoods may be united several species of perennial Larkspur, particularly Delphinium grandiflorum, and exaltatum; and the stavesacre, (*D. staphisagria*.) The common Columbine (*Aquilegia vulgaris*) when very double, and of good colours, makes a pleasing variety. All the large species of *Iris*, particularly the Germanica, sambucina and Sibirica, here deserve a place. The common and the white-flowered Willow herb (*Epilobium angustifolium*), and the double and double fistular varieties of Feverfew (*Pyrethrum parthenium*) are showy when in flower. Several tall species of Aster and of Solidigo are also proper for the shrubbery, as well as some of the perennial Sunflowers, particularly Helianthus decapetalus, and the single and the double flowered H. multiflorus. To these may be added Rudbeckia laciniata, and Thalictrum aquilegifolium or columbine-leaved meadow-rue.

Besides tall plants, some of humble growth may with propriety be placed in the shrubbery or shrubbery border. Patches of sweet Woodruff (*Asperula odorata*), for instance, have a pleasing effect; the stalks and leaves gathered when the plant is coming into flower in May, and kept in small bundles in paper under some degree of pressure, retain their fragrance for a long time. Patches of the double wood Anemone (*Anemone nemorosa*) are likewise very ornamental; and this is the appropriate place for the Lily of the Valley (*Convallaria majalis*), of which there is a double and a red flowered variety.

478. The borders for perennial flowers are seldom less than four or five feet in breadth. The plants are not placed immediately behind each other, but in the quincunx order; the distance between each plant varying, according to the size of their border, and in some measure according to the nature of the plant, whether it be apt to spread or to form a compact tuft. In regard to soil, it may be sufficient to observe, that most of the hardy herbaceous plants grow very well in a soil that is moderately light and mellow, such as a sandy loam. For certain plants, strong loam, turf mould, or vegetable earth, are proper; and this circumstance is generally noticed when treating of the particular plant.

479. Of the tall-growing perennials, one of the most ornamental is the double-flowered Scarlet Lychnis already mentioned (*Lychnis chalcedonica*, fl. pl.) The large heads of flowers have a most brilliant appearance in the back part of a flower-border. Every attention should be paid by those fond of fine flowers to the propagating of this plant. Several stems should with this view be cut down before the flower appear: these are to be divided into pieces five or six inches long, which are stripped of leaves, except at the top, and sunk up to the leaves in the earth; they are covered for a few weeks with a hand-glass, and may either be planted out in the autumn, or allowed to remain under the glass till the spring. There is a white-flowered single variety, which is also deserving of a place.

480. The hyssop-leaved Dragon's-head (*Dracocephalum Ruyschiana*,) and the great-flowered (*D. grandiflorum*,) are elegant blue flowers. The Silver-rod, or branched asphodel (*Asphodelus ramosus*,) is a good border plant, with fine white flowers. Two species of Mullein, the rusty-flowered and the purple (*Verbascum ferrugineum* and *phœniceum*,) may be admitted; together with the fine branched Lythrum (*L. virgatum*), which is covered for about three months with purple flowers. Two or three species of the extensive genus *Centaurea* deserve to be cultivated; such as C. orientalis, with yellow flowers; C. Caucasica, with white flowers, and C. montana, with blue flowers; all of them hardy perennials. The double Siberian Larkspur (*Delphinium elatum*) has flowers of a fine dark azure colour. *Phlox pyramidalis* and *P. paniculata* are handsome showy flowers, of a pale bluish purple colour; of the latter there is also a white variety. The linear-leaved Willow-herb (*Epilobium angustissimum*) is worthy of a situation in the border, the foliage being fine, and the flower large, of a beautiful purplish red colour. Black Masterwort (*Astrantia major*) being of a singular appearance, may perhaps also merit a place. *Coreopsis verticellata* is an ornamental plant, and produces flowers of a fine deep yellow colour. Different species of Speedwell are elegant; particularly *Veronica Virginiana*, with blush coloured and with white flowers; and *V. longifolia* (formerly *maritima*) with blue, white, and flesh-coloured flowers. The variegated Wolf's-bane (*Aconitum variegatum*) is a very pretty plant; and the large flowers of *Rudbeckia purpurea* make a good appearance. *Liatris spicata* deserves a place in every collection.

The *Acanthus mollis* grows best when its roots get into the crevices of an old wall, near to the foot of which it may happen to be planted. In such a situation it will flower every year; while in a rich border soil, flowers seldom appear. The leaves of this plant accidentally surrounding a basket, are supposed to have given rise to the Corinthian capital.

Of the fine genus *Spiræa*, which is partly herbaceous and partly shrubby, two species are common natives. S. ulmaria or queen of the meadow, and S. filipendula or dropwort. Double flowered varieties of both these are kept in gardens; but it is worthy of remark, that while the single queen of the meadow is exceedingly fragrant, the double-flowered variety is quite destitute of odour. S. trifoliata is very elegant; it grows best in a peat soil, such as is generally prepared for American plants.

481. In the extensive genus *Campanula* or bell-flower, of which Persoon enumerates more than a hundred species, there are several showy perennials. Such are the peach-leaved or C. persicifolia, with single blue and single white flowers, and with double flowers of both colours: a very large flowered variety of the single blue, deserves particular attention; it has been figured in the *Botanical Magazine* as a distinct species, under the title of C. maxima. The nettle-leaved bell-flower, (*C. trachelium*), when double, forms a showy border flower. The pyramidal or steeple bell-flower (*C. pyramidalis*) is highly prized as an ornament in halls, being for this purpose often kept in pots. In the open border the plant requires a sheltered warm situation; and when seeds are wanted, it is found

useful to fix in the ground four stakes with niches at top, to receive a hand-glass to cover the plant during heavy rains.

482. The ornamental plants which are of middling size are so numerous, that it is somewhat difficult to make a selection.

Several species of Achillea are ornamental, particularly the Sweet maudlin (*A. ageratum.*) A double-flowered variety of our native sneezewort (*A. ptarmica*) very well deserves a place in the border. The spring Adonis (*A. vernalis*) is a perennial species, producing large yellow flowers in the beginning of April, when flowers are scarce. A double variety of Rose-campion (*Agrostemma coronaria*) is a highly elegant plant; it is properly only a biennial, but it may be continued for several years by parting the roots in autumn. The perennial flax (*Linum perenne*) is a very pretty native plant, deserving of a situation in the border. The round-headed Rampion (*Phyteuma orbicularis*) is another native, not less worthy of a place.

A curious variety of the common Toad-flax (*Linaria vulgaris*, H. K.), with five nectaries and five stamina to each corolla, is cultivated in some gardens, and much admired, it not being without reason that Miller styles it a "beautiful monster." It was first described in the "Amœnitates Academicæ," under the title of Peloria, and it is figured under the same name in "English Botany."

483 Several species of *Dianthus*, besides the carnation and pink, are much cultivated in gardens. D. barbatus, or bearded pink, more generally known by the name of Sweet William, is very common. It is a perennial, and may be increased by slips; but it is generally raised from seeds, seedling plants producing the strongest flowers: in this way, too, a great variety in the colours of the flowers is procured. When a very good kind occurs, it should be planted apart, at a considerable distance from all others, and the seed should be saved. The principal variations of colour are, deep red, pale red or rose-coloured, bluish purple, purple and white, white spotted; red with a white border, called Painted Ladies; purple with a white border, and pure white. Double flowers of several of these varieties are carefully preserved by the curious, and propagated by offsets and by cuttings; the double crimson and rose-coloured are particularly esteemed. The narrow-leaved bearded pink is called Sweet John. A very remarkable and beautiful variety is the Mule Pink, supposed to have proceeded from the flower of a carnation acted upon by the pollen of the narrow-leaved bearded pink.

484. Two species of *Eryngium* are very ornamental, E. alpinum, and E. amethystinum. In the former, the fine azure blue, with streaks of green and white, of the large involucrum, never fail to attract admiration. It generally ripens its seed in this country, and seedling plants may be observed near the parent plant, frequently under the shelter of the box edging. The other species has the upper part of the stem, as well as the head of flowers, of the richest amethystine colour, and therefore produces a very fine effect on the border. It is only in good situations, and in favourable seasons, that the seeds of this species come to maturity. Our natives species E. maritimum, or sea-holly, is admired for the glaucous hue of its leaves and stems: it may be planted in a mixture of sand and gravel: it is not easily dug up on the sea-shore, the roots running very deep into the sand: it should be removed in autumn. The roots of this species were formerly candied. Along with these eryngiums, may be classed several species of *Statice* or Thrift, in particular S. latifolia, scoparia, tatarica, and speciosa, all natives of Russia or Siberia.

485. Fraxinella or *Dictamnus albus* is a plant which merits a place, being both beautiful and curious. When gently rubbed the plant emits an odour like that of lemon peel. The pedicels of the flowers are covered with glands of a rusty red colour: from these a viscid juice or resin exudes, which is exhaled in vapour, and is said occasionally to produce a slight explosion: this phenomenon is to be observed in a warm, dry, and clear night in June, by approaching a lighted candle to the flower of the plant. The usual colour of the fraxinella is white; but there is a red variety.

486. The Cardinal's Flower (*Lobelia cardinalis*) is a very elegant plant: But it is now in a great measure supplanted by another species of the same genus, of still greater brilliancy, *L. fulgens*. The flower of this last is among the brightest scarlets of the vegetable kingdom. The plant is readily propagated by offsets, but it will scarcely endure our winters without protection. A few plants may be left to their fate, while others may be covered with hand-glasses in the borders; but it is safest to pot a number of plants, and keep them under a frame during winter.

487. *Catananche cærulea* requires a dry soil and sheltered situation; it is often indeed kept in pots, and placed under glass in winter. Its flowers are of a very fine blue; and there is a double variety, which however is not common. The Canadian Columbine (*Aquilegia Canadensis*) is a delicate looking flower, highly ornamental. Garden Wall-flower, (*Cheiranthus cheiri*) when double and of dark colour, is much prized; there is also a pretty variety of the native species, *C. fruticulosus*, with double flowers. The Red and the Scarlet Chelone (*C. obliqua* and *barbata*) make a pretty appearance in autumn, when flowers are beginning to grow scarce. A new species of chelone, (*C. major*) has of late been introduced, being figured in the "Botanical Magazine" for November 1816. It is, like the others, an American plant, and perhaps more hardy than them: it is at the same time the most showy of the genus, producing fine peach-coloured flowers in large and close spikes. German Goldilocks (*Chrysocoma linosyris*) has bright yellow flowers in the form of an umbel; when handled, the plant gives forth an aromatic agreeable scent. *Tritoma media*, although a native of the Cape of Good Hope, endures our winters, with a very slight degree of protection, and produces its beautiful spikes of orange flowers either in November or in March. Two species of *Monarda* should be admitted; the Oswego tea or M. didyma, which has scarlet flowers, and M. fistulosa, the flowers of which are purple. The perennial Lupine (*Lupinus perennes*) is now a rare plant; but a more showy species, from Nootka Sound, (*L. Nootkatensis*) has received the name, and is generally and deservedly cultivated. Of the Poppy genus two perennial species are worthy of attention; the Oriental (*Papaver orientalis*) with large bright orange flowers, and the Welch, (*P. Cambricum*) with flowers of a deep yellow. Red Valerian (*Valeriana rubra*), when of a dark colour, is highly ornamental, and there is a white variety which forms a fine contrast. Several kinds of Peony, particularly the double dark red and double blush (varieties of *Pæonia officinalis*), and the white-flowered, (*P. albiflora*), are magnificent border plants. The smooth-leaved Bell-flower (*Campanula nitida*) is very ornamental, appearing for some weeks completely covered with its blue flowers; the Dutch, it may be observed, have a double variety of this, which has not yet found its way into our gardens. Of the numerous genus *Aster*, three species are of proper size for the middle of a border, and shew fine lively blue flowers; the Italian starwort, or A. amellus; the alpine, or A. alpinus; and the A. spectabilis.

Ragged-Robin, or *Lychnis flos cuculi*, a native of our meadows, when double-flowered, makes a beautiful appearance, and is, of course, perfectly hardy. The varieties of L. dioica, with double red and with double white flowers, are also very showy: In England, these often get the name of red and white Bachelors' Buttons, while in Scotland this name is more commonly given to the double varieties of Ranunculus aconitifolius and acris. The plantain-leaved crow-foot (*Ranunculus amplexicaulis*) may be mentioned as a desirable spring plant, displaying its pure white flowers in April and May: it succeeds best in a strong loam.

Of the Garden Rocket or dame's violet (*Hesperis matronalis*,) there are are double white and double purple varieties; the former is the kind generally seen in gardens, the latter being rare. They are both excellent border flowers, being at once showy and fragrant. If the stock-plants be allowed to remain long without transplanting, they are apt to die off; a supply should therefore be prepared by slips or cuttings every year.

The Virginian Spiderwort (*Tradescantia Virginica*) with fine blue flowers, and the varieties with red and with white flowers, should not be omitted; they grow best in a mixture of loam and peat-earth. The bell-flowered Pentstemon (*P. campanulata*) is a fine peach-coloured flower; the *Uvularias* are uncommon looking yellow flowers, particularly U. grandiflora and sessilifolia; and some species of Solomon's-seal, particularly Convallaria polygonatum and multiflora, afford greenish-white blossoms.

If the Asiatic Globe-flower (*Trollius Asiaticus*) be not planted in a bed by itself, it may be introduced into the border, where its rich orange flowers are very brilliant; it requires a strong loam. The common globe-flower of our upland meadows (*T. Europæus*) may also have a place, the flowers being handsome and of a fine yellow, and being the *lucken gowans* mentioned by Burns in his poems.

In any moist and rather shady situation, the American cowslip (*Dodecatheon Meadia*) will grow and freely display its very elegant flowers in the month of May. If some peat-earth be mixed with the soil, the plant becomes more strong. Barrenwort (*Epimedium alpinum*) is a plant of considerable beauty, which thrives in similar situations.

488. Among *low-growing flowers* for the front of the border, the double purple Jacobea (*Senecio elegans*) holds a distinguished place. It is, strictly speaking, only an annual; but the double variety is continued by cuttings. If a few small plants be preserved in the green-house during winter, they will afford cuttings in the spring, which, as soon as they are well established, are to be planted out in the borders. There is also a variety with double white flowers, which is not uncommon in gardens in the vicinity of London.

Several Phloxes are very ornamental, particularly the common Lychnidea (*P. suaveolens*) with variegated leaves; the early flowering, P. divaricata; P. subulata or awl-leaved, and P. setacea or fine-leaved; with P. ovata, and P. stolonifera or creeping. Phlox subulata should be allowed to form a large patch on the ground in front of the border, being in this way extremely brilliant when in flower; in this way, too, the plant suffers less during winter. This species and the P. setacea are best propagated by cuttings; the others, by parting the roots in autumn.

The great flowered Siberian Fumitory (*Fumaria nobilis*) is very handsome, and continues long in flower. *F. formosa*, remarkable for its delicate blush coloured blossoms, may also be noticed; and the yellow species (*F. lutea*) is valuable, as affording a patch of this colour in the border from April to November.

Our common Bloody Crane's-bill (*Geranium sanguineum*) is not unworthy of a place; and the same may be said of the striped variety, commonly called Geranium Lancastriense. The streaked crane's-bill (*G. striatum*) is a delicate looking flower, which generally pleases.

The yellow species of Monkey-flower (*Mimulus luteus*) introduced about 1812, is an acquisition, as it is rather pretty, and continues several months in flower: Though a native of Chili, it proves quite hardy. Different species of *Oenothera* are of humble growth, and produce fine yellow flowers, particularly Œ. Fraseriana, fruticosa, and pumila. Patches of the purple Alyssum (*Farsetia deltoidea*) are very beautiful in the spring and early part of summer, when covered with flowers. A common native plant, Marsh-marigold (*Caltha palustris*) is likewise very showy in the early part of the year; a large patch of it makes a brilliant appearance for several weeks; being naturally a marsh plant, it grows best in a moist border. Feather-grass (*Stipa pennata*,) when its long and delicate awns are displayed in August and September, is justly admired for its light and airy appearance.

Violets of different kinds are well known ornaments; the Canadian (*Viola Canadensis*) is particularly elegant; and the Sweet, or March violet, (*V. odorata*) is not only desirable for its fragrance, but the large flowered double variety is beautiful.

Different species of Anemone, chiefly with blue flowers, may adorn the front of the border; such as the splendid Pasque-flower (*A. pulsatilla*;) different varieties of the star anemone, (*A. hortensis*;) the blue mountain and the meadow anemone (*A. apennina* and *pratensis*.) Some of the Gentians are also fine border plants, especially Gentiana asclepiadea and cruciata, both with blue flowers.

489. Among the flowers which have now been enumerated, a good many are natives of North America, such as all the species of the elegant genera Phlox and Chelone. A separate *American Garden* is, however, a desirable thing. Into this the trees, shrubs, and herbaceous plants of the New World are only to be admitted; so that, on entering the garden door, a person possessed of a botanical eye will find himself transported, as it were, across the Atlantic. One of the most complete American gardens in this country is at Milburn Tower, near Edinburgh, the seat of Sir Robert Liston, Bart. formerly British ambassador to the United States.

490. Flowers which are cultivated in beds by themselves are now to be considered. These are in a peculiar manner distinguished by the title of *Florists' flowers*. The principal are, the tulip, ranunculus, anemone, iris, dahlia, pink, carnation, polyanthus, auricula, hyacinth, polyanthus-narciss, and crocus.

### *Tulip.*

491. The tulip (*Tulipa Gesneriana*, L.) is a native of many parts of Turkey and of Persia, where the flower is principally of a red colour, each petal having a black mark at its base. It was not brought into the north of Europe until after the middle of the 16th century; and it was first cultivated in this country by a Mr Garret, an apothecary of London, about the year 1577. A hundred years after its introduction, the *tulipomania*, or rage for fine tulips, attained its height: it prevailed chiefly at Haarlem, and other parts of the Netherlands. High sounding and bombastic names were bestowed on the favourite varieties, a practice which is still continued by florists. The Viceroy and Semper Augustus were two sorts, the bulbs of which sold at the most extravagant prices, or rather gave occasion to the most foolish gambling speculations. Twelve acres of land were covenanted to be given by one person, and 4600 florins, besides a new carriage, with horses and harness, by

another, for a single tulip bulb, the flowers of which should possess certain almost ideal perfections. In the present day, tulip collectors possess a few sorts on which they place a high value; but in general the very finest varieties may be procured at 5 guineas a bulb; and a great many of what are reckoned prime kinds at perhaps 5s. a piece.

Tulips were formerly divided into *præcoces*, or early flowering; *mediæ*, or middle-timed: and *serotinæ*, or late flowering. One of the præcoces, it may be noticed, is a distinct species, T. suaveolens; this is the early dwarfish sweet-scented tulip, or Duke Van Thol of the catalogues: when planted in a small bed by themselves, these Van Thol tulips, when in flower in April, form one of the most resplendent scenes presented by the flower garden. Parkinson, so long ago as 1629, enumerates 140 varieties of tulips, and hints that there were many more. Maddock, in his catalogue, gives the names of 665 choice late tulips, independent altogether of early sorts, double flowered, and what are called parrot tulips.

492. Late tulips are the only kind now attended to by florists, the double and parrot sorts being in little esteem with them. They are divided into six families, distinguished by barbarous titles, a mixture of French and Dutch. 1. *Primo baguettes*, very tall, (the term *baguette* inferring that they resemble a small walking-stick, or switch,) cups with a white ground broken with fine brown; and all from the same breeder. 2. *Baguettes rigauts* (or *rougeaudes*,) with strong stems, though not so tall, very large cups, with a white ground, likewise broken with fine brown, and all from the same breeder. 3. *Verports*, (or, as they are more commonly called in this country, Incomparable Verports, or simply Incomparables,) with very perfect cups, having a beautiful white ground, or bottom, well broken with shining brown approaching to rose colour, and all from the same breeder. 4. *Roses*, allied to the verports, the petals streaked with cherry and rose colours, on a white ground. 5. *Bybloemens*, sometimes contracted into *bybloems*, with the ground white or nearly so, from different breeders, and broken with variety of colours. 6. *Bizarres*, (probably a corruption from *bigarée*,) with a yellow ground, from different breeders, and broken with variety of colours.

The terms *breeders*, *whole blowers*, and *seedlings*, are all applied to such flowers, raised from seed, as are plain or of one colour, have a good bottom or ground colour, (visible at the base of the petal,) and are well shaped. They may thus be either bybloemens or bizarres. The petals of these, in the course of time, break into various elegant stripes, according to the nature of their former self-colour. In correct language, the term *breeders* would mean plants, from the seed of which young tulips are to be raised.

493. The florist's criterion of a fine flower is frequently at variance with that of the world at large. Many tulips which would excite the admiration of thousands, are rejected by the connoisseur. The properties of a fine tulip, as set forth in the Florist's Directory, are the following. The stem should be strong and tall, two feet or more. The flower should be large, with six petals; the petals at the base proceeding for a little way almost horizontally, and then sweeping upwards so as to form an elegant cup, with a rounded bottom, and somewhat wider at top than below. The three outer petals should be rather larger, or broader at the base, than the three inner ones; all the petals should have the edges perfectly entire; the top of each should be broad, and well rounded; the ground colour at the bottom of the cup should be clear white or yellow, free from stain or tinge; and the various rich stripes, which are the principal ornament of a fine flower, should be regular, bold, and distinct on the margin, terminating in fine broken points, elegantly feathered or pencilled; while the centre of each petal should contain one or more bold blotches or stripes of colour mixed with small portions of the original or breeder colour, broken into irregular obtuse points; this last character, however, of central stripes or blotches, not being indispensable, and any trace of the breeder colour displeasing many florists.

494. The raising of tulips from the seed is a tedious process; but in this way alone are new varieties and vigorous bulbs to be expected. Seed is collected only from flowers of one uniform colour, or which are self-coloured, and at the same time of good shape; for, contrary to what might naturally be expected, experience, it seems, has shewn that the seed of the most beautiful striped tulips does not yield so fine a produce as is got from the plain coloured. The tulips intended for seedling are planted deeper than usual, perhaps eight or nine inches deep, in order that the stem may be kept longer in a vigorous state; and they are placed in a border where they may enjoy the full benefit of the sun. Towards the end of July the pods begin to open; they are then cut off, and kept, with the seeds in them, in a dry place, till the beginning of September, when the seed is sown. This is generally done in shallow boxes containing fresh light earth; a covering of about half an inch thick, of the same light or sandy earth, is sifted over them. These boxes are placed in a sheltered situation for the winter. By the middle of March the seedling tulips shew their grass-like first leaves; these continue green for about two months, and then gradually decay, so that they entirely disappear in June. After another year, the small bulbs are raised, and transplanted into a nursery bed, two inches deep and at two inches apart. If the bed be in an exposed situation, haulm or mats are placed over it during the severity of the winter. In this bed the bulbs remain for the third and fourth years. They are then raised, kept some short time out of the earth, and transplanted to another bed, in which they are placed four inches separate. Here they remain other two years; and in this interval many of them begin to shew flowers. Such as have tall stems and rounded petals are now transferred to a separate bed, and treated like full grown bulbs; and after they have flowered for two or three years, their real value may be pretty nearly ascertained: If they be very promising, that is, tall, well shaped, with clear bottoms, and self-coloured. they are retained for a longer time, in expectation of improvement. A few come finely striped at once, and are of course retained; but these are apt quickly to degenerate. Those that appear with short stems and sharp-pointed petals are rejected without hesitation.

The tendency to break is promoted in the breeders, by shifting the bulbs every season into different kinds of soil, and placing them in different situations. The soils preferred are such as are fresh, but poor, dry, and sandy. The compost recommended by Miller consists of a third part fresh earth from old pasture land, having the sward rotted with it; a third part sea-sand; and a third part old lime rubbish sifted, all well mixed and frequently turned. The beds are made two feet deep, and the bulbs are planted in drills about four inches deep, and six or seven inches from each other in every direction. When a breeder breaks completely, losing all traces of its self-colour, and continuing till the petals decay without shewing any tendency to return to its former colour, it is marked, named, and enrolled among the choice tulips, and its offsets are carefully preserved. A tulip, when it breaks, never attains the height or size of the breeder; if a breeder be three feet high, its variegated progeny does not exceed two, and the flower is proportionally less. Whether the breaking is the cause or the consequence of debility, does not appear; but it seems to be a general fact, that variegated flowers or plants are more tender than such as are plain.

The directions for the planting and management of breeders are applicable to striped tulips in general. A practice not uncommon with gardeners must here be condemned; it is the planting of tulip bulbs with a dibble. This ought never to be done. The pressure of the dibble renders the earth compact where it ought to be loose, and in many cases a partial hollow must remain below the bulb, which is particularly injurious when wet weather follows, and moisture lodges about the root. It is better when drills are formed six or seven inches deep, and the bulbs covered in with the loose earth. A still more proper way is, to prepare the bed some inches lower than it is intended ultimately to be; to put the bulbs in their places on the surface; and then to add the necessary quantity of soil. The bed is improved by being made to slope a little from the centre to each side; the stronger bulbs should be situated in the middle, as they thus receive the thickest covering of soil which they ought to have. In all the modes of planting, it is a good rule to put a little dry and fine sand around each bulb.

495. The bed of choice tulips is, by the true florist, at first protected by hoops and mats, from hail showers and storms, and afterwards, when the season of flowering arrives, covered by an awning of thin canvass. In this way only can the delicate colours be fairly brought out; even half an hour's full exposure to the sun's rays has been known to alter them; besides, the enjoyment of the fine sight is prolonged for near a month. Though the scent of the tulip is so slight as scarcely to be perceptible in single specimens, the united odour of so many, confined in some measure by the cover, becomes quite evident. Watering is scarcely ever necessary for tulips. The seed-pods of all fine tulips are cut off as soon as they appear; for these, as already said, are by no means the best from which to procure seed, and the bulbs exhaust themselves in forming them. The bulbs are lifted in the course of the month of June, the proper time being ascertained by observing when the foliage has decayed, and two or three inches at the top of the stem begin to acquire a purple tinge. If they be left longer in the earth, the flowers are apt to become foul the next season. The bulbs are cleaned, and laid in a dry place till October. The offsets, chives, or babies, are taken off and marked, in September; these are planted in a separate bed, not so deep as the parent bulbs, and about a month earlier. It may be remarked, that all young bulbs or offsets that are of a round shape, though small, may be considered as likely to produce flowers. The general time of planting old bulbs is the end of October or beginning of November. At this time the outer brown skin is carefully stripped from the bulb, which is committed to the ground in a bare and clean state. By the end of February most of the tulips appear above ground: the surface is at this season gently stirred with the fingers, aided perhaps by a little bit of stick; this stirring tending greatly to promote their health and growth.

The finest and most extensive collections of tulips in this country, at present, are probably those of Davy, nurseryman, King's Road, and of Milliken, florist at Walworth, both near London. Some private collectors, however, principally near the metropolis, have small beds of very fine and select kinds.

### *Ranunculus.*

496. This well known flower (*Ranunculus Asiaticus*) is a native of the Levant and of the Greek Islands. It was cultivated by Gerarde in the end of the 16th century. Very many new varieties of singular beauty have been raised from semi-double flowers, both in this country and in Holland: some of these possess also a considerable fragrance. A judicious and industrious cultivator of this plant near Edinburgh (Mr John Fletcher, superintendant of experiments to the Caledonian Horticultural Society) has excelled many of his cotemporaries in the number of his distinct and well marked varieties, and the beauty of his flowers, many of which have been raised from seed by himself during the last thirty years. He plants each variety in a row, or sometimes in two rows, by itself, in narrow beds, divided by small paths; each distinct variety has a numbered tally, and the number of choice sorts exceeds 180; the proper contrast of colours is studied, and the whole, when in full flower, produces a very brilliant effect. By some florists the varieties are split down till they extend to many hundreds, so that it has been found difficult to invent names for them. Mr Maddock divides the colours into twelve families: Dark and dark purple; light purple and grey; crimson; reds; rosy; orange; yellow and yellow spotted; white and white spotted; olive; purple and coffee-coloured striped; red and yellow striped; and red and white striped. The Turquoy, or turban-shaped ranunculus, is a very distinct sub-variety.

497. The qualities of a fine double ranunculus, as described by him, consist in the flower being of a hemispherical form, at least two inches in diameter, the numerous petals gradually diminishing in size to the centre; the petals broad, with entire, well rounded edges; their colours dark, clear, rich, or brilliant, either of one colour, or variously diversified on an ash, white, sulphur, or fire-coloured ground, or else regularly striped, spotted, or mottled. The stem should be strong and straight, and from eight inches to a foot in height.

The root is composed of several thick fleshy fangs or claws, uniting at top into a head. When the plant becomes strong, several subordinate or lateral heads are formed, and each of these may be taken off with their proper claws, to form a new plant. These offsets, it may be observed, form better flowering plants than the central head, which is exhausted by flowering.

The soil preferred for the ranunculus bed is fresh rich loam, inclining to clayey. It should be deep, perhaps little short of three feet; for it is surprising to what a depth the fine fibres from the tubers penetrate downwards. Some gardeners raise the bed a few inches above the surrounding ground. If manure be at any time added, it should be well rotted, and must be introduced at the very bottom of the bed at least two feet and a half below the tubers. Miller mentions three feet as the proper depth of soil for the beds, adding, that on such beds plants will produce forty or fifty flowers, which in a shallow soil would not afford a dozen. The beds are kept flat on the surface, not raised in the middle as for tulips. Miller directs, that the roots should be planted six inches apart each way; but this is too wide: Five inches between the rows, and three or four inches between each plant in the rows, are sufficient. In some situations, the plants grow stronger than in others; and a good general rule is, to observe the size which the leaves commonly acquire, and then, in that garden, to plant so close as that the grass or foliage of contiguous rows may just meet; the ground being kept in a desirable state of moisture by this close covering of leaves. The tubers should not be more than an inch and a half deep in the earth; and they should be placed with the claws pointing downwards or the bud upwards. It is not right to plant ranunculuses year after year in the same bed. If a little fresh soil be introduced, they may do twice; but after this, the earth of the bed should be entirely changed, or a new bed should be made in a different part of the garden.

The time of planting is either the latter end of October, or the first mild and dry weather in February. When put in in October, the buds sometimes appear above ground in November; in this case, a thin covering of half an inch of light soil is cast over them before severe weather sets in. Autumn planted ranunculuses also require attention in the spring; if hard frosts occur when the flower-stems appear, a covering of hoops and mats may be proper for a few days.

The beds are weeded with the hand, and by careful cultivators the earth between the rows is stirred up only with the fingers, a hoe being very apt to cut and injure the tubers, or break too many of the fine roots. When the flowers begin to expand, the florist does not fail to guard equally against nightly frosts and scorching sun-beams, by means of a canvas awning, or at least of mats laid over large hoops. When drought occurs, liberal watering proves very beneficial to the ranunculus bed.

When the flowering is over, and the leaves have begun to decay, the tubers are carefully lifted on a dry day; being thoroughly cleared of earth, they are dried in the shade, and then deposited in separate drawers or boxes, or in paper bags, till wanted for replanting.

When it is wished to raise seedling ranunculuses, the seed is collected from flowers having not fewer than five or six rows of petals, of good colour. It is sown in August, in boxes or pots, on the very surface of the earth, and a little very fine mould is sifted over it, so as hardly to cover the seeds. The young plants are kept under a glass frame during winter; and most of them flower the second year.

*Anemone.*

498. The garden anemone is of two kinds, the broad-leaved, (*A. hortensis*,) and the narrow-leaved, (*A. coronaria*.) The former is the more hardy, being a native of Italy and the south of France; the latter grows naturally in the islands of the Archipelago, where it appears of all colours.

499. A fine double anemone should have a strong upright stem, eight or nine inches high; the flower should be from two to near three inches in diameter; the outer petals should be firm, spreading horizontally, except that they turn up a little at the end, and the smaller petals within these should be so disposed as to form an elegant whole. The plain colours should be brilliant and striking; the variegated ones, clear and distinct. The flowers are generally divided by florists into red and pink, rosy and crimson, white and white spotted, dark and light blue.

In preparing an anemone bed, the surface soil of some old pasture, with the turf itself, is to be mixed with some well rotted cow-house dung, and allowed to lie for a year in heap, but occasionally turned over. Large stones are to be cast out, but the soil should not be screened, or at least should not be made too fine.

The roots are tuberous, and very irregular in shape. They are commonly planted six inches apart in each direction, and about two inches deep, taking care to place the bud uppermost. The best season for planting is considered to be the month of October; but some roots are generally kept back till December; and others are not put in till February, in order to render them later in coming into flower, and thus to prolong the anemone show. Where the flowers are prized, the beds are sheltered during the severity of the early spring, by mats laid over hoops; for it is remarked by practical men, that double flowers often become single, by "the *thrum* (collection of narrow thread-like petals) that is in the middle of the flower being destroyed." In April and May, if the weather prove very dry, they are regularly refreshed with water.

In July, when the leaves decay, the roots are taken up, but always in dry weather. They are cleared of earth, either with the fingers, or by washing. They are then packed in baskets or drawers till the planting season recur. Of choice sorts, the smallest offsets are valuable; and as these are minute, and very much of the colour of the soil, great attention is requisite to have them all picked up at the time of lifting.

500. New varieties are raised from the seeds of single garden anemones, commonly called Poppy Anemones, preferring those of good colours. Some care is necessary towards the separating of the seeds, which stick together like those of carrots; it is most effectually done by rubbing them among dry sand. The seedlings require attention and protection for the first year, particularly in the spring months, when the frost is apt to throw them out of the ground. In the second year, many of them flower; and the rest probably in the third year. The most promising are then selected.

The poppy anemones themselves, of bright red and blue colours, are highly ornamental in the garden borders. They require little attention, being only taken up every second year. They generally flower in February, and form the gayest parterre ornament at that chill season. Double anemones likewise, if left in the border all the year, come very early into flower.

*Iris.*

503. The genus *Iris* or Flower-de-luce is extensive, containing about fifty species, many of which make very handsome flowers for moist and shady borders; but when a bed of irises is formed, only a few species enter into it. Different varieties of what are called the English or bulbous iris (large rooted and small rooted, or *Iris xiphioides* and *I. xiphium*) form a principal part. The seed of these is gathered and sown by florists, and in this way new and sometimes curious varieties are obtained. The most common colour is blue, deeper or lighter; but the colour is often yellow, or white; sometimes blue, with white or yellow shades, or violet with blue shades; and it is variegated in many other ways. I. pallida or pale Turkey iris, with I. variegata and cristata, are sometimes admitted into the bed. I. tuberosa or snake-head iris, is a singular species, both in regard to foliage and flower, and is likewise occasionally planted.

The soil of the iris bed should be a light loam, with a mixture of sandy peat. The loam should, if possible, be procured from an old pasture, and the sward should be taken along with it. No manure should be added. On an east border, the flowers make a finer appearance than if fully exposed to the south.

The Chalcedonian Iris (*I. susiana*) is yearly imported from Holland, and produces its magnificently rich and large flowers the first summer, but seldom shews flower till three years afterwards. It too agrees with a light loamy soil, but must have a warm sunny situation; and it is to be observed, that moisture, which agrees well with most of the species, is hurtful to this one. In severe winters it is apt to perish: the best roots should therefore be placed in pots, and kept under a frame during winter.

*Dahlia.*

504. There are two species of *Dahlia* mentioned in

*Hortus Kewensis*, D. superflua, and D. frustranea. Of the former there are purple and rose-coloured varieties; and of the latter, scarlet and yellow varieties. Seeds have repeatedly been ripened in this country; and the plants from these have become so far acclimated to Britain, that in a few years they are likely to be ranked as hardy perennials.

Till Mr R. A. Salisbury published his observations on the cultivation of Dahlias, they were little known in this country. Being natives of Mexico, they come into flower in October and November, the period corresponding to their usual time in their native country. They may, however, be brought to shew their flowers more early. This is accomplished by checking the luxuriance of the herbage, by means of planting the roots in very poor soil, sometimes even in screened gravel. Water is supplied only till the flower-bud be discernible in the heart of the leaves; after which none is given.

The roots, which are large and tuberous, like those of peony-rose or yellow asphodel, are taken up every year, and kept for some weeks in sand. Some cultivators always plant them in pots, the restraint thus imposed on the roots having the same effect as planting in gravel. The growth in the spring may, in this way, be forwarded, by placing them under a frame; and the pots may be sunk in the dahlia bed in June. If the bed be situate close to a south-east or south wall, the flowering of the plants is greatly promoted. The more tender sorts, such as the scarlet variety of D. frustranea, may be placed next to the wall, and have its branches nailed to it, in the way practised with love-apple. All secondary branches are pinched off while young and tender, and even some leaves are removed, if the plant shew a disposition to be very luxuriant.

*Pinks.*

505. The common pink and the carnation, though considered as distinct kinds of flowers by the florists, have originated chiefly from one and the same species of plant, the Dianthus Caryophyllus of Linnæus, or Clove Pink. It grows naturally in rocky situations in some parts of Germany; and Sir J. E. Smith has even given it a place (*English Botany*, t. 214.) as a native of Britain. Carnations and pinks seem to have been entirely unknown to the ancients; for Pliny does not describe them, and the classic poets make no allusion to them.

Pinks were not held in much esteem by our own ancestors; indeed they seem to have risen to distinction with florists only in the 18th century. They are divided by them into several classes; such as damasks, cobs, and pheasant's-eyes. The first are white, and flower early; the cobs are red, and flower late. Both of these kinds are considered as originating from D. caryophyllus; but the pheasant's-eye, of which there are numerous varieties, is regarded as having sprung from D. plumarius.

When it is wished to propagate good kinds of pinks, this is readily done either by layering or by using cuttings or pipings. This last mode is the most commodious, the pink growing freely in this way. The difference between a cutting and a piping consists in this, that in the former a joint is cut through horizontally, while a piping is drawn from its socket, leaving a pipe-like hollow. The proper time for gathering cuttings or pipings is when the plants begin to come into flower. They are best when between two and three inches in length; and they should be firm and compact, not *drawn*. Some part of a bed or border having been worked fine, or the surface soil having been screened by means of a sieve, the pipings are stuck into it at three inches square, and the earth is firmly applied to them with the fingers. A copious watering is then given, and hand-glasses are firmly pressed down over the plants: if the weather be bright, these may have some dry earth thrown against them while the glass is moist, in order to produce a degree of shade, or some large leaves may be laid on them for a few days. These hand-glasses are not removed till the new growth of the pinks be distinctly perceived, which happens generally in the course of a month or five weeks; water is however occasionally applied around the covers. The plants are afterwards transferred to a larger bed, or to a garden border, in time to permit them to become well rooted before winter. Slips of pinks, four or six inches long, drawn from the sides of main shoots, and planted any time in the spring, seldom fail to grow.

New varieties are procured by raising plants from seed: for this purpose the seed of the best sorts only is saved; it is produced sparingly in such flowers as are not perfectly double; it is procured more plentifully from semi-double flowers, and if these be of good colours, the offspring is frequently very promising. It is sown in the spring, and the plants are nursed up in beds, and afterwards planted out. From a considerable bed, only a few can be expected worthy of being preserved; and these are likely to be found among the weakest plants.

506. Those flowers, the petals of which are elegantly laced with colours, while the edges are scarcely notched, or are as nearly as possible rose-leaved, are considered the finest. Being very double, and at the same time opening fairly or without bursting, are qualities highly prized. A clear white for the body of the flower is always desirable. In the lacing, a rich black, shaded toward the centre with red, is much esteemed. Scarlet lacings are most rare, and much in request. A purple lace is greatly admired, as in the variety known by the name of Davy's Duchess of Devonshire, which may be considered as the model of a perfect pink. Pinks are carefully tended by the zealous florist. When the flower-stalks rise, they are tied to a small stick to keep them up; and when the petals begin to appear in the pod, those pods which seem apt to burst on one side are restrained by a small piece of slit card-paper. The finest flowers, when expanded, are covered with pieces of tinned iron in shape of inverted funnels or little umbrellas, equally to save them from rain and from the sun's rays.

*Carnations.*

507. Formerly these were divided into *Carnations*, often called Bursters, having very large leaves and flowers, and into *Gillyflowers* (*girofliers*, F.), the leaves and flowers of which are smaller. The former are now called Tree-carnations; the latter, Common carnations. The florists of the present day distinguish carnations into four classes. 1. *Flakes*, having one colour only, on a white ground, the stripes large, and the colour extending through the substance of the petal: when the stripe is pink, and of high colour, the flower is called a Rose flake. 2. *Bizarres*, flowers with two colours, on a white ground: they are called scarlet, purple, or pink bizarres, as these colours happen to abound; when deep purple and rich pink occur together, the flower is accounted a crimson bizarre. 3. *Piquettees*, with a white, and sometimes a yellow ground, spotted with scarlet, purple, or other colours, the edges of the petals generally notched or serrated. 4. *Painted ladies*, with the petals red or purple on the upper side, but white below. This last class is often associated with the pinks.

508. According to florists, the following are the chief

properties of a good carnation. The stem should be strong and straight, nearly three feet high; the flower should expand freely and equally, and should not be less than three inches in diameter; the outer circle of petals, or the guard leaves, should be strong, so as to support the interior petals; these should be numerous, but not crowded; they should regularly decrease in size as they approach the centre; the petals should be rose-shaped, or the edges should be entire, without notch or fringe; the colours should be bright and distinct, the stripes narrowing gradually to the base of the petal; and almost one half of each petal should be of a clear white.

In the culture of carnations, the preparing of a proper compost or soil is of some importance. For producing strong flowers, Maddock recommends a compost consisting of one half well rotted stable dung, one third fresh sound loamy earth, and one sixth sea or river sand; the ingredients to be thoroughly mixed by repeated turnings at intervals of several weeks. If, however, it is wished to preserve entire and brilliant the colours of the flowers, a compost containing much less dung and more loam is greatly to be preferred.

The finest carnations are planted in pots a foot wide at top, and are placed on the shelves of a stage at the time of flowering: they are hence often called Stage-flowers. The potting is performed toward the end of March. The plants are then placed in an open airy part of the garden, under an arch of hoops, so that they may be protected by a covering of mats in case of need. Watering is carefully attended to; the water is not sprinkled over the whole plant, but is applied only to the root. The stems are tied to stakes as they advance. In this situation the plants continue till their stems become too tall for remaining under the hoops. They are then placed on the stage for flowering. Here slender stakes, four feet in length, and sometimes painted, are employed, and the stems are neatly tied to them at the distance of every six inches. As the flower-buds advance, they who are nice watch any appearance of irregular bursting, and prevent it by slight ligatures, as already mentioned in the case of fine pinks. Only three or four principal flower-buds are allowed to come forward; the smaller lateral ones being cut off as they appear. When the earliest flowers begin to expand, tinned iron or common paper covers, such as those above described, § 506, are placed over them. When the flowering becomes general, a canvas awning is resorted to. A tulip-bed frame answers perfectly well for covering carnations; and tulip bulbs are raised and stored, before carnations come into flower: every one therefore, who delights in tulips, should also cultivate carnations, that his canvas frame may thus be occupied with vegetable beauties twice in the year.

Earwigs prove very injurious, sometimes almost destructive to carnations. They should be daily looked for, hunted out, and destroyed. Numbers may be entrapped in dried hollow stalk of rhubarb, reeds, or similar fistular plants. Some have been at the pains to insulate the raised stage, by setting its supporters in vessels filled with water; forgetting perhaps that earwigs occasionally take wing. When the flowers are heavy and apt to droop, bits of fine brass-wire are used as supports. Zealous carnation florists sometimes *dress* the flowers, by removing with a pair of pincers small or ill-coloured petals, and arranging the rest so as to hide the defect.

509. When the plants have passed the height of their bloom, *layering* must not be neglected. The lower leaves of the layers being stripped off, and the terminal leaves cropped, an incision is made below the second or third joint, and continued through the joint; the loose portion of stem below the cut joint is removed, so that the layer may bend freely. It is kept down by a slight peg of wood, or, what is more convenient and neat, of the brake-fern or pteris; such fern pegs are naturally formed in the stalk of the frond, and they decay of themselves when no longer needed. If the weather be dry, watering proves useful. In about a month most of the layers are found to be rooted, and may be transplanted, taking care not to plant too deep. Carnations may also be propagated by pipings; but this is a more difficult mode. The pipings being dressed, by cutting about half a line below the *second* joint from the extremity of the shoot, and shortening the foliage as for layers, are placed in water for some time, to *plump* them, as florists speak. They are then pricked into an exhausted hot-bed, and covered with hand-glasses. The soil is kept moist till fibres be sent out; but it is proper to observe, that after watering, the glass should not be replaced till the leaves of the pipings be dry. When they begin to shoot upwards, air is regularly but cautiously admitted. Layers or pipings, when properly rooted, are removed, and, if choice kinds, generally planted in pots, three or four in each pot. For the winter season, carnations, whether young plants, or surviving mother plants, are best preserved in a repository similar to that commonly used for auriculas. Here they remain till after the middle of March, when they are placed in pots singly for flowering, as already mentioned.

It is of course only by means of seed that new varieties can be obtained. When it is wished that carnation plants should perfect their seeds, they are removed from the canvas awning to a place completely exposed to the sun; or, in the northern part of the island, into an airy green-house; and the plant is not mutilated, by making layers or pipings. It may be remarked, that plants recently raised from the seed, are themselves most productive of seed, and that varieties which have long been propagated by layers and cuttings, scarcely produce any. In flowers approaching to the double state, but few seeds can in any case be expected, and these few often require to be fostered; the withered petals are drawn out from the pod, leaving the styles, or stigmata, which proceed from the top of the germen or seed-pod; an incision is also sometimes made in the calyx down to the base of the germen, so as to prevent any water from lodging there. The seed ripens in September, but it is kept in the pod till April, when it is sown in pots. The young plants are afterwards transplanted into a bed, where they are allowed to show flower; such as prove single-flowered, are cast out; and the best of the double flowers are layered.

It may here be noticed, that carnations are susceptible of the operation of grafting. A good double-flowered sort may be grafted on the stem of a healthy single kind; the most woody part of the stalk is to be preferred, and whip-grafting is best.

### *Polyanthus.*

510. Of the fine genus *Primula*, several elegant species are natives of Britain. Every one is delighted with the appearance of the common primrose (*P. vulgaris*) on our banks in the spring time, and many are the varieties cultivated in gardens under the name of Polyanthus. The well known cowslip or paigle (*P. officinalis*) decks the pastures and margins of corn fields, particularly in the south and west of England, and the gathering of the pips for the making of wine furnishes, in many places, a pleasing employment for children. The oxlip (*P. elatior*) is much less common than the cowslip, and is found chiefly in woods, and

by the margins of woods. It seems to be the parent of several of the small-flowered polyanthuses. The bird's-eye primrose (*P. farinosa*) is certainly one of the prettiest natives we can boast, and it grows on the poorest moors. Of the exotic species, the auricula or bear's-ear (*P. auricula*) is a well known favourite, of which we shall speak, after treating of the polyanthus.

511. According to the florist, the properties of a good polyanthus are the following: The tube of the corolla above the calyx should be short, well filled at the mouth with the anthers, and terminate fluted rather above the eye. The eye should be circular, of a bright clear yellow, and distinct from the ground colour below. The ground colour is most admired when shaded with a light and dark rich crimson, resembling velvet, with one mark or stripe in the centre of each division of the limb or border, bold and distinct from the edging down to the eye, where it should terminate in a fine point. The petal should be large, quite flat, and round, excepting the minute indentations between each division, which divide it into five (sometimes six) heart-like segments. The edging should resemble a bright gold lace; it should be bold, clear, and distinct, and nearly of the same colour as the eye and stripes.

Endless are the varieties of polyanthuses; and as they are easily raised from seed, they are generally the first kind of flower that a young florist cultivates. Seed is kept in the shops for sale; but by sowing this, very few good varieties may be expected. The seeds should be saved only from flowers with large upright stems, producing many flowers upon a stalk, which are large, finely shaped, which open flat, and are not pin-eyed; and all ordinary flowers near to these should be cut over, to avoid any intermixture of pollen. The seed is ready in June, and the pods should be gathered as they successively ripen. The seed is commonly sown in boxes in January. The seedlings are regularly watered in dry weather, and shaded from the forenoon sun. They are fit for pricking out in the end of May; and they are transplanted, in August and September, to the borders where they are to flower, which should be somewhat moist and shady, and exposed only to the east. A loamy soil answers best. Most of them will flower in the succeeding spring, and then those that are indifferent may be cast out, or transferred to the shrubbery. The select plants, being again transplanted, will bloom in full strength the second year; and, if the kinds be very good, will, in collective beauty and brilliancy, be little inferior to a show of auriculas.

After this, they must be yearly removed, and the roots must be parted, else the flowers will inevitably degenerate. The truth is, that seedling plants produce stronger and more brilliant flowers than offsets; and they who would have polyanthuses in perfection must save seed from their finest plants, and sow annually. The best way is, to raise two or three of the finest plants, with a ball of earth attached, and to plant them in another part of the garden, where they may be free from intermixture of pollen, and may be regularly watered, attention to watering being found very conducive to the production of vigorous and healthy seed. The plants which thus yield seed are much weakened, and often perish. In some gardens, the choice flowers are always kept in pots.

Snails and slugs infest polyanthuses in the spring of the year, and should be watched in the morning. In summer the red spider often forms its webs on the rough under side of the leaves, which is indicated by their becoming yellow and spotted. If the plants thus attacked be not removed, the whole polyanthus bed will be destroyed. An effectual cure is found in soaking the foliage of the diseased plants for two or three hours in an infusion of tobacco leaves, and planting them at a distance from the others.

### *Auricula.*

512. The Auricula is a native of the Italian Alps; and there the most common colour is yellow, but it occurs also purple and variegated, with a white powdery eye. The varieties raised by florists are innumerable; many of them are of great beauty, and some extremely curious. Parkinson, in 1629, names twenty varieties, and mentions that there were then many more. Rea, in his Flora, 1702, describes several new sorts raised by himself and cotemporary florists. A century afterwards, Maddock's catalogue enumerates nearly 500 varieties.

513. The properties of a fine auricula are the following: The stem should be strong, upright, and of such a height that the umbel of flowers may be above the foliage of the plant. The peduncles or foot-stalks of the flowers should also be strong, and of a length proportional to the size and number of the blossoms or pips: these should not be fewer than seven, in order that the umbel may be close and regular. A pip or single flower consists of the tube, eye, and border; these should be well proportioned; if the diameter of the tube be one part, that of the eye should be three parts, and that of the whole flower or pip six parts nearly. The circumference of the border should be round, or at all events not what is called starry. The anthers ought to be large, and to fill the tube; the tube should terminate rather above the eye; and this last should be very white, smooth, and round, without cracks, and distinct from the ground colour. The ground colour should be bold and rich, equal on every side of the eye, whether it be in one uniform circle, or in bright patches; it should be distinct at the eye, and only broken at the outer part into the edging. Black, purple, or bright coffee-colour, form excellent contrasts with the white eye; a rich blue or a bright pink are pleasing; and in a deep crimson or glowing scarlet, edged with bright green, are concentrated the hopes and wishes of the florist, which however are seldom realised. On the green edge much of the fine variegated appearance of the auricula depends, and it should be nearly in equal proportion with the ground colour. The dark grounds are generally strewed with a fine white bloom or powder, which gives a rich appearance: the leaves of many sorts are thickly covered with the same kind of powder, which seems destined by nature to save them from the scorching effects of the sun's rays.

Mr Maddock considers the forming of a proper compost for auriculas to be of great importance. The ingredients and proportions recommended by him are these: One half well rotted cow-dung; one sixth fresh sound earth, of an open texture; one eighth vegetable earth, from tree-leaves; one twelfth coarse sea or river sand; one twenty-fourth soft-decayed willow wood, from the trunks of old willow-trees; the same proportion of peat or bog earth; and a like proportion of the ashes of burnt vegetables, to be spread on the surface of the other ingredients. This compost is to be kept for at least a year, exposed to sun and air, several times turned, and passed through a coarse sieve. Mr Curtis properly remarks, that if the compost be rich and light, it is not necessary to adhere rigidly to the above prescription. He mentions, that two-thirds of rotten dung from old hot-beds, and one-third containing equal parts of coarse sand and of peat-earth, form a very suitable compost.

514. Choice auriculas are always kept in pots. The inner diameter of these at top may be six inches, at bottom four inches, and they should be about seven inches deep. A little gravel in the bottom is proper as a drain below the roots of the plants. Auriculas are annually repotted in May, soon after the bloom is over. The balls of earth are to be preserved around the roots, and only a certain portion of new mould given: Mr Maddock, indeed, advises the shaking of the earth from the roots; but this necessarily gives a check, from which the plant does not recover in the course of a year. At the same time offsets are taken, and planted in separate pots. The whole auriculas are then placed in an airy but rather shaded situation, not however under the drip of trees. The place is generally laid with coal-ashes, to prevent the earth-worm from entering the pots, and the pots are often set on bricks, to allow a freer circulation of air about them. Here they remain till October. They are then placed under a glass frame, or other repository, to shelter them for the winter months, giving as much air as circumstances will permit. In February they are earthed up; that is, the superficial mould, to the depth perhaps of an inch, is removed, and replaced by fresh compost, mixed with a little loam, to give it tenacity. This is found greatly to aid the flowering. When several flower-stems appear in one pot, a selection is made of one or two of the strongest, and the others are pinched off. As the flowers advance, the plants are arranged in the covered stage, which contains four or five rows of shelves rising one above another. The roof is generally of glass; and the front, which is placed facing the north or the east, is furnished with folding doors, which may be shut when desired. Here the plants are regularly watered two or three times a week, care being taken not to touch the flowers or foliage with the water. A good collection of auriculas, treated in this way, forms, when in flower, a very captivating sight. Sometimes the richness of the scene is increased, by introducing mirrors into each end of the frame, and by having a bed of hyacinths, and perhaps a row of fine polyanthuses, both of which flower at the same period, in front of the stage, and covered with a thin awning. The soft light, passing through the awning, heightens the effect of the auriculas. It may be mentioned, that in order to secure the filling of the stage with good flowering plants, which alone ought to appear there, it is necessary that the collector possess at least twice as many plants as the stage is calculated to hold.

The interest of the florist's pursuits receives in this, as in all other cases, a great increase, when he attempts the raising of new varieties from seed. To purchase auricula seed in shops is a bad plan. It is much better to encourage the ripening of the seeds of a few very good flowers, which may be done merely by exposing them fully to sun and air, and saving them by hand-glasses from heavy rains. The seed ripens about the end of June; but it should be kept in the umbels till sown. This may be done, either in autumn or early in spring, in boxes; and the seed should be very slightly covered with willow earth, or any light vegetable mould. The boxes are of course to be kept under shelter during the winter; but in good weather the seedlings should have plenty of air; they must not, however, be exposed directly to the sun's rays, which would destroy them in a short time,—at least the more weakly, which are always of the greatest promise. When of a proper size, they are transplanted into other boxes, and nursed till they be fit for pots. If one plant in thirty prove worthy of a place in the collection, the success is great; the rest may be planted out as border flowers, where they continue very ornamental for a few years.

*Hyacinth.*

515. The garden Hyacinth (*Hyacinthus orientalis*, L.) is one of the flowers to the culture of which florists have particularly devoted themselves. It is originally from the Levant, but has been brought to its present improved state in the Low Countries. Double hyacinths are now the only kind prized, though formerly these were as little sought after as double tulips are now, the beauty of the flower being then regarded as consisting in the regularity of the shape and disposition of the blossoms, and in the richness of the colour. Whole acres of nursery ground are covered with this flower near Haarlem and Utrecht in Holland. Here new varieties are annually produced from the seed, which is collected from multiplicate or semi-double flowers, and from very fine single flowers. When a new variety, of good qualities, is procured, it is named and enrolled in the select list. The choice flowers are divided into classes, according to their colours. John Kreps and Sons of Haarlem enumerate near one thousand varieties in their catalogue, classed in this way: Reds; rosy and flesh-coloured; white, with rosy and flesh-coloured eyes; yellow; white with yellow eyes; white with red eyes; pure white; white with violet and purple eyes; dark blackish blue; dark blue; porcelain and pale blue. The names of the finest and newest kinds are, as usual, high-sounding, and calculated to attract English curiosity,—the Monarch of the World; the Honour of Amsterdam; the Princess Charlotte; the Earl of Lauderdale, &c. &c.

516. The properties of a fine hyacinth are the following: the stalk tall, strong and upright; the blossoms numerous, large, well filled with petals, so as to appear rather convex, suspended in a horizontal direction; the whole flower having a compact pyramidal form, with the uppermost blossom quite erect; the plain colour should be clear and bright, and strong colours are preferable to pale; when the colours are mixed, they should blend with elegance.

The hyacinth grows best in a light sandy, but fresh earth. If manure of any sort be given, it must be placed far below the bulb. The time for planting is from the middle to the end of September. Old tanners'-bark is kept spread over the beds during winter, unless when mild weather seems to set in for some days. When the plants come into flower, a slight awning, which can easily be removed, is placed over them; and by this means they continue a month in glory. Hyacinths in beds never require any watering. When the flowering is over, the Dutch *move* their hyacinths with the spade, so as to break the root fibres, and prevent farther nourishment, but do not raise them completely from the ground for a fortnight. Even then they are laid in a bed nearly in a horizontal position, with their leaves and stems lying outwards; in this way, a great part of the juice in their thick succulent leaves and stems evaporates, instead of returning into the bulbs. This is called "ripening the roots." When choice hyacinths are cultivated in pots, as is commonly the case in this country, the pots are laid on their sides, after the flowering, till the leaves decay. Bulbs four or five years old flower most strongly in Britain, and they then gradually fall off; but in Holland they endure a great number of years. It is remarked, that they succeed best in situations near the sea. It is curious that bulbs imported from Holland flower more beautiful in this country the first year, than they ever do afterwards.

*Polyanthus-Narcissus.*

517. The Polyanthus-narcissus (*Narcissus tazetta*) is a

native of Spain and other parts of the south of Europe. The flowers are very ornamental, and come early. The plant has long been a favourite with the florists of Holland and Flanders. There are several principal varieties: Some have yellow petals, with cups or nectaries either orange or sulphur coloured,—others have white petals, with orange, yellow or sulphur coloured nectaries; in a third set, both the petals and the nectaries are white; and there are double flowers of all the varieties. The subordinate varieties are more than a hundred in number. A double variety, called the Cyprus Narcissus, is curious and beautiful; the outer petals are white; those in the middle partly white and partly orange; and it has a very agreeable scent. A pure white variety is called the Paper Narcissus.

The florists of this country generally depend on the supply of bulbs imported from Holland. The seed, however, often ripens in good seasons here, and there is no peculiar difficulty in raising the plants in this way. The seed is sown in shallow vessels in the manner of tulip seed. The seedling bulbs are not raised or transplanted till the third year; in other two years the flowers make their appearance. The beds containing young bulbs require to be defended from severe frost by means of a covering of peas-haulm, straw, or fern.

Full grown bulbs are planted in the beginning of September. They do not require to be raised every year; it is better indeed not to remove them oftener than once in three years. They flower in April and May; and if they be choice kinds, they should be saved from sun and rain by an awning, as practised in the case of tulips.

*Crocus.*

518. The crocus, though a well known flower, has only of late years been accurately studied as a genus. Miller admits only two species, the autumnal or saffron (*C. officinalis*), and the spring crocus, (*C. vernus*). Sir J. E. Smith mentions three species as natives of Britain, C. vernus, nudiflorus, and sativus. Of the former there are several varieties, blue and purple, yellow and white, and striped; and besides these, the following species are cultivated in crocus beds: C. versicolor, or party-colour crocus, a kind which requires a light loam, while most of the others grow best in sand; biflorus, or yellow bottomed; mæsianus, or common yellow; susianus, or cloth of gold; and aureus, or true gold. The Scots crocus is a beautiful striped variety.

The bulbs may be planted in any light soil; but they succeed best in sand; and some cultivators to the westward of London have been at the pains to carry sea-sand fifty miles for this purpose. They should not be planted deep, not being covered more than an inch. In February the flowers begin to appear; in March they are in glory; and by the end of April the seeds begin to ripen. In good seasons these are produced plentifully, and by means of them new varieties may be procured. The leaves of most of the species grow chiefly after the flowering is over: these should not be cut, as is often done, the bulbs being thereby deprived of much of their nourishment; they may, however, very properly be tied up.

*Annual Flowers.*

519. Many of these are very beautiful; and, in fine flower-gardens, they not only appear in patches on the borders, but some of the elegant sorts are cultivated in beds in a separate compartment, called the Annual Flower-garden.

They are commonly divided into Hardy, Less Hardy, and Tender. The hardy are sown in the spring, in the natural ground where they are to remain; the less hardy are raised on a slight hot-bed, and planted out in April and May; and the tender require to be passed through two nursery beds before planting in the open border, and in the northern parts of Britain they are kept almost always under glass. In this place only a few of the most beautiful or curious of each of these divisions can be named. Pretty ample and correct tabular lists of them may be found in Abercrombie's *Practical Gardener*, under the head *Flower-garden.*

520. Of the *Hardy Annuals*, different species of *Adonis* are showy, none more so than the Pheasant's-eye, A. autumnalis: this, if not a native, has become completely naturalized in fields near London, and quantities of the flowers are every summer sold in the city by the name of Red Morocco. Several species of Snapdragon (*Antirrhinum*); white and purple Candytuft (*Iberis umbellata*); Lobel's Catchfly, red and white (*Silene armeria*;) Venus' Looking glass (*Campanula speculum*); with the purple and the red topped Clary (*Salvia horminum*), are very ornamental. Varieties of the Convolvulus major and minor, and of the Bluebottle (*Centaurea cyanus*), with the Sweet Sultan (*C. moschata*); the Fennel-flower (*Nigella damascena*), with many sorts of Scabious (*Scabiosa*), and the well known Stock Gillyflower (*Mathiola incana*), deserve cultivation. The Yellow Balsam (*Impatiens noli tangere*) is remarkable for its ripe capsules exploding the seeds upon being touched; it thus sows itself, and should therefore be placed in a by-corner. The yellow blossoms of the Bladder Ketmia or Flower of an hour, (*Hibiscus trionum*) are extremely perishable if the sun be bright, but they are produced in long succession. Many varieties of Larkspur (*Delphinium Ajacis*), single and double, branched or with simple stems; with several kinds of Lupine (*Lupinus*), and of Sweet Pea (*Lathyrus odoratus*) are well known, and very ornamental. The varieties of Carnation Poppy (*Papaver somniferum*) are very showy; they are generally allowed to sow themselves. Strawberry Blite (*Blitum capitatum*) is a curious plant, the fruit resembling strawberries only, however, in appearance. Belvedere (*Chenopodium Scoparia*) is a handsome plant, resembling in its close pyramidal shape a dwarfish cypress-tree; from which circumstance it is often called Summer cypress. The Caterpillar (*Scorpiurus vermiculata*), Hedgehog, and Snail plants (*Medicago intertexta* and *scutellata*) have no beauty, but are remarkable on account of their vermiform pods. The Eternal Flower (*Xeranthemum*) is excelled by none, and there are red, white, purple, and blue varieties of it. Mignonette (*Reseda odorata*) is universally liked; it is generally sown in large patches, or an entire border is filled with it, commonly in front of the conservatory or greenhouse.

Hardy annual plants are generally sown in circular patches, traced with a hand trowel, with which, at the same time, the earth is broken small. A bit of stick is placed as a mark in the centre of each patch. Usually two or three successive sowings are made, from the middle of March to the middle of May, the season of flowering being thus prolonged. The plants must afterwards be thinned, according to the nature of their growth, the belvedere, the sunflower, and some others standing quite detached. After thinning, a plentiful watering is proper, in order to settle the earth about those that remain; and in dry weather, frequent watering will ensure the production of much finer and stronger plants. Most of the kinds bear transplanting in dull and showery weather. The tall-growing plants should of course be placed in the back part of the border; the low-growing in front. When the flowering is nearly over, some of the earliest and strongest plants should be marked for affording a supply of seed, and should, if tall, be tied to stakes, to prevent their being broken, or falling down. It often happens that some of the kinds spring up in the borders from seeds sown naturally the former year; from these the best and ripest seed may be expected.

521. The list of *Less hardy* annual plants embraces many fine flowers, such as different varieties of the African Marigold (*Tagetes erecta*), and of the French Marigold (*T. patula*); the Amaranth or Love lies bleeding (*Amaranthus caudatus*), and Prince's Feather (*A. hypochondriacus*); the rich and elegant Balsams, many varieties, (*Impatiens balsamina*); different kinds of Chrysanthemum, particularly C. tricolor, and also of Zinnia; with the Indian corn (*Zea mays*), and Tobacco plant (*Nicotiana tabacum*), which are curious. For these and others a moderate hot-bed is necessary, on which they may be sown in March or April, so as to be ready for transplanting into the borders in May or June. It is better, however, instead of removing the seedlings at once to the open border, to prick them into a nursery border, covered with a canvas awning, or hooped over and protected by mats at night: here they may be allowed to establish themselves and get hardy, for some weeks. In dry weather, frequent watering is essential, especially at the times of transplanting.

522. The list of *Tender* annual plants is not numerous, unless the balsam and some others from the less hardy list be included, which in the northen part of the island is always the case. Many varieties of Cock's-comb (*Celosia cristata*), with scarlet, purple, and yellow heads, some of the plants dwarfish, others three or four feet high, are exceedingly ornamental. The Globe amaranth (*Gomphræna globosa*) of various sorts, with the Amaranthus tricolor, having each leaf composed of three colours, bright red, yellow and green, are likewise among the more showy of the tender annual flowers. The Egg-plant deserves the same character; not on account of its flower, but of its singular and elegant berry, which has much of the shape and appearance of a large egg, as already noticed (§ 403). The Ice-plant (*Mesembryanthemum crystallinum*), remarkable for its stalks and leaves being covered with crystalline globules like small icicles, and the well-known Humble plant (*Mimosa pudica*), may also be mentioned. These are raised, in March, in a small hot-bed that is in a pretty strong state of fermentation, and afterwards transferred to one that is larger and of more moderate warmth. In general, the plants are subsequently kept in flower-pots, and are placed near the green-house plants, or perhaps in the greenhouse, the shelves of which they may thus decorate, while the proper inhabitants are abroad. Here too, if properly attended to in regard to watering, they will ripen their seeds, which they seldom do in our climate without the protection of glass. A few cock's-combs, globe-amaranthts, and egg-plants, likewise make a fine appearsnce on the back shelves of a hot-house.

*Biennial Flowers.*

523. Some flowers which are, strictly speaking, *biennial*, are often cultivated among the annual kinds: Such are, the Indian pink, (*Dianthus Chinensis*); the Palma Christi, (*Ricinus palma Christi*); and the Sensitive plant, (*Mimosa sensitiva*). Others are always treated as biennial plants, being kept in nursery rows for the first season, and planted out the next. Some of the most common are, Honesty or satin-flower, (*Lunaria annua*,) white and purple flowered; French Honeysuckle, (*Hedysarum coronarium*,) red and white; Yellow Horned Poppy, (*Glaucium luteum*); tree-primrose, several species, (*Oenothera biennis*, &c.); and Mullein of different kinds, (*Verbascum*.) particularly the Moth-mullein, (*V. blattaria*,) yellow and white flowered.

*Rock-work.*

524. In forming a piece of rock-work, it is found very useful to have at least the two or three outward layers of stones composed of *moor-stones*, that is, of such as have long lain exposed to the action of the weather. At the bases of greenstone and basalt hills very suitable masses may generally be found: those should be selected which have cavities in them, or are unequal on the surface; keeping in view also that they must be of such shape as to be capable of being piled on each other in a sloping direction without cement. If such weather-worn stones be selected, and mossy earth be used in place of cement, many kinds of ferns, and various cryptogamous plants, will be found to thrive, which would not succeed on sandstone, or on masses of any kind of rock fresh dug from a quarry. Besides, some part of the stones being always seen, the appearance of these is to be considered. Masses covered with lichens, especially Lichen atro-flavus, geographicus, ventosus, perellus, and stellaris, are therefore desirable. Pieces of plum-pudding stone and of serpentine have likewise a very good effect; some joints of columnar basalt are in some places introduced, and large petrifactions, or casts in sandstone or limestone, of the trunks and branches of trees. Large shells, too, particularly valves of the Chama gigas, are occasionally placed in the rock-work; and among sand in these some plants will thrive, such as Cotyledon umbilicus. All plants which grow naturally in a dry soil may be accounted fit for the rock-work. Several species of Dianthus, particularly D. deltoides, armeria, and cæsius, are highly ornamental. Red Valerian, (*Valeriana rubra*,) and a white variety of it, grow very readily among stones. If peat-earth be used, Erinus alpinus is a desirable plant. It forms close tufts, and produces its pretty purple flowers from April to July; and when well established, it often ripens its seed, and sows itself. Different species of Madwort are suitable, particularly Alyssum saxatile and deltoideum. Cerastium repens grows freely, but is apt to overrun the other plants: indeed, if it be wished at any time entirely to hide a heap of rubbish with garden plants, this is one of those to be selected for the service. To those already mentioned may be added, Erigeron alpinum; Cyclamen Europæum and herderæfolium; the spring Gentian, Gentiana verna; Soldanella alpina; purple Saxifrage, (*Saxifraga oppositifolia*,) and double Sengreen, (*S. granulata*, fl. pl.); the borage-leaved Mullein, (*Verbascum Myconi*); alpine Lychnis, (*Lychnis alpina*); and different species of Primula, P. nivalis, integrifolia, helvetica, and marginata. The basil-leaved Soapwort (*Saponaria ocymoides*) is one of the most beautiful little plants that adorns the flower-garden, and it is peculiarly well suited for rock-work. All the smaller species of hardy Stone-crop deserve a place, in particular Sedum album, glaucum, rupestre, aizoon, and sexangulare; as well as several species of House-leek, especially the cobweb kind, (*Sempervivum arachnoideum*). In small flower gardens, the rock-work is often constructed on the margin of a little pond for hardy aquatic plants.

*Aquarium.*

525. The shape of the pond is generally either circular or oval. Its dimensions must be regulated by the size of the neighbouring parterre or lawn, and by the taste of the owner for the cultivation of aquatic plants. If it be wished

to have the white and yellow water-lily (*Nymphæa alba* and *Nuphar lutea*) in perfection, it must be at least three feet deep. If the ground be open, especially if the subsoil be sandy or gravelly, the bottom should be well laid with puddled clay, and the sides should also be lined with the same material, in order to prevent the escape of the water. On the margin a kind of small terrace or shelf is formed, immersed only a few inches under water, and commonly laid with channel; on this are placed pots containing various marsh plants, such as the Marsh Calla, (*Calla palustris*), a native of Lapland and other northern parts of Europe. In some gardens, (as formerly noticed, § 191.) the margin is occupied with the American cranberry.

Several of our native aquatic plants are very ornamental; particularly the yellow and the white fringed Bog-bean, Menyanthes nymphoides, and trifoliata; the Flowering-rush (*Butomus umbellatus*,) and the Water-violet, or Feather-foil, (*Hottonia palustris*,) which grows in deep ditches near London. The Cats-tail or Reed-mace (*Typha latifolia* and *angustifolia*) has a singular appearance, especially when in flower, but it is apt to overrun a small pond.

*Rosary.*

526. The rose has always been deservedly a favourite; and at no period was it ever more high in repute than at present. Every hardy species is now carefully cultivated, and many new varieties raised from seed have of late years been introduced. The catalogue of Lee and Kennedy, of Hammersmith, enumerates no fewer than 315 varieties; but the *species* are not distinguished. Many of the finest varieties have been beautifully figured by Miss Lawrence, in her splendid collection of Drawings of Roses. Most of the species throw out suckers. These should be annually removed in October, and in this way abundance of plants may soon be procured. Still better plants however may be prepared by laying down branches; and this is the chief way of propagating adopted by the dealers in roses. Few of the kinds need any other pruning than shortening some of the strongest shoots, to cause them to push new buds and bear more flowers.

The following are the species generally preferred, but a few only of the varieties can be enumerated.

Hundred-leaved rose. (*Rosa centifolia.*) Of this there are many varieties, as the Dutch, blush, velvet, and Burgundy, the latter an elegant little plant, sometimes not more than a foot in height.

Red rose, or Crimson rose, (*R. Gallica.*) This is the kind, the unexpanded petals of which are used for making conserve of roses. A sort with variegated flowers is called Rosa Mundi.

Damask rose, (*R. Damascena.*) Of this there are some pretty variations, as the blush damask, the York and Lancaster, and the red and the white monthly roses, these last continuing to flower in succession during most of the summer.

Provence rose, or Cabbage rose, (*R provincialis.*) is one of the most beautiful of the tribe, and perhaps the most fragrant of all the roses. Of it there are likewise some favourite varieties, as the scarlet, the blush, and the white Provence; the rose de Meaux, and the pompone or dwarfish rose de Meaux. It may be remarked, that if the new wood be in a great measure cut down every year, after the flowering is over, the plants throw out more vigorous shoots, and yield a greater profusion of flowers.

The Moss rose (*R. muscosa*) is well known in gardens in a double state; but it is curious, that the single moss rose is quite unknown to us. The double is often propagated by budding on other stocks; but better and more durable plants are procured by laying down the branches. A white moss rose has lately appeared in the London nurseries; but it is still scarce and high priced.

The common White rose, (*R. alba*,) both single and double, deserves a place; as well as the varieties called large, small, and cluster maiden blush.

Single yellow rose, (*R. lutea.*) The Austrian rose, with the petals orange or scarlet at the base, is considered as a variety of this. Both kinds grow better in upland places than in the richest and warmest situation.

The Double yellow rose (*R. sulphurea*) is remarkable for the flowers seldom opening fairly. It should be planted in a cool and rather shady situation, or at least it does not succeed against a south wall. It is quite a distinct species from the single yellow; the leaflets, for example, are simply serrated, not glandular, and they are glaucous underneath; while in the single yellow, they are doubly serrated, glandular, and of a shining green.

Of the Cinnamon rose, (*R. Cinnamomea*,) a variety with double flowers is usually cultivated. It is the smallest and the earliest of the double roses, often coming into flower in the beginning of May.

Scots rose, or Burnet rose, (*R. spinosissima.*) Of this species, which, as a native plant, is more common in Scotland than in England, several varieties have long been known, particularly the red, the semi-double white, and the semi-double red. Messrs Brown, of the Perth nurseries, have of late years raised several new and very beautiful varieties of this rose. The Rosa Ciphiana, celebrated in a Latin ode by Sir Robert Sibbald, the earliest illustrator of the natural history of Scotland, was a variety of this species. Professor Martin says, it was found on his "Ciphian farm;" but the fact is, that the name of Sir Robert's estate was the unpoetical one of *Kips*, from which, *euphoniæ gratiâ*, Ciphia, was formed.

Sweet-briar-rose, (*R. rubiginosa.*) Of this well known species, the Eglantine of the poets, there are several varieties,—the common double flowered, mossy double, marbled double, and red double. A single flowered yellowish variety is kept in some gardens, but it is very scarce.

The Musk rose (*R. moschata*) is a climbing kind, flowering late, and continuing till the end of October. It varies with double flowers.

The deep red China rose, (*R. semperflorens*,) if placed against a south wall, or in front of a green-house, flowers for the greater part of the year. There is a pale China rose, by some considered as only a variety of R. semperflorens.

The Indian rose, (*R. Indica*, already noticed, § 472 ) is a very great acquisition to our gardens, being perfectly hardy. Although but lately introduced, it has now become very common; and by means of it we possess, in the open air, or against a wall or paling, full blown red roses in March and April, and in November and December. The common sort has very little smell; but a fragrant variety has been raised, thus uniting all the excellent properties of the rose.

In order to have a continued succession of roses, for instance, of the common moss rose, the best plan is, to cut off in May the tops of shoots produced the same spring. In this way new shoots are elicited, which come into flower late in autumn.

Beds of roses, of different shapes, are now commonly formed in the lawn near the mansion-house, or by the sides of the approach to the pleasure garden; when of an oval form, they are often called *baskets* of roses. The surface of the circle or oval is made to rise in the middle; the shoots are layered, and kept down by means of pegs till they strike roots into the ground; the points only, with a few buds on them, appear above the earth. By this sort of management, in two or three seasons, the whole surface becomes covered with a close and beautiful mixture of flowers and leaves. Sometimes only the moss rose is employed for this purpose; but frequently several kinds are intermixed. Even a single plant, particularly of the moss rose, may, by continued attention, be made in this way to cover a large space, and to afford at once perhaps several hundred flowers. Plans for rosaries of different shapes, circular, oval, square, and octagonal, have been published by Lee and Kennedy, and circulated along with their list of roses.

*Climbing Plants.*

527. In many gardens a walk is arched over with trellis work, either of wood or wire, principally for the purpose of affording a proper opportunity of cultivating the finer kinds of climbing shrubs, and enjoying the beauty and fragrance of their flowers, which render such a berceau walk extremely delightful in the warm weather of July and August. The finest of them, however, flourish only in the milder counties of England, and are planted in vain to the northward of Yorkshire.

The Kidney-bean tree (*Glycine frutescens*) shews elegant clusters of purple flowers; and the Virginian silk-tree (*Periploca Græca*) produces bunches of flowers of the same colour. *Smilax aspera*, sometimes called Rough Bindweed, and *S. excelsa*, although their flowers are not showy, are desirable climbing plants, as they retain their verdure during winter. Of the honeysuckles, besides different varieties of the common Woodbine, (*Lonicera Periclymenum*,) the trumpet-honeysuckle (*L. sempervirens*) particularly deserves a place. The yellow and the white Jasmine (*Jasminum fruticans* and *officinale*) are well known plants. Three species of *Atragene* are now cultivated; the Austrian, (*A. Austriaca*.) the Siberian, (*A. Sibirica*,) and the American, (*A. Americana*): the two former were long confounded under the name of A. alpina; they resemble each other, but the Austrian comes into leaf and flower two months before the other; the American species is also early. Several kinds of *Clematis*, or virgin's-bower, are highly ornamental, particularly the purple, (*C. viticella*,) and the double-flowered variety of it, with red and blue varieties of the single; the Virginian, (*C. Virginiana*,) with white flowers; and the evergreen, (*C. cirrhosa*,) which produces its greenish flowers about mid-winter. The common Traveller's-joy (*C. vitalba*) is too rampant to be trusted near to delicate climbers. The common Passion-flower (*Passiflora cærulea*) succeeds in some sheltered places, but in general it flowers better when trained against a wall.

528. For covering walls, some other plants are well suited. If the exposure be good, *Bignonia radicans*, or ash-leaved Trumpet-flower, is highly ornamental, being covered with orange flowers in the autumn: this is a plant, however, which requires some management as to pruning; all small weak shoots must every year be removed, and when the plant has filled the space allotted to it, a quantity of new or young wood for flowering is procured, by annually shortening a number of strong shoots. Common Ivy (*Hedera helix*,) with the silver-striped and gold-striped varieties, and the large-leaved or Irish, are very desirable; as is likewise the Virginian Creeper or five-leaved ivy, (*Vitis hederacea*.) The double Pomegranate has been already mentioned (§ 180.) as admirably adapted for covering a wall, or the end of a house, especially if it have a south aspect.

529. It has been more than once noticed, that the most effectual way of *acclimating* the plants of warmer countries is, to endeavour to bring such plants to ripen their seeds in the open air in this climate with as little assistance as possible, and then to sow these seeds, from which a more hardy progeny is likely to spring. Some plants, however, seem gradually to become inured to our climate, even without being reproduced by seed; or perhaps these plants were at first accounted more delicate than they really are. Several Japan shrubs have of late years become common ornaments of our gardens, particularly the Loquat or Mespilus Japonica; the Japan apple, (*Pyrus Japonica*,) which requires a south wall; the Sophora Japonica; and the Corchorus Japonicus. This last was introduced only about 1804; yet it may now be seen growing like a willow in our borders; and, if kept near to an east or a west wall, to save the buds from severe frost, producing a profusion of its yellow blossoms early in the spring. Trained to the back of a hot-house at the Botanic Garden at Edinburgh, and of course with a northern exposure, it has for several years past stood remarkably well, and has been regularly clothed with flowers in March and April. The Tea-plants (*Thea bohea* and *viridis*,) which are natives of the north of China, stand in the open border in the southern counties of England; but in severe winters they require some degree of protection. Edwardsia grandiflora and microphylla are natives of New Zealand, which flower in February in our sheltered borders, or trained against a wall. Several natives of the south of Europe now inhabit our borders; such are, Jupiter's-beard, Anthyllis barba Jovis; Coronilla glauca; and Moon trefoil, Medicago arborea. Two species of Leptospermum or South Sea myrtle, L. junipermum and baccatum, succeed in the milder parts of England, if trained against a wall; and Metrosideros lanceolata, likewise from New South Walès, has already been noticed as trained on the open wall in the College Botanic Garden at Dublin, § 28. Rhamnus glandulosus, from Madeira, is an addition to our evergreens. Some perennial species of *Convolvulus*, formerly accounted tender, are now trained against the border walls; particularly C. bryoniæfolius from China, and C. althæoides from the Levant. Of the common myrtle (*Myrtus communis*) there are several varieties, some of which are more hardy than others: a single-flowered sort, resembling the double-flowered, but with narrower leaves than the Dutch broad-leaved, is the most hardy; and a variety of the narrow-leaved, called the bird's-nest myrtle, seems also to be more hardy than the Dutch broad-leaved kind.

*Framed Borders.*

530. They who are curious in flowers frequently have a border covered with glazed frames, which can be easily removed during the warm season of the year, from the middle of June to September. Many plants, particularly of the bulbous kind, grow much better when planted in a large border than when confined to flower-pots. Bulbs in general require a deep soil; for they commonly send their fibrous roots, by which they draw their nourishment, to a considerable depth in the earth. Some of the bulbous plants which succeed well in such covered borders are, several species of Ixia, of African Gladiolus, of Hæmanthus or blood flower; and the Tigridia pavonia, or Tiger-flower, equally remarkable for its gorgeous beauty and its transitory nature. Tuberoses (*Polyanthes tuberosa*,) after having been fostered on a slight hot-bed, may be sunk in pots in a framed border, in order to their flowering. Several species of the splendid genus *Amaryllis* might be added to the list, particularly the Belladonna lily (*A. belladonna*,) the Jacobea lily (*A. formosissima*,) and the Guernsey lily (*A. sarniensis*.) Concerning this last, it may be ob-

served, that a few plants only can be expected to flower every year; for, as noticed by Miller, the same plant does not flower in two successive years, nor probably till after the lapse of several years. Dr Macculloch (*Scottish Hort. Mem.* vol. ii. p. 60.) has given an account of the cultivation of this favourite lily in Guernsey. Even there, the Doctor informs us, "scarcely five flowers are produced among a hundred healthy roots." Boxes containing parcels of the bulbs, generally with the flower-stems formed, are annually sent from the Channel Islands to the nurserymen of London, and by them distributed through Britain. Miller has justly remarked, that this lily may more properly be cultivated in a bed on a south border than in pots; it is therefore peculiarly well adapted to the framed border. For the soil, he recommends a third part fresh earth from some light pasture ground; about an equal part of sea-sand; and the remaining third to be composed equally of rotten dung and sifted lime-rubbish.

The different species of Cyclamen or sow-bread are humble plants, likewise well adapted to the framed border, where they make a very beautiful appearance.

In many gardens, where fine bulbous plants are much attended to, as at the Botanic Garden at Liverpool, all the borders immediately in front of the various hot-houses are covered with moveable frames. In these framed borders, it may be added, many alpine plants may likewise be preserved during winter; for such plants being accustomed, in their native place of growth, to the protection of a thick covering of snow during that severe season, are impatient of intense cold.

*Green-house.*

531. The proper situation for the Green-house has been already pointed out (§ 55.) as being somewhere in the flower garden. Its aspect ought of course to be towards the south. In fixing on the plan and elevation of a green-house, there is great scope for fancy and taste; for the indulgence of these is quite consistent with the production of a house, which shall afford shelter during winter to plants which require little more than to be saved from the effects of frost. It is scarcely ever wished that the temperature should exceed 45° Fahrenheit; and when the weather is such that air can be given, it is enough if the thermometer indicate from 38° to 42°. To every part of the house, however, light ought to be freely admitted, else some of the plants will necessarily become *drawn up* and distorted: a great part of the front of the roof should therefore be of glass. Nicol observes, that a green-house may have two straight sides, but should have circular ends; he is better pleased, however, with an octagon, whose sides are not equal, but which has two opposite longer sides, forming as it were an "angular oval." In some gardens the green-house forms a complete circle; in others it is of an oval shape: in these cases, and indeed in general, it is now constructed of glazed frames on every side. The roof is not made nearly so lofty as formerly; indeed, it seldom exceeds in height ten or twelve feet from the paved walk. The furnace and stock-hole are of course as much concealed as possible; and if the house be circular or octagonal, the smoke is carried by a flue under ground to some distance, and then discharged by a small chimney, hid by shrubbery. The interior is fitted up with stages and shelves for holding the plants. These are arranged according to their sizes, the shape of the leaves, and the general tint of colour: the smaller plants are chiefly placed in front, and those that are likely to flower during winter have conspicuous stations allotted to them: the taller plants occupy principally the back shelves: in this way a symmetrical mass of varied foliage is presented to the eye, interrupted only by projecting clusters of variously coloured blossoms. Several of the sashes, or perhaps each alternate sash, should be made moveable, for the admission of air; and ventilators are also proper for promoting a circulation, when the state of the weather prevents the admitting of air by the roof. Very little water is given to the plants during winter; and they are cleared of dust rather by means of a bellows than by the application of the syringe.

The roots of green-house plants are generally examined twice in the year, by turning the plants gently out of the pots. Many kinds only need repotting once in the year; and this operation is commonly performed in August: but others require it twice in the year, and the other period is usually March. It is not always necessary that the plants should be shifted into larger pots; on the contrary, it is often better to retrench the matted roots, and keep to pots of the same size. It is always proper that some small gravel or shivers of broken flower-pots be put in the bottom of the pots, to drain off moisture. And here a very common error in the manufacture of that earthen-ware article may be pointed out: the hole in the bottom is frequently made so as to have a small unintended rim on the inside, which necessarily retains a portion of water; whereas the sides of the hole ought to have a slope from the interior, so as to allow every particle of water to escape.

532. In the course of this treatise, the different sizes of flower-pots have more than once been mentioned in the technical style employed by gardeners, such as "eights," "sixteens," &c., or "No. 1," "No. 3," &c. These terms it may be proper here to explain. The meaning of them will be rendered obvious by a tabular view; but it may first be observed, that potters usually make seven *sizes*, also called *numbers*, of pots; that the pots of each particular size are sold in what are called *casts*; and that the number of pots in a cast increases proportionally as the size of the pots decreases. Of No. 1., which is the largest kind of pot in common use, there are eight in the cast, and a pot of this class is called either a "No. 1," or an "eight."

| | | | |
|---|---|---|---|
| No. 1. | first size, | has 8 in the cast, called | Eights. |
| —— 2. | second size, | 12 . . . . . . . | Twelves. |
| —— 3. | third size, | 16 . . . . . . . | Sixteens. |
| —— 4. | fourth size, | 24 . . . . . . . | Twenty-fours. |
| —— 5. | fifth size, | 32 . . . . . . . | Thirty-twos. |
| —— 6. | sixth size, | 48 . . . . . . . | Forty-eights. |
| —— 7. | seventh size, | 60 . . . . . . . | Sixties. |

Pots larger than eights, or of extra size, such as 4 in the cast, are often made, for the accommodation of large plants; and, on the other hand, pots of a smaller size than sixties are sometimes manufactured, particularly for holding small seedling plants, or very young Cape heaths. These very small pots are among gardeners called *thumbs*.

533. Plants suited to the green-house are extremely numerous, and constantly on the increase: the selection of them must depend on the taste of the owner, and the size of the house. To give any enumeration seems unnecessary: it may be sufficient to refer to those excellent lists, the Epitome of Hortus Kewensis, and the Cambridge Catalogue; in these the plants suited to the green-house are marked G; and their duration or character are indicated by the marks usually employed by botanists and gardeners; ⊙ for annual; ♂ for biennial; ♃ for perennial; and ♄ signifying that the plant is shrubby or arbo-

reous. In the first mentioned catalogue, the plants which require a black heath mould, or peat soil, have an asterisk * prefixed to them. In the Botanical Magazine, edited by Sims, (formerly mentioned § 18.), all new and curious green-house plants are figured and described as they come into notice.

534. To keep up the show of plants actually in flower in the green-house, especially in the early spring months, a usual and very proper expedient is, to plant a number of the common ornamental bulbous plants, in pots, in the month of October; to forward these in the stove, and to place them, as the flowers appear, upon the shelves of the green-house. For this purpose some of the many varieties of hyacinth, with single and double jonquil, white and yellow polyanthus-narcissus, Persian iris, and the early sweet-scented tulips, are well adapted. The jonquil bulbs, it may be observed, must be two years in the pots before they can be expected to flower properly.

535. We may take this opportunity of noticing the mode of bringing these bulbous plants into flower by means of water alone. It was described by Miller in a communication published in the 37th vol. of the Philosophical Transactions, for 1731. November is the usual season for beginning this sort of chamber-forcing. The flower-glasses are filled up to the bottom of the bulb with fresh soft water; and it is kept up to this point by adding to it as often as necessary. The water should be entirely changed once in the week or ten days. The glasses should be situated in a light room, where a fire is kept, and, if possible, near to windows exposed to the forenoon sun. If they be placed in a hot-house for a few weeks, they are greatly forwarded, and appear in perfect flower in January. The numerous varieties of hyacinths, raised by the incredible industry of the Dutch florists, answer extremely well for this purpose; likewise the different sorts, white and yellow, of the polyanthus-narcissus. The jonquil, also, is pretty well adapted; but to many its fragrance is too powerful in a room. The small tulips, called Duc de Vanthol, Claremont, and Pottebakker, may be treated in this way; and the Persian iris is sometimes brought to flower, but is rather apt to fail. The common poetic narcissus, and the common daffodil, may be made to bloom in the same way.

### *Conservatory.*

536. The Conservatory is distinguished by its interior being laid out in beds and borders, in which exotic trees, shrubs and perennial plants are cultivated as in the natural soil. The sides and roof are of glass; and not unfrequently this last is so formed, that it can be removed during the summer months. The parapet wall should be arched, in order to allow the roots of plants in the border next to it to penetrate to the exterior border, in quest of food. In general the flue passes under the walk, and has cavities at each side, to let heated air escape through holes in the earthen tiles with which it is covered. The side borders are occupied with some of the smaller ornamental shrubs of New Holland, and with some others, which, though occasionally placed in the open border, are apt to perish during winter; such as the scarlet Fuchsia of Chili, and the fragrant Vervain of the same country (*Verbena triphylla*); the Dutch double-flowered myrtle, and the tea plants. To these may be added some of the showy species of Polygala, Hermannia, and Gnidia. The bed in the middle of the house should be formed of compost soil to the depth of at least two feet; the bottom being laid with some hard material, to prevent the roots from penetrating, particularly if the subsoil be indifferent. For the general soil, Nicol recommends a perfectly homogeneous compost of 3-4ths brown loam, being the sward of an old pasture, and 1-4th vegetable earth, preferring that resulting from decayed tree-leaves. The earth should not be screened; indeed it is the better for having small stones mixed with it. This middle bed is occupied by some lofty New Holland plants, such as different species of *Acacia*, particularly A. decurrens and longifolia; the dwarfish fan-palm, Chamærops humilis; Clethra arborea, one of the ornaments of Madeira; Olive-trees, and frequently one or two of the Citrus genus. The different varieties, red and white, single and double, of the Japan rose (*Camellia Japonica*) deserve a place; with Daphne odora; the red-flowered Anise-seed tree, Illicium Floridanum; the Malabar nut, (*Justicia Adhatoda*); the Camphor-tree (*Laurus camphora*); several of the elegant genus Protea, and one or two of the no less pleasing and curious genus Banksia. Where the house is of an oval or oblong square shape, and is composed of glass only on three sides, the back is covered with a trellis, to which several of the arborescent Cranes-bills, (such as *Pelargonium inquinans*, different varieties, *P. peltatum*, *cuculatum*, and *lateripes*) are trained; and these, when in flower, have a very brilliant appearance. In some conservatories, a small *aquarium* is formed, where several of the foreign species of Nymphæa and Menyanthes may be brought to flower.

537. Sometimes the characters of the green-house and the conservatory are to a certain extent combined in one house. In particular, some ornamental climbers are planted in the borders, trained against the rafters and pillars, and often led in festoons from place to place. Several species of Passiflora, such as cœrulea, aurantia, and incarnata, and of Glycine, become in this way very elegant, and the large bell flowers of Cobbea scandens make a fine appearance; with different species of Convolvulus, and the Maurandia semperflorens. The Caper-bush, already noticed, § 405. is at once showy and in some measure useful.

538. In a few fine gardens, where the cultivation of curious plants is much attended to, a separate *heath-house* is erected, and appropriated to the numerous Ericæ from the neighbourhood of the Cape of Good Hope. This tribe of plants, it is justly remarked by Professor Martyn, has within these few years "risen from neglect to splendour." Miller, in the edition of his Dictionary published in 1766, mentions only five sorts, four of which are indigenous to this country, and the fifth a native of the south of Europe. The stores of the Cape were then nearly unknown. In 1775, Mr Francis Masson, travelling botanist to the king, sent home many new species from Southern Africa; and the same botanist revisited that country in 1787, and was equally successful in his researches. More lately, Mr Niven of Edinburgh, by extending his travels, made a rich harvest among the same tribe of plants. The Cape ericæ are now about two hundred in number, and many of them both beautiful and fragrant. In construction, the heath-house differs in no respect from a small green-house with a low roof. The plants thrive best in a light rather poor soil; such as a mixture of bog-earth, light loam and sand. They are propagated chiefly by cuttings; the cuttings preferred are very small, inserted closely together in fine soil, sifted over with very pure and fine sand, and covered with small crystal glasses, so as to prevent evaporation; the pots are kept in a moderate heat, but shaded. Cuttings of E. retorta, articularis, and several others, do not grow without great difficulty: such species are therefore often layered. Several kinds ripen their seeds in this country; and by sowing these, great numbers of plants are frequently raised.

*Hot-houses.*

539. The hot-houses for exotic plants have already been mentioned, under the title of Dry Stove and Bark Stove, (§ 199, 200). It was there observed, that in the latter some of the more delicate kinds of grape vines are often trained along the rafters, and that pots with kidney-beans and strawberries are sometimes placed on the side shelves. In first rate gardens, where the stove is entirely appropriated to ornamental plants from tropical climates, the house is sometimes formed of glass on all sides, those plants which naturally grow in shady woods in their own country being placed on the north side of the house. It may here be mentioned, that a book, in folio, on the Construction of Hot-houses, Green-houses, &c. has been published by Mr George Tod, including plans and elevations of some of the fine stoves for exotics at Kew gardens, which were executed by Mr Tod, under the direction of the late distinguished Mr Aiton.

Many curious and beautiful plants might be mentioned as deserving a place in the bark stove, but only a very few can here be named. Among the curious may be noticed, the Date-palm tree (*Phœnix dactylifera*); the Sago-palm (*Cycas revoluta*); the Cyperus Papyrus of Egypt, which afforded the scrolls of bark on which the ancients wrote with the stylum; the Coccolobo pubescens, remarkable for producing the largest round-shaped leaves in the world; Hernandia sonora, or the whistling tree of the West Indies; Musa paradisiaca, the plantain tree, and M. sapientum, the banana; several of the larger species of Acacia, which yield gum arabic; with others which, in our Eastern or Western possessions, afford well known commodities, such as the sugar-cane, the coffee-tree, the pimento and the clove-tree, the indigo plants, and the Ficus elasticus, from which the substance called Indian rubber is procured.

The Papaw-tree (*Carica papaya*) deserves a place in every large hot-house, on account of its possessing a remarkable property, which has been long known to those who have resided in the West Indies, but which has only of late been particularly described in this country by Dr Holder,—that of intenerating butchers-meat or poultry. This singular property is not even hinted at in the last edition of Miller's Dictionary. The juice rubbed on beef or mutton has the effect of rendering the meat as tender as veal or lamb, without injuring its other qualities. Indeed it is affirmed, that if a fowl be hung against the trunk of a papaw-tree, it becomes intenerated in a short space of time by mere proximity; and that the oldest poultry may thus be rendered as tender as chickens. In stoves in England, the papaw-tree has been known to attain the height of twenty feet in three years, and to produce its flowers and fruit: it is not however a durable plant.

Among the more showy stove plants may be mentioned, the different species of Strelitzia, Limodorum Tankervilli, Plumbago rosea, Canarina campanula, and Lantana odorata. Along the rafters may be trained Passiflora quadrangularis, which in the West Indies affords the fruit called Granadilla, but which in this country requires the utmost heat of our stoves to induce it to shew its brilliant and fragrant flowers. P. alata is also highly deserving of a place.

## *Diseases of Plants.*

540. In treating of the different kinds of fruit-trees and esculent plants, several of the maladies to which they are subject have already been noticed, as well as the usual means adopted either for prevention or cure. The diseases of plants shall therefore be only very slightly touched in this place. Any extensive discussion of the subject, indeed, could not be attempted: our knowledge of it is yet in its infancy. Some authors have no doubt given us lists of diseases of the vegetable race, drawn up in the formal style of nosological nomenclature; but they are in general destitute of the requisite permanence and precision of type and character. We shall therefore continue to use the popular terms, such as *Canker*, confessing at the same time that they are sometimes much too indefinite.

541. *Canker* is by far the most prevalent and the most fatal disease incident to fruit-trees in this country. It may be described as a sort of gangrene, which usually begins at the extremities of the branches, and proceeds towards the trunk, killing the tree in two or three years. It seems, in different situations, to arise from different causes; very often from bad subsoil, trees planted over a ferruginous and retentive soil being observed to be very liable to it. Sometimes it appears to take its origin merely from some external injury, or from injudicious pruning, and leaving ragged wounds and snags. In other cases, it makes its first appearance after exudations of gum; and Mr Spence of Hull has remarked, that the foundation of canker in full grown trees is often laid by the attacks of insects, particularly the larvæ of Tortrix Wœberana. It frequently happens that cions for grafting have been taken from infected trees; and the young trees produced in this way are, as might be expected, peculiarly obnoxious to the disease. Among apple trees, those which come soonest into a bearing state, such as the Nonsuch and Hawthorndean, are observed to be most subject to canker. Trees trained as standards or against espalier rails are more liable to it than wall-trees; the more tender and finer sorts of fruits than those that are hardy,—the reasons of which seem to be, that the young wood, not being thoroughly ripened, is killed in the course of the winter, or the buds and early shoots are incurably injured from the same cause.

In order to guard against canker, if the subsoil be indifferent, the trees should be planted as much on the surface as possible. (See § 78. and 110.) If certain varieties of fruit seem peculiarly liable to the disease in any particular garden, other varieties should be introduced by means of grafting. The greatest care should be taken, in pruning, to make the cuts quite clean, and to cover with a plaster any accidental wound. Where the extremities of unripe shoots are nipped by the frost, they should be carefully removed with a sharp knife. Mr Forsyth, as is well known, was remarkably successful in overcoming the ravages of canker, in the Royal Gardens at Kensington, by means of heading down the trees, and thus procuring new branches; an example which may in similar cases be followed. Mr Knight seems to consider canker as principally affecting those varieties of fruit-trees which are in an advanced stage of existence, or which have long been propagated by means of grafts or buds; and the observation is probably well founded. Mr Sang of Kirkcaldy (*Scottish Hort. Mem.* i. 339.) very justly insists on the importance of grafting only on healthy *stocks*, and mentions a case which occurred in his own experience, where many stocks became diseased with canker, apparently from having been raised in an unpropitious soil. For further information regarding canker, the reader may be referred to a paper on that subject by Mr James Smith, gardener at Hopeton House, published in the first volume of *Scottish Horticultural Memoirs*, p. 221, *et seq.*

542. *Blight* commonly means the effects of cold winds, or of hoar-frosts, on the foliage and blossoms of trees. In

this country, easterly winds, accompanied with fogs, often produce blight; the buds are nipped, and the tender vessels burst; innumerable minute insects soon appear, feeding on the extravasated juices, and these are often erroneously supposed to have been wafted hither by the wind, or "engendered by the hazy" *east*. When some fine weather has induced the blossom to expand itself prematurely, and frost supervenes, blight very often ensues. It is not therefore desirable, especially in the northern parts of Britain, that fruit trees should come early into flower: on the contrary, it would be advantageous if the flowering were retarded. Various devices are resorted to for protecting early blossoms, some of which have already been described, § 84.

543. What is called *suffocation* is very commonly induced by the stems and branches being overgrown with lichens and mosses; an evil to which the trees in old orchards, where perhaps the bottom is naturally moist, and has not been drained, are peculiarly liable. The remedy is simple, consisting in rubbing off the parasitical plants, an operation which is much more easily and effectually performed in wet than in dry weather. A round-mouthed iron scraper is sometimes used for this purpose; but one of hard wood answers perfectly well. The trunk and larger branches are afterwards hard swept with a birchen rubber, and it is found very useful, even after both these operations, to wash the branches with old soap-suds or any penetrating liquid, or to apply a coating, of the consistence of paint, of a mixture of equal parts of quicklime, cow dung, and clay.

544. Sometimes *blotches* or dark spots appear, terminating in ulcers. If these occur on old branches, the best remedy is to cut off the diseased parts, if practicable, and to apply a plaster. This may be composed of horse-droppings and clay wrought together, these ingredients being found to answer every useful purpose. Many however prefer a mixture of cow dung and old lime; and where the wounds are small, this is more easily applied. This last, indeed, is very nearly Forsyth's "composition," the specification of which the reader may like to see. It is as follows: Take one bushel of fresh cow-dung, half a bushel of lime rubbish of old buildings, half a bushel of wood-ashes, and a sixteenth part of a bushel of pit or river sand; the three last articles to be sifted fine before they be mixed; then work them well together with the spade, and afterwards with a wooden beater, until the stuff is very smooth, like fine plaster used for the ceilings of rooms. Chamber-lye and soapsuds are to be added, till it be reduced to the consistence of a pretty thick paint, which may be applied to the trees with a painter's brush. The application of such plasters or paints, it may here be remarked, is proper wherever any accident has occurred to fruit trees, or where large branches are lopped off.

In some cases, especially in peach-trees, blotches appear on the young shoots, which must of course be entirely removed. Mr. Kinment, gardener at Murie in Scotland, has assigned some reasons for believing that such blotches on the young wood of the peach-tree, are induced by the gross feeding of the tree; in other words, he observed, that blotches always occurred on trees where the borders were manured with simple dungs, but that where fresh soil or well prepared compost only was added to the border, the trees continued in a healthy state.

545. When a tree becomes *hide bound*, or when the stem swells too fast for the bark, the usual remedy is, with a knife, to score or divide the outer bark longitudinally in various places.

546. In cases where the outer bark has become rough and full of chinks, so that small insects deposit their eggs and produce their larvæ below this bark, it is a good practice entirely to remove it. This sort of decortication is by no means a novelty in gardening; it is recommended by several of the authors mentioned in the introduction to this article. Thus, Le Gendre, (§ 10) writing about 1650, says, "Those trees which have their bark base, you must with a bill take away the old bark to the quick; for the trees being thus cleared and discharged, do shoot forth with new strength, bearing fairer and better nourished fruit." (Translation, p. 136) And Hitt (§ 14) who wrote in 1754, recommends for trees that have been neglected or ill dressed, "taking off the old rind, and cleansing cankered parts, thus destroying many insects, as also their eggs, concealed in these places." (*Treatise on Fruit Trees*, 3d edit. p. 271.) Of late years Mr Knight practised decortication on some old fruit trees, particularly red-streak apples, and found the new growth thus produced quite surprising, so that the growth of some trees deprived of their external bark in 1801, exceeded in the summer of 1802, the increase of the five preceding years taken together. (*Treatise on Apple and Pear*, 4th edition, p. 86)

547. More recently, a zealous horticulturist at Edinburgh, Mr P. Lyon, surgeon, has called the attention of the public to the advantages of decortication. At first Mr Lyon recommended the removal of the bark only in cases where it was cracked and rugged, and chiefly with the view of destroying the *ova* of insects; but of late he has inculcated the stripping off the outer bark even of young trees, and of the new shoots of full grown trees, even where the bark is sound and healthy. The beneficial effects of the former practice we have repeatedly witnessed; old trees which usually bore very little fruit, and produced little new wood, becoming, after the removal of the outer bark, fruitful, and rather exuberant in the production of shoots: the fruit, however, though plentiful, has in general been of smaller size than usual. The depriving young trees and new shoots of their bark is quite a different thing. We know that it is the earnest endeavour of many excellent practical gardeners to keep the bark *on*, provided they can preserve it in a clean and healthy state. We shall only, therefore, for an explanation of this part of Mr Lyon's doctrines, refer to his book, entitled "A Treatise on the Physiology and Pathology of Fruit-trees," 8vo. Edin. 1816,—warning the reader that he must make allowance for no small proportion of extraneous matter.

548. In order to clear trees, especially wall-trees, of insects and their eggs and larvæ, and to prevent the breeding of these, the trunk, branches, and even twigs, are, by careful horticulturists, regularly washed with some penetrating liquid every winter. Some of the most experienced practical gardeners in Scotland have followed this plan, tedious and laborious although it may seem, for a number of years past, and have found the greatest benefit result from it. They have very generally adopted a mixture recommended by Mr Nicol, and from his writings, therefore, the recipe shall be given: "Take of soft soap, 2lb; flower of sulphur 2lb.; leaf or roll tobacco 2lb.; nux vomica, 4 oz.; turpentine, a gill English measure. These ingredients are to be boiled in eight gallons English of soft or river water, down to six gallons." This mixture is applied by means of a house-painter's brush and a sponge, generally when in a milk-warm state. All the branches in succession are loosened from the wall, and completely rubbed or anointed on every side, particular attention being paid to the cleansing of angles or cavities. If the trees have been much overrun with insects, even the wall should be anointed, or

the trellis in the case of espalier trees. This operation may be performed any time from the beginning of November till the middle of February.

549. Sir George Mackenzie has lately communicated to the Caledonian Horticultural Society, the result of an extensive experiment of anointing the stems and branches of trees with oil, or oily matter, for the purpose of destroying the eggs and pupæ of insects. The experiment has succeeded beyond expectation; but care must be taken not to touch the buds, particularly those which are to produce blossoms. Apricot and cherry trees are the only kinds which seemed to suffer injury from oil, every other kind having made vigorous shoots, and the bark of those which had a diseased appearance having sloughed, and shown the advance of new healthy bark; and aphides, &c. seeming to have been banished.

The same gentleman has discovered a nocturnal enemy in a Curculio, supposed to be C. vastator, whose ravages have been attributed to caterpillars. This kind of weevil conceals itself during the day about the foot of the stems of trees in the earth, from which, owing to its brownish-grey colour, it is difficult to distinguish it; and at night it crawls up, and attacks the young shoots and blossoms. It is very destructive to young grafts. The method which Sir George Mackenzie took to destroy them was, to tread the earth about the foot of the stems of the trees, at night when the weevils were on the trees, and putting small flat stones, pieces of slate, or the like, on the trodden space. In the morning the enemy having retreated under these, were destroyed. The trees and grafts should, however, occasionally be examined by candle light, and the insects picked off. They have been found sometimes to harbour also in the clefts of branches, and about portions of dead or decayed and rugged bark.

550. *Mildew* consists in a thin whitish coating, investing the leaves especially of peach-trees and the finer kinds of fruits. It is observed that it commonly appears in the warm months, when the ground is dry, the weather calm, and when hazy vapours or slight fogs appear in the evenings. It is a remark of experienced gardeners, that trees washed during winter with such a liquid as that above described, are scarcely ever known to be affected with mildew, probably owing to the leaves being perfectly healthy and able to withstand the immediate cause of the evil, whether it be minute fungi or the slime of aphides. Washing the foliage with the garden-engine is found very useful in removing the mildew or in stopping its progress.

551. What is called the *scale* seems to be the nidus of an insect, or a collection of its minute eggs, covered with a thin pellicle. It very much resembles a drop from a spermaceti candle. The hatching of the eggs and consequent bursting of the pellicle, have been observed and described by Mr Thomas Thomson, an excellent Scottish gardener. It generally appears in August, and it continues in the state of a scale during the winter. The larvæ usually emerge about the time when the trees are in blossom, and they immediately begin to devour the tender parts of the flower. Afterwards, as they acquire strength, they attack the young leaves and even the new shoots of the trees. When about to undergo their transformation, they involve themselves in leaves drawn together with fine silky threads: from this retreat they come forth in the form of small moths, but the species has not been ascertained. The most effectual method of destroying these scales consists in removing them with the nail of the finger at the time of winter dressing. In rainy weather they are most discernible, being of a lighter colour than the wet bark. Another simple method of overcoming them is, to make a paste of fine clay of the consistence of thick paint, and with a coarse brush completely to anoint the branches of the tree. This should be done in March; and if heavy rains do not immediately wash away the coating of paint, the breeding of the insects at the proper season is prevented, and their destruction thus ensured.

Several of the diseases of plants, we have thus seen, arise from the attacks of insect assailants. Some more of these remain to be mentioned, and also a few enemies of larger size.

*Enemies to Garden productions.*

552. *Aphides* or green-flies, of many species, very much annoy wall-trees in the spring and early part of summer, attacking the leaves while just expanding, and preying much about the points of the young shoots. A fumigation with tobacco is the common cure, and it very generally proves effectual. In the case of wall-trees, a large cloth, preferring one that is waxed or oiled, is placed over the tree, and the tobacco smoke applied under it with bellows; the wall and the tree are previously wetted with the garden engine, the moisture having a tendency to detain the smoke. The tree is then briskly washed with the force-pump, and the border is delved over, so as to bury the stunned aphides. In the same way gooseberry or currant bushes may be freed from them. In hot-houses the fumigation is easily performed, while the doors and sashes are kept close. It is likewise very readily accomplished in melon or cucumber frames, the crops in which are sometimes infested. In the kitchen-garden, kidney-beans are subject to the attacks of aphides; and in the flower-garden, rose-bushes are peculiarly obnoxious to them.

The Apple-aphis (*A. lanigera*), sometimes called American blight, which has of late proved exceedingly destructive to young apple-trees, first appeared in the neighbourhood of London only about the year 1795. It is a minute insect covered with a long cotton-like wool; it breeds in chinks and rugosities of the bark, and at length almost covers the infected tree. It is said that the application of the spirit of turpentine to the bark proves an effectual remedy; and we know that it has been wholly banished from a garden where it had spread, by merely smearing the infested branches with oil, as recommended by Sir George Mackenzie. Sir Joseph Banks extirpated it from his own apple-trees, by the simple means of removing all the rugged old bark, and then scrubbing the trunk and branches with a hard brush. Mr William Salisbury, in his "Hints to the Proprietors of Orchards," published in 1816, gives it as his opinion, that this is the same insect which has of late infested larch-trees. He supposes it to have been brought to this country by the Protestant refugees in the reign of Louis XIV.; but he has assigned no reason for this extraordinary opinion, nor has he attempted to explain why so destructive an insect had lain dormant for so many years, and at length suddenly extended its ravages in so striking a manner. He observes, that some of the insects descend during winter to the upper roots, and lodge there; in cleansing the trees, therefore, these should be examined, as well as the trunk and branches.

553. There are several distinct kinds of *gooseberry-caterpillar*. One species, of a whitish colour, becomes a longish fly, with golden-tinged wings, a yellow body, and yellow thighs; probably the Tenthredo capreæ. Another, of a greenish hue, which becomes T. flava, often proves quite destructive to the foliage of the plant, and consequently to the fruit. A third, of a larger size, and sometimes very common, is the larva of the magpie-moth (*Phalæna grossulariata*, Lin. *Abraxas* of Leach. (The young of this last haunt during winter about the crevices of the bark; and

this is considered as the best time for destroying them. Their destruction may be effected merely by hard rubbing of the stems and branches, or by pouring boiling hot water over these parts, which at this season does not injure the bushes. The larvæ of the saw-flies or tenthredines penetrate about an inch under ground in July, and, passing into the chrysalis state, remain there till the following spring, when they come forth in the form of flies. For destroying these, one of the most effectual means consists in delving the ground about the bushes very deep during winter, taking care to bury the surface-soil in the bottom. In this way the chrysalids are placed beyond the genial influence of the atmosphere, or, if the transformation be accomplished, the fly is unable to gain the surface.

Different species of *Coccus*, particularly C. hesperidum, often called *scaly insects*, infest the plants of the greenhouse and the conservatory, particularly the myrtle, the orange, and the olive. A thorough washing with soap and water, rubbing the leaves with a woollen rag or bit of sponge tied on a small stick, is the remedy usually resorted to, the plants being afterwards well syringed with pure water. Coccus vitis infests vines placed in stoves, and is often very injurious, covering their stems, as it were, with little tufts of white cotton. The means of freeing pineapple plants from the coccus have already been adverted to, § 223.

554. The *red spider* (*Acarus telarius*) infests not only the pine-stove, vinery, and melon frames, but often proves very injurious to ornamental stove plants. Water applied with the syringe is destructive to it. Some persons recommend the use of lime-water; but it is not commonly employed, being found hurtful to the foliage; nor does any addition to the water seem necessary.

555. The finer kinds of fruits, as they approach ripeness, are subject to the attacks of different insects. Among these *wasps* (*Vespa vulgaris*) may be first mentioned. Various expedients are resorted to for destroying them. In some places, phials half filled with honey and water, or any sweet liquid, are hung in different parts of the tree; and great numbers are thus ensnared. The most effectual means, however, of keeping down the numbers of this formidable enemy is, to destroy the females in the early part of the season, and the nests in the autumn. From hot-houses they are, in some places, excluded, by employing temporary doors and temporary frames below the sashes, covered with thin muslin or gauze: both kinds of doors are never allowed to be open at the same time, and the gauze or muslin does not prevent the access of sufficient light and air. Where their exclusion is not thus effected, it is found very useful to have a plant of Hoya carnosa established. This is an ornamental climber (named in honour of Mr Thomas Hoy, a distinguished botanist, who has for about half a century been head-gardener to the Duke of Northumberland at Syon House), and may be trained along any spare parts of the house. It flowers freely; and as long as the blossoms continue, which they do for several weeks, the wasps give a decided preference to the sweet exudation they afford, leaving grapes and peaches untouched.

556. *Earwigs* (*Forficula auricularia*) attack all sorts of ripe fruit. No remedy is known but ensnaring and killing them. Short cuts of reeds, or of strong wheat-straw, or hollow stalks of any kind, are placed here and there among the branches, and also at the roots of the trees. Into these the earwigs take refuge in great numbers; and from the tubes they are blown into a bottle containing water.

557. The *woodlouse*, called *sclater* in Scotland (under which name are included the Oniscus asellus and Porcellio scaber of naturalists) is often entrapped along with the earwig. It is almost equally injurious to ripe fruit as that insect.

558. *Flies* of many different species, and belonging to various genera, may be numbered among the enemies of ripe fruit. The wasp, the earwig, and the woodlouse, commence the attack, and "sap the blushing rind;" the flies enter the openings made by these more powerful insects, and extend the devastation. Several *muscæ* are very frequently to be observed, particularly M. tenax, Cæsar, and canicularis. Wherever the juices begin to corrupt, the large blow-fly (*M. vomitoria*) is to be found in every hollow.

559. The *caterpillars*, which devour the leaves of cabbages, savoys, and broccoli, are principally the larvæ of Noctua brassicæ, and N. oleracea. The completely green caterpillar, which frequently preys on cauliflower and broccoli plants, is the larva of *Papilio rapæ*, Lin. (*Pontia*, Fabr.) The cabbage tribe is observed to be most subject to the attack of caterpillars in the neighbourhood of towns and in long cultivated soils, where much crude manure has been applied. The best and simplest remedy consists in turning up the soil in ridges in the autumn, and leaving it exposed to the action of the winter's frost; but the application of quicklime is also useful.

560. The *wire-worm* is an indefinite sort of name for any small thread-like grub, which lodges in the roots of culinary plants, particularly such as are of a bulbous or tuberous nature. These grubs appear to be principally the larvæ of different species of Elater. They sometimes attack also the roots of ornamental plants kept in pots: The remedy, in this case, consists in repotting, shaking the roots clear of the old earth, and using fresh soil brought from some old pasture at a distance.

The *maggot* which infests onions and shallots (§ 335 and 344), is a small larva, the transformations of which have not yet been traced by naturalists.

For further information concerning the natural history of the insect enemies of fruits and culinary vegetables, we may refer to the first volume of a very entertaining and instructive work, entitled "An Introduction to Entomology," by Messrs Kirby and Spence, 8vo. London, 1815; and to the article ENTOMOLOGY in this work.

561. The other enemies of garden productions can only be very slightly noticed here.

*Slugs*, meaning principally Limax cinerarius and L. flavus, are often very mischievous to wall-trees, which they ascend in the spring months, cutting off the fruit at the time of setting. Inverted flower-pots are sometimes placed as decoys at the bottom of the trees, the slugs being induced to take shelter within them. Ducks are very good destroyers of slugs; and a few are often turned into gardens for this purpose; they must be kept in it for two or three days, and get no food but what they cull for themselves.

*Snails* (meaning chiefly *Helix aspersa* of Montagu, or *H. hortensis* of Pennant) often abound, especially where the garden-walls are old or rugged. In well kept gardens they are looked for in the mornings, particularly after showers, when they never fail to appear, and are destroyed.

*Moles* (*Talpa Europæa*) are sometimes very injurious in gardens, and must be extirpated wherever they appear. Traps are set for them by persons who have studied their habits: and the expertness of some of these in taking them is wonderful. The moles seem to be social animals, keeping together in families or societies. The great art in catching them depends on ascertaining their recent and frequented galleries or subterraneous roads, and in placing the traps neatly in these.

*Mice* (principally the field-mouse, *Mus sylvaticus*) frequently devour newly sown peas and beans, if these have not been duly covered with soil; and they sometimes likewise attack the beds of tulips, ranunculuses, and crocuses. They may soon be subdued by placing a number of *fourth-figure* traps (as they are called, from resembling in shape the Arabic 4) in the garden: this kind of simple but effectual trap is figured and described both in Nicol's "Calendar," and in Abercrombie's "Practical Gardener."

Many kinds of *birds* may be numbered among the enemies of gardens. Even the beautiful bulfinch (*Loxia pyrrhula*) destroys many blossoms of fruit-trees, scooping them clean out; but whether the bird feeds on the blossom, or only nips it off for the sake of caterpillars contained within it, is not known. The jay (*Corvus glandarius*,) the black-bird (*Turdus merula*), and the mavis (*T. musicus*,) make great havock among the best kinds of cherries, where means are not resorted to for saving them. Rooks (*Corvus frugilegus*) often attack pear-trees, and destroy vast quantities of the fruit; and jack-daws (*C. monedula*) are sometimes also guilty of this sort of trespass. The common sparrow (*Fringilla domestica*,) and the chaffinch (*F. cœlebs*), likewise commit great depredations. For the protection of large standard trees, dead birds are occasionally hung up, so as to wave with the wind; and such scares are of considerable service in deterring depredators. In the case of espalier and wall-trees, nets are generally employed, being hung over them, and fixed close to the ground. It may be remarked, that different species of titmouse (*Parus cæruleus* and *ater*) with the common creeper (*Certhia familiaris*), and all the Motacillæ or warblers, may be considered as useful in destroying insects or their larvæ, which are their principal food, and should therefore be winked at in gardens, although they may possibly destroy a certain quantity of the blossom.

### *Implements of Gardening.*

562. The principal tools employed in horticultural operations have already been mentioned incidentally; but it may be proper in this place to enumerate them together.

The spade may be first named, as the oldest and most indispensable garden tool. Besides common sized spades for delving, small spades are required for working in the flower-borders. The manufacture of spades is carried on to a great extent at Dalston near Carlisle; at Gateshead, Newcastle; Bedburn, near Durham; Burton upon Trent; and Ulverstone in Lancashire; and of late years, some Scots forges, particularly those at Cramond, near Edinburgh, and Dalnottar, near Glasgow, have disputed, with those mentioned, the palm of excellence in this useful and important article of our iron manufacture. Shovels of different sorts are made at the same manufactories. Forks are necessary for pointing over ground where it is improper to use the spade: They are of different sizes, and some have flat and others rounded tines: asparagus-forks have been already mentioned (§ 353.) Hoes of different sizes are indispensable, with small weeding and thinning hoes, and also the sort called the Dutch hoe. Rakes of different sizes are necessary: for large ones, those in which the teeth are of iron, and the head of well-seasoned ash, are best; and for small ones, those in which the teeth and head are formed of one solid piece of iron are to be preferred. Shears for clipping hedges, and a kind with bent handles for dressing grass verges, are not to be forgotten. A flat faced hammer, with large headed nails, both of wrought iron and of cast iron, and a stock of lists or *roonds* are requisite for the nailing of wall-trees: as well as a proper wall-ladder, such as is described, § 245. Pruning, grafting, and budding knives, with hand-bills, chisels, and small saws, are indispensable. Some recently invented pruning instruments might here be noticed. One called the Averuncator has a handle from 5 to 8 feet in length; by means of a cord and pulley, a lever connected with a cutting blade is acted upon; so that a person standing on the ground may prune the greater part of ordinary sized trees. The Pruning-shears are more easily managed, and are found very useful on many occasions, making the cuts more clean and neat than can be done with any kind of knife. Both instruments take off branches an inch and a half in diameter with great ease. The form of the averuncator is given at Fig. 6. of Plate CCCXII., and of the pruning-shears at Fig. 7. of the same Plate. Trowels of different sizes and shapes, with planting irons and dibbles, are all very useful implements. These, with scythes and paring-irons, and similar instruments, are manufactured to a great extent at Sheffield; and from the subdivision of labour there established, they are furnished at rates so cheap as cannot fail in a great measure to command the market: but it is not to be disputed, regarding hoes and rakes in particular, that the blacksmiths of some towns not distinguished as manufacturing places, such as Edinburgh, produce these instruments of better materials, if not of neater workmanship. A garden reel and line is constantly needed. Sieves of iron or of brass wire of different degrees of closeness are required, wherever attention is paid to the raising of exotic seedlings. Fumigating bellows are useful for green-houses, vineries, and melon-frames. Where forcing is practised, or where a collection of stove-plants is kept, thermometers are necessary: those graduated to the scale of Fahrenheit are universally in use: what is called the botanical thermometer differs in no respect from another, excepting that some terms, such as "Ananas," are inscribed at the proper degrees on the sides of the scale. One thermometer is placed in the open air; and in the centre of each of the hot-houses there is another: by comparing these, the propriety of increasing or diminishing the fire-heat, or the quantity of fuel, is regulated. Watering-pots are made by tinsmiths, with pipes of different lengths, and with roses more or less closely perforated: for watering delicate seedlings, pots with brass nozles finely perforated are used, producing an extremely light or minutely divided shower.

563. The *garden engine* has been repeatedly mentioned, and its use recommended, (§ 92, 205, &c.) Considerable improvements having been made on this instrument at Edinburgh, a few words additional concerning it may be excused. The engine consists of a force pump or barrel, commonly two inches and a quarter in diameter, to the bottom of which, above the valve, is connected an air-vessel: into this the water is forced; and it is emitted from it, by the action of the compressed air, through the directing pipe in a continued stream. This pipe is attached to the top of the air-vessel by means of a swan-neck swivel joint, with double screws, which are water tight: in this way the pipe can be moved in any direction. Formerly, leathern valves and a leathern flexible director-pipe were in use; but from occasional exposure to drought, the seams of the leather were very apt to open, and allow water to escape; well executed brass work, on the other hand, is of all others least liable to derangement. The pump and air-vessel are fixed in a copper cistern, sixteen inches deep, and capable of containing about twenty-two gallons of water, wine measure. The cistern has likewise a strong

wooden bottom, to which are attached two rollers, an improvement of Mr John Hay's, which greatly facilitate the moving of it when taken into hot-houses or vineries. The engine is, at the same time, fitted to a barrow with wheels, for the conveniency of wheeling it through the garden; and to this the rollers form no obstacle, as they pass between the *steels* of the barrow. The pump is worked by a lever, and requires very little exertion. The water can be projected about fifty feet; so that wall-trees of any height may be washed, while the engine remains on the gravel walk.

The best writers on the various branches of horticulture, particularly British authors, have been mentioned, either in the introduction to this article, or in the course of treating the different parts of the subject; but it may be useful to recapitulate them here in alphabetical order. (P. N.)

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HOSPITAL. See Infirmary.

HOT-BATH. See Bathing.

HOT-BED. The common hot-beds in use in this country are composed of new or fresh stable dung in the following manner. The dung is collected in a heap, under cover, if possible, and kept for about a week in this situation, when the heat arising from fermentation becomes considerable. It is then turned over, well mixed, and again formed into a heap, to remain for five or six days more, in order that the heat may be equally distributed. It is now transferred to the site of the intended hot-bed. Here it is again very completely intermixed by means of the dung-fork, in the course of making up the bed; at the same time every layer is settled compactly, and beat smooth. The bed is usually five or six feet in breadth, according to the size of the glazed frames, beyond which it ought to extend on every side about eight or nine inches; and it is from four feet to two feet and a half thick or deep,—the thickest beds being used in winter, and the thinner in the spring months. The part of the dung which is *shortest*, or freest from litter, is placed on the top, forming a close covering, through which steam or vapour may not readily pass; sometimes a layer of cow-dung is placed on the surface, with the same view. After the bed is made up, it is allowed to remain for a few days, during which it sends off a good deal of vapour, and acquires an equal temperature throughout. When the heat declines, it is revived by adding *linings* on the outside; but for information respecting these, as well as concerning the use of tanner's bark and decayed tree leaves in forming hot-beds, see Horticulture, § 257, 355, &c.

HOT-HOUSE See Horticulture, *Index*.

HOTTENTOTS, an extraordinary people in the southern extremity of Africa, originally occupying the territories around the Cape of Good Hope. They are altogether an insulated tribe, confined to a small corner of the African Continent, and bearing no resemblance either to the Negro race along the western coast, or to the Caffre nation to the eastward. Various conjectures have been proposed, but nothing very satisfactory has yet been established, respecting their origin, or affinity. Kolben, in full consistency with his multitude of marvelious stories on the subject, affirms, that they have a tradition among themselves, of having been thrust upon the promontory of the Cape out of some narrow passage; and, as a narrow passage might signify a door-way or window, he forthwith concludes, that it could be nothing else than the window of Noah's ark, out of which they crept. Mr Barrow considers them as approaching nearest in colour, and in the construction of the features, especially in the shape of the eye, to the Chinese or Tartar race; and accounts for this relation, by supposing them to have proceeded from the Egyptians, who have been not improbably represented as originally the same people with the Chinese. In support of this opinion, he adduces the strong resemblance between the physical character of the Bosjesmans, or real Hottentots, and the descriptions given by ancient writers, particularly by Diodorus Siculus, of the Egyptians and Ethiopians, especially of the Pigmies and Troglodytes, who are said to have dwelt in the neighbourhood of the Nile. The early Portuguese writers, also, mention a colony of Chinese in the vicinity of Soffala; and the natives in the interior of Madagascar are described as a small race of Tartars, resembling the Hottentots in stature, colour, and countenance. The name Hottentot, though frequently represented as their native appellation, is now ascertained to be of modern fabrication, and has no place or meaning in their own language. They take it to themselves, under the idea of its being a Dutch word; and it is conceived to have been applied at first as a term in some degree imitative of the remarkable clacking made by them in speaking, which is said to sound like *hot* or *tot*. Each horde had formerly its particular name, as the Attaquas, Hessaquas, Houtiniquas, Namaquas, and Coranas; but the designation by which the whole nation was distinguished, and which they still bear among themselves in every part of the country, is Quaïquæ.

The whole of the Hottentot country, comprehending all the different tribes of the race, extends along the east coast to the 32° of S. Latitude, and to the 25° on the West. None of the first discoverers of the Cape of Good Hope, nor of the early Portuguese navigators, had much communication with the natives; and the Hottentots were scarcely known to Europeans till about the year 1509; when Francisco D'Almeyda, Viceroy of India, returning home after his quarrel with Albuquerque, landed at Table Bay, and was killed, along with seventy of his people, in a scuffle with the natives. A Portuguese captain, having touched on the coast, about three years afterwards, planned the following cowardly scheme of avenging his countrymen. He landed a piece of ordnance loaded with grape shot as a pretended present to the Hottentots; and while the unsuspecting natives were crowding around the engine, the brutal Portuguese fired off the piece by means of a rope which was attached to it, and viewed with savage delight the mangled carcases of the deluded creatures, who had trusted their professions of friendship. They were occasionally visited for refreshments by the English, Portuguese, and Dutch traders, in their voyages to the East Indies, till the establishment of a colony among them by the last mentioned nation, in the year 1650. They made little opposition to the new settlers; and were soon induced, by their passion for brandy and tobacco, first to sell their country and cattle, and next to become themselves the servants of the purchasers, for the purpose of guarding those flocks and herds, which had so recently been their own property. These wretched people, duped out of their possessions and their liberty, have entailed upon themselves and their offspring a state of subjection, which is comparatively worse than slavery; inasmuch as, in consequence of their not being transferable property, their immediate value is diminished, and their treatment less tempered by the self-interest of their oppressors. In the remoter parts of the colony, especially, they are subjected to cruelties, which have not been surpassed in the worst of the West India islands. Instant death is not unfrequently the consequence of that brutal rage to which they are exposed. To fire small shot into their legs or thighs is no unusual punishment. One of the gentler chastisements which they endure is, to be lashed or rather bruised with thongs, cut from the hide of the sea-cow or rhinoceros, which are nearly as hard and heavy as lead. With these horrid instruments they are flogged at leisure, not by a number of blows, but by a period of torture; and the savage master makes it one of his favourite recreations to regulate the time of their suffering, by smoking as many pipes of tobacco as he deems proportionate to the offence.* These boors or Dutch farmers are authorised by an old law of the colony to claim as their property all the children of the Hottentots in their service, to whom they may have given in their infancy a morsel of meat; and, though the same regulation directs their emancipation at the age of twenty-five, this is a privilege which they are generally too ignorant to claim, or too feeble to enforce. At most, the poor wretches, after spending the prime of their strength in an unprofitable servitude, are turned adrift at last, with no other earthly property except the sheep skin upon their back. Those who are apparently free, and engage themselves from year to year, are not much better provided for. If they have families when they enter the service, their children are encouraged to run about the farm house, where they receive their morsel of food; and upon this ground, are often claimed as the property of the farmer, when their parents are desirous to remove, or perhaps forcibly turned away. Those who are unmarried, as well as free, are doubtless the least wretched; but even their personal service is easily converted into the hardest bondage. Their paltry wages are stopped upon every frivolous pretext; and should any of the cattle entrusted to their care be missing, they must prolong their service, without pay, till they have earned the value of what was lost. Or, should no damage of this nature be imputable to their negligence during the year, they may still have nothing to receive at the end of it, in consequence of a bill for brandy or tobacco, brought against them, to the full amount of their wages. In such circumstances, they have little inducement to en-

* Among many instances of the cruel treatment to which the helpless Hottentots are daily exposed, the following are recorded by Mr Barrow as peculiarly striking: "We had scarcely parted from these people, when, stopping at a house to feed our horses, we by accident observed a young Hottentot woman, with a child in her arms, lying stretched on the ground in a most deplorable condition. She had been cut from head to foot with one of those infernal whips, made from the hide of a rhinoceros or sea-cow, known by the name of Sambocs, in such a barbarous and unmerciful manner, that there was scarcely a spot on her whole body free from stripes; nor had the sides of the little infant, in clinging to its mother, escaped the strokes of the brutal monster." "The only crime alleged against her was the attempt to follow her husband, who was among the number of those of his countrymen that had determined to throw themselves upon the protection of the English." "The next house we halted at upon the road presented us with a still more horrid instance of brutality. We observed a fine Hottentot boy, about eight years of age, sitting at the corner of the house, with a pair of iron rings clenched upon his legs, of the weight of ten or twelve pounds; and they had remained in one situation for such a length of time, that they appeared to be sunk into the leg, the muscle being tumified both above and below the rings. The poor creature was so benumbed and oppressed with the weight, that, being unable to walk with ease, he crawled on the ground. It appeared, upon inquiry, that they had been rivetted to his legs more than ten months ago." "The fellow shrunk from the inquiries of the indignant general; he had nothing to allege against him, but that he had always been a worthless boy; he had lost him so many sheep, he had slept when he ought to watch the cattle, and such like frivolous charges of a negative kind," &c.

gage in marriage; and when they do enter into that state, they are frequently without any offspring, or at most have seldom more than two or three children. Their extreme poverty, scanty food, and constant dejection of mind, appear to exhaust the prolific powers of nature; and their practice of marrying only among their own limited horde is considered as an additional hindrance to their increase. Multitudes of the more independent tribes, also, have perished by the hostilities of the Caffres, and the ferocity of the wild beasts, as they receded towards the interior of the country.* From all these causes combined, the Hottentot race is rapidly diminishing, and in all probability will soon become wholly extinct. Many of their tribes, mentioned by the earlier travellers, have entirely disappeared; and, at the commencement of the present century, not a kraal or village was to be found about Camtoos river, where, only 20 years before, hundreds of the natives were met in groupes. In the whole extensive district of Graaff Reynet, there is not a single horde of independent Hottentots; and the whole number within the limits of the colony does not amount to fifteen thousand. Much has been done since the colony came last into the possession of Great Britain, especially by the measures of Sir John Craddock, and the progress of missionary settlements, to protect and preserve this oppressed race of beings; but, though a little remnant may thus be collected, the nation, it is to be feared, is almost already extinguished. A mixed breed, called Bastaards, produced from Hottentot women and European fathers, or the slaves from other countries, are likely to supplant the original inhabitants. They are already a numerous race in the colony; and are a tall, stout, and active people.

The ancient manners and primitive character of the Hottentots are acknowledged to have been greatly changed during their connection with the colonists of the Cape; and it may not, therefore, be a sufficient proof of the inaccuracy of the former accounts, that they do not correspond with the observations of recent travellers. At the same time, so many of the strange and ridiculous stories, published on the subject, have been discovered to have originated in ignorance, credulity, or deliberate fiction, that little dependence can be placed upon any of the narratives which preceded the enlightened enquiries and personal observations of Barrow, Truter, Somerville, &c. The Hottentots of one district differ considerably, in the present day, from those of another, in consequence of their living together in particular clans, and mixing with different kinds of people; but from observing their manners in those parts of the colony which have been most recently occupied, some approach may be made to a sketch of their original native character. The personal appearance of the Hottentots, though by no means prepossessing, is not nearly so revolting as has been often represented. Their countenance, indeed, is in general extremely ugly. Prominent cheek bones, and a narrow pointed chin, give to the face the form nearly of a triangle. The nose, in most of them, is remarkably flat, and rather broad between the eyes. The eyes are of a deep chestnut colour, long and narrow in their shape, and the eye-lids, at the extremity next the nose, instead of forming an angle, as in Europeans, are rounded into each other, exactly like those of the Chinese. Their mouth is of the ordinary size, the lips thinner than those of the Negroes and Caffres, and the teeth beautifully white. The hair of their heads is of a singular nature, growing in small tufts at certain distances from each other, and extremely hard and frizzled, resembling, when short, the bristles of a shoe-brush twisted into round lumps about the size of a large pea, and, when suffered to grow, hanging about the neck in strong tassels like fringe. The colour of their skin is that of a yellowish brown or faded leaf. Their figure, especially when young, is not devoid of symmetry. They are erect, clean-limbed, and well proportioned; their hands, feet, and all their joints, remarkably small; and the muscular parts of their body delicately formed, so as to indicate rather feminine inactivity, than masculine exertion. Some of the women, in their youth, and before child-bearing, are described as models of perfection in the human figure; every joint and limb being well shaped and turned; their breasts round, firm, and distant; their hands and feet small and delicately formed; and their gait not altogether deficient in grace. But, at an early period of life, and immediately after the birth of their first child, their beauty vanishes; their breasts begin to grow loose and flaccid, and at length become enormously distended; their bellies protrude, and their posteriors acquire immense masses of fat, so as to give to the spine an appearance of extraordinary curvature inwards. It is very rarely that a cripple or deformed person is seen among the Hottentots of either sex; and they are not subject to any particular diseases. Their health is generally sound; and their life, if not cut short by accident or violence, is usually terminated by a gradual decay. But they are not so long-lived as the natives of most other countries, which resemble their own in point of temperature; and it is a rare occurrence when any of them attains the age of sixty years.

The dress of a Hottentot is very simple; and in summer is so trifling, as not to deserve the name of covering. It consists of a belt cut from the hide of some animal, and fastened round their body. From this strap is suspended in front a kind of case or bag made of the skin of a jackal with the hair outwards; and which is intended to receive those parts, which modesty requires to be concealed. From the back part of the girdle hangs a piece of stiff dried skin, shaped like an isosceles triangle, with the point uppermost, and reaching nearly to the middle of the thigh. Sometimes two of these pieces are used; but these straps, especially when the wearer is walking or running, entirely fail to answer the purpose of concealment; and are conjectured to have been originally intended rather as a kind of artificial tail, to fan the body by its motion, and to lash away troublesome insects. In the winter months, they wear cloaks made of skins, generally of sheep, which are worn, as the weather requires, either with the wool inwards or outwards; and which serve as blankets and bedding through the night, as well as for a garment through the day. The women suspend from their belt in front a kind of apron made of skin, but cut into threads, which hang in a bunch between the thighs, and reach about half way to the knee; or they wear a smaller apron about seven or eight inches wide, not divided into threads, but ornamented with shells, metal buttons, and any of their most showy trinkets. In place of the tail worn by the men, they have a sheep's skin, which entirely covers the posterior part of the body from the waist to the calf of the leg, and makes a rattling noise as they walk. Instead of the thongs of dried skin, which formerly covered their legs from the ankle to the knee, as a protection against the bite of poisonous animals, they have substituted strings of glass beads and shells. These they wear also in great abundance around their necks and arms. Some of them have skin caps on their heads, differently shaped and adorned, according to the fancy of the wearer; and they have sheep skin cloaks resembling those of the men. When these cloaks are laid aside, which is commonly the case in the warmer weather, both sexes may be said to be nearly naked; but their bo-

* One woman mentioned to Mr Campbell that she had born ten children, who had all been destroyed by lions, tygers, and serpents.

dies are in some measure protected from the influence of the sun or air by the unctuous matter which they rub over the whole of their persons; and which, however filthy in itself, is a very natural and useful resource in hot climates, to prevent the skin from being parched and shrivelled by the scorching heat. It is supposed that a similar practice in parallel latitudes would prevent that disgusting and dreadful disorder, the elephantiasis, which is so common in many hot countries, but which, with most other cutaneous diseases, is wholly unknown among the Hottentots.* This greasy covering, applied from time to time, and accumulating perhaps for a whole year, sometimes softening in the sun, or melting before a fire, catches up the dust and dirt, and gradually covers the surface of the body with a thick black coating, which entirely conceals the natural colour of the skin. This native hue is perceivable only on the face and hands, which are kept rather cleaner than the other parts of the body, not by washing them in water, which would have no effect upon the grease, but by rubbing them with the dung of cattle.

The Hottentots are often reduced, especially in their native state, to live upon gums, roots, and the larvæ of insects, and at times make a kind of bread from the pith of the palm tree; but their universal delight is to indulge in animal food. They are remarkably patient of hunger, and are able to fast a very long time; but are equally voracious when supplied with their favourite diet, and are described as the greatest gluttons on the face of the earth. Their manner of eating sufficiently indicates the voracity of their appetite. They cut a large steak from the carcase upon which they feed, and, passing the knife in a spiral manner from one edge till they reach the middle, form it into a string of flesh two or three yards in length. This they coil round and lay upon the hot ashes; and, when the meat is just warmed through, they grasp it in both hands, and, applying one end of the string to their mouth, proceed without intermission, and with considerable expedition, to the other extremity. They do not think of cleaning the meat from the ashes of the green wood, which serve as a substitute for salt; and they wipe their hands, when done with eating, merely by rubbing them on different parts of their body. They are passionately fond of ardent spirits and tobacco; and, to make as much as possible of the flavour of the latter luxury, they purposely employ a very short pipe.

The Hottentot families, who engage in the service of the colonists, live in small straw huts around the farm house. In a more independent state, they horde together in kraals or villages, where the houses are commonly ranged in a circle, with the doors opening towards the centre, and thus forming a kind of court, into which their cattle are collected at night, to preserve them from the beasts of prey. The huts are generally circular in their form, resembling a beehive, covering a space about twenty feet in diameter, but commonly so low in the roof, that, even in the centre, it is rarely possible for a man of middle size to stand upright. The fire place is situated in the middle of the apartment, around which the family sit or sleep in a circle; and the door, which is seldom higher than three feet, is the only aperture for admitting the light, or letting out the smoke. The frame of these arched habitations is composed of slender rods, capable of being bent in the desired form, some parallel with each other, some crossing the rest, and others bound round the whole in a circular direction. Over this lattice work are spread large mats, made of reeds or rushes, which are about six or ten feet long, and sewed together with a kind of thread, or rather catgut, made from the dorsal sinews of different animals. These materials are easily taken down, and removed on the backs of the oxen, when there is occasion to change the place of residence.

These free Hottentots depend for subsistence upon the milk and flesh of their cattle, and the produce of their skill in the chace. They are excellent marksmen with the musket, but still make use occasionally of their ancient weapons, the Hassagai or javelin, and bow with poisoned arrows. The Hassagai is an iron spear about a foot in length, fastened to the end of a tapering shaft about four feet long, which is thrown from the hand by grasping it in the middle, raising it above the head, and delivering it with the fore-finger and thumb. The bow is a plain piece of wood, seldom much more than a yard long, and sometimes tapering to a point at each extremity. It is furnished with a string composed of hemp, or the fibres of animal-tendons twisted into a cord. The arrows are short, and consist of a reed about a foot in length, with a piece of solid polished bone at one end, about five inches long, the top of which is sometimes pointed to serve as the head, but generally cut square, and provided with a small sharp piece of iron in the shape of an equilateral triangle. This is bound tight to the bone with threads, along with a bit of pointed quill, turning to the opposite end of the arrow by way of barb, and intended at once to increase the difficulty of extracting the weapon from the wound, and by tearing the flesh to make the poison mix more readily with the blood. The poison is frequently taken from bulbous roots, or the most venomous serpents; but is also prepared by macerating the leaves or branches of poisonous plants, and thickening the juices, by boiling on the fire or evaporation under the heat of the sun. This preparation, in the consistence of varnish, is laid with a brush over the thread which binds on the tip of the arrow. Whenever an animal is killed with these arrows in hunting, the flesh around the wound is instantly cut away, and the blood squeezed out of the flesh. The quiver is made of a piece of wood hollowed out, frequently of the stem of an aloe, with a lid of skin or leather; and generally contains a dozen arrows, a brush for laying on the poison, and a sand stone to whet the points of the weapons.

The Hottentots may be said to be entirely ignorant of arts and manufactures, except the formation of coarse earthen ware, the sewing of sheep skins for their winter garments, the preparation of poisons, and the making of bows and arrows.

They discover very little taste for music; but a few instruments of sound have been observed among them. One is a kind of guitar with three strings stretched upon a piece of hollow wood, which has a long handle, and is called in their language *gabowie*. Another consists of a piece of sinew or intestine, twisted into a small cord and fastened upon a hollow stick about three feet long, by a piece of quill at one end fixed into the stick, and by a small peg at the other, which is made to turn for the purpose of stretching the string to the degree required. This instrument is called the *gowra*, and is played by applying the mouth to the quill, and producing faint murmuring notes, by giving a vibratory motion to the string. A sort of flute made of the bark of trees is also used among them.

The physical knowledge of the Hottentots is extremely limited. All their astronomy consists in having a name for

* A similar practice prevails among the inhabitants of Tombuctoo, as observed by the American sailor Adams. "It is the universal practice of both sexes," says his Narrative, "to grease themselves all over with butter produced from goats' milk, which makes the skin smooth, and gives it a shining appearance. This is usually renewed every day; and, when neglected, the skin becomes rough, greyish, and extremely ugly."

the sun, another for the moon, and a third for the stars. Their reckoning of time scarcely extends beyond the period of a day, and expresses events past only by saying, that they were before or after some memorable occurrence. They indicate the time of the day when any thing happened, by pointing to the place in the heavens where the sun then was; and the seasons of the year, by the number of moons before or after the time when the roots of the *iris edulis* (once a considerable article of their sustenance) are ready for use. None of those whom Mr Barrow saw in the more distant parts of the colony could reckon beyond the number five, or put two numbers together without the help of their fingers.

The language of the Hottentots is perhaps one of the most extraordinary forms of speech in use among human beings. Its principal peculiarity is, a strong clacking of the tongue, in uttering every monosyllable, and every leading syllable of larger words. This sound is formed by suddenly retracting the tongue from the teeth or palate, according to the signification of the word to be uttered, and in some measure answering the part of inflexions, &c. The sound of the dental clack is said to be exactly the same as that which is sometimes used to express impatience; and that of the palatial stroke is more full and sonorous, not unlike the clucking of a hen to her chickens. These sounds are thrown out at the same moment with the syllable, so that they cannot be said to precede or follow, but rather to accompany it. Though the difficulty of uttering and appropriating these sounds appear to Europeans extreme, yet it is not insurmountable; and most of the Dutch colonists are able to speak the Hottentot language with great fluency. Many vocables in the language seem to have been originally exact imitations of nature, and many of the names of animals, especially, are obviously suggested by their distinguishing cry; such as, *kraak*, a frog; *mnoo*, an ox; *meau*, a cat; *hahæ*, a horse; *hurroo*, the sea; *kaboo*, a gun. This last word particularly is so pronounced as to imitate the report of a musket. The syllable *ka* is thrown out with a strong palatial stroke of the tongue, expressing the stroke of the flint; while the last syllable *boo* is uttered with a full mouth, outstretched lips, and prolonged sound, descriptive of the report. We add a few of the common vocables; and a Hottentot version of the Lord's prayer, as a slight specimen of the language.

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|---|---|---|---|
| *Surrie*, | the sun. | *Hoonooei*, | Lightning. |
| *Kā*, | the moon. | *Qūa*, | Wind. |
| *Kōro*, | the stars. | *Tōōkai*, | Rain. |
| *Kōo*, | the earth. | *Quaina*, | a man. |
| *Kom*, | air, or light. | *Quaisha*, | a woman. |
| *Ei*, | Fire. | *Toona*, | a dog. |
| *Ham*, | Water. | *Haisa*, | To-day. |
| *Hō ōnoo*, | Thunder. | *Quātrie*, | To-morrow. |

NUMERALS.

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|---|---|
| *Qūæ*, | One. |
| *Kăm*, | Two. |
| *Gŏna*, | Three. |
| *Haka*, | Four. |
| *Gose*, | Five. |

*Cita eip - ne nanoop na - sa ons*
Our father - the heaven in - thy name
*anooke - sa koop ha - sa ei i -*
hallowed be - thy kingdom come - thy will be done -
*hoop ei - ne nanoop na koommi - cita*
earth on - the heaven in as - our
*ceeorobe bersp mata - neei - i cita*
daily bread give us - this day - and our
*soorootikoo oobekata - cita soorooti*
debts forgive us - our indebted
*aukoo citee oobeka koommi - i*
men we forgive as - and
*ta oowa keikata - gawe eereta*
not temptation lead in us - but deliver us
*eip ga - o sa ne koop ke - i de*
evil from - for thine the kingdom is - and the
*keip - i de isa - i amo.*
power - and the glory - in eternity.

Few ancient usages are retained among the scattered tribes of the Hottentots; and all traces even of their religion, if they ever had any knowledge or observances on the subject, are now lost. No particular ceremonies are observed either at their marriages or funerals; and they are more like a people who have never been formed into any kind of communities, than the remains of a tribe or nation who had once possessed any laws or customs common to them all. The truest specimens of the unmixed Hottentot people and practices are probably to be found among the Bosjesmans, (see BOSJESMANS;) but, whether that wretched race existed in their present condition before the dispersion of the Hottentots, or in consequence of that event, must remain a subject of mere conjecture. A few detached customs and practices of the Hottentots may be briefly stated. One of the customs still generally prevalent is, to shave the heads of young girls as soon as the first symptoms of maturity appear, to remove all their ornaments, and wash the whole body thoroughly; and to restrict them to a milk diet, and seclude them from the company of men during the continuance of the periodical symptoms. Though they inter their dead without any ceremony, it is a common practice to pile a heap of stones over the grave; and it is firmly believed among them, that some misfortune would soon befal the individual who should pass the place without adding a stone to the heap. This custom is supposed to have originated in a wish to secure the bodies of the deceased from being dug up and devoured by wild beasts. The Hottentots, in drinking from a pool or stream, throw the water in their mouths with their right hand in a very expert and expeditious manner, seldom bringing the hand nearer the mouth than the distance of a foot. They generally wash their poisoned wounds with a mixture of urine and gun-powder, besides frequently using the actual cautery; and, for the most part recover easily, unless wounded severely. They kill their cattle, by thrusting a sharp-pointed instrument into the spinal marrow immediately behind the horns; and the animal being thus instantaneously deprived of life, the throat is cut to let out the blood. Among the Hottentots who reside at the mouth of the Orange river, a superstitious practice prevails, similar to what has been observed among the South Sea islanders, of cutting off the first joint of their little finger, as a remedy for a particular disease, to which they are subject when young.

The most prominent point in the habits and dispositions of the Hottentots is their extreme indolence, which even the urgent calls of hunger are scarcely able to overcome. Provided they are allowed to sleep, they would willingly fast the whole day, rather than undergo the trouble of digging the ground for roots, or procuring food by the chace; and Mr Barrow particularly relates, that in the course of his journies, the Hottentot servants frequently passed the day without a morsel of food, rather than walk half a mile for a sheep. They are habituated from their infancy to a life of sloth; and having obtained what is barely sufficient to support nature, contentedly spend the day as well as night in sleeping under a bush upon their sheep-skin. Even in the service of the Dutch colonists, they are rather confirmed in their laziness, than cured of it; as, in every farm-house there is so great a multitude of servants, that little work falls to the share of each individual. It is not uncommon to see twenty or thirty, where there is not employment for more than four or five; so that one of the domestics, during the space of a whole day, may have only to bring his master's whip from the next apartment; another to fetch his mistress's fire-box and place it under her feet; and a third to supply some of the family, three or four times in the day, with lighted wood, to kindle their tobacco pipes. They are by no means, however, a stupid people. They are uncommonly expert in finding out a passage over a desert uninhabited country. They are remarkably quick-sighted, and can discover the game in the chace at a very great distance. They will follow with the eye the flight even of a bee to an incredible distance, watching its motions, and tracing out its nest. They are able to distinguish the prints of the feet of whatever animal they chance to pursue, if they be at all acquainted with it; and would single out among a thousand foot-marks those of their companions. They learn the Dutch language with great facility; and though seldom employed as domestic servants by the colonists at the Cape, they can be taught to do every kind of work with as much propriety as Europeans. They are a mild, quiet, and rather timid people; but endure pain with extraordinary patience, and when led on by superiors, will encounter danger with sufficient alacrity. They are honest and faithful, and have little of that cunning which savages generally possess; but are ready to divulge the truth, when charged with crimes of which they have been guilty. They seldom quarrel among themselves, or make use of provoking language; but are kind and affectionate to one another, and ready to share the last morsel with their companions. Though extremely phlegmatic, they are not incapable of strong attachments, and are particularly sensible to any act of kindness. These are sensations, however, which they have, unhappily, few opportunities of indulging. In the state of hard bondage and cruel oppression under which they spend their miserable existence, the muscles of their countenance are rarely seen to relax into a smile, but are constantly overspread with the deepest melancholy. It has been sufficiently proved, that under humane treatment they are capable of being rendered active, industrious, and useful members of society. About 500 of them had been embodied by the Dutch in a corps called the Cape Regiment; and, though unsupported, had acted with considerable spirit in opposing the British troops at the capture of the colony in 1795. General Sir James Craig found it expedient to take them into the British service, and to increase their numbers. They became excellent soldiers, orderly, tractable, and faithful, ready on all occasions to obey the commands of their officers with cheerfulness and alacrity. "Never," says the above-mentioned officer, "were people more contented, or more grateful for the treatment they now receive. It is with the opportunity of knowing them well, that I venture to pronounce them an intelligent race of men. All who bear arms exercise well, and understand immediately and perfectly whatever they are taught to perform. Many of them speak English tolerably well. We are told, that so great was their propensity to drunkenness, we should never be able to reduce them to order or discipline; and that the habit of roving was so rooted in their disposition, we must expect the whole corps would desert the moment they had received their clothing. With respect to the first, I do not find they are more given to the vice of drinking than our own people; and as to their pretended propensity to roving, that charge is fully confuted by the circumstance of only one man having left us since I first adopted the measure of assembling them, and he was urged to this step from having accidentally lost his firelock."—"Of all the qualities, it will little be expected I should expatiate upon their cleanliness; and yet it is certain, that at this moment our Hottentot parade would not suffer in a comparison with that of some of our regular regiments. Their clothing may perhaps have suffered more than it ought to have done in the time since it was issued to them, from their ignorance of the means of preserving it; but those articles which are capable of being kept clean by washing, together with their arms and accoutrements, which they have been taught to keep bright, are always in good order. They are now likewise cleanly in their persons; the practice of smearing themselves with grease being entirely left off. I have frequently observed them washing themselves in a rivulet, where they could have in view no other object but cleanliness." These men shewed themselves highly deserving of this favourable testimony, during three years service in the distant district of Graaff Reynet, where they were required, by an unfortunate train of events, to act against their own countrymen and comrades; yet, during all that time, according to the testimony of Mr Barrow, they never shrunk from their duty, and only one man deserted in the whole corps. They became so attached to the British government, that, after the evacuation of the colony, they refused to enter again into the service of the Dutch; and most of them, upon being disbanded, fled into the interior to join their oppressed countrymen.

The labours of Christian missionaries, particularly of the Moravian Brethren, have not been less successful in forming the Hottentot race to live under the influence of religious principle, and to fulfil the duties of civilized society. The progress of their disciples at Bavian's Kloof, so far back as the year 1798, is thus described by Mr Barrow:—"Early in the morning I was awakened by the noise of some of the finest voices I had ever heard; and, on looking out, saw a group of female Hottentots sitting on the ground. It was Sunday; and they had assembled thus early to chaunt the morning hymn. They were all neatly dressed in printed cotton gowns. A sight so very different from what we had hitherto been in the habit of observing, with regard to this unhappy class of beings, could not fail of being grateful; and at the same time, it excited a degree of curiosity as to the nature of the establishment."—"These missionaries have succeeded in bringing together into one society more than six hundred Hottentots, and their numbers are daily increasing. These live in small huts dispersed over the valley, to each of which was assigned a patch of ground for raising vegetables. Those, who had first joined the society, had the choicest situations at the upper end of the valley near the church; and their houses and gardens were very neat and comfortable; numbers of the poor in England not so good, and few better. Those Hottentots, who chose to learn their respective trades, were paid for their labour as soon as they could earn wages. Some hired themselves out by the week, month, or year, to the neighbouring peasantry; others made mats and brooms for sale. Some bred poultry; and others found means to subsist by their cattle, sheep, and horses."—"On Sundays, they all regularly attend the performance of divine service; and it is astonishing how ambitious they are to appear at church neat and clean. Of the three hundred, or thereabouts, that composed the congregation, about half were dressed in coarse printed cottons, and the other half in the ancient sheep skin dresses; and it appeared, on inquiry, that the former were the first who had been brought within the pale of the church; a proof that their circumstances at least had suffered nothing from their change of life."—"The deportment of the Hottentot congregation during divine service was truly devout. The discourse, delivered by one of the fathers, was short, but replete with good sense, pathetic, and well suited to the occasion: tears flowed abundantly from the eyes of those, to whom it was particularly addressed. The females sung in a style that was plaintive and affecting; and their voices were in general sweet and harmonious." This establishment is described by Lichtenstein, little more than six years afterwards, as containing two hundred houses and huts, built in regular streets, and occupied by nearly 1100 Hottentots; several of whom had become very expert in various kinds of iron work, particularly in the manufacture of knives. "The men are clothed in linen jackets and leather small clothes, and wear hats; and the women have woollen petticoats, cotton jackets with long sleeves, and caps. Other missionaries have collected the wilder Hottentots in the more distant parts of the colony; and have succeeded in instructing and civilizing them in various degrees, proportioned to the duration and circumstances of the different establishments. Even the Bosjesman Hottentots have been found, in places beyond the limits of the colony, to be a docile and tractable people, inoffensive in their manners, and extremely grateful to their benefactors. The recovery of the colony by the British has at least secured to these defenceless tribes a protection from cruel oppression, and an encouragement to every benevolent exertion for their benefit, which they never enjoyed under the Dutch government. See Sparrman's *Voyage to the Cape of Good Hope*. Paterson's *Journies into the Country of the Hottentots*. Barrow's *Travels into the Interior of Southern Africa*. Campbell's *Travels in Africa*. Lichtenstein's *Travels in Southern Africa*. (*q*)

HOUNDS. See Dog, Hunting, and Mammalia.

HOU-GANG, or Hoo-Quang. See China.

HOURS. See Chronology.

HOUSSA, or Haoussa, the capital of a kingdom of the same name in Africa, is supposed to be situated two days journey south from the Niger, and about 200 miles south east from Tombuctoo. As it appears to have been unknown to the African geographer Leo, it is suspected to be of modern date; and, as Park could hear nothing of Tokrur or Tekrur, mentioned by Edrissi and Abulfeda as the metropolis of a great central empire of Africa, it is conjectured that Houssa must have superseded that ancient capital as the seat of government. Former accounts represented it as almost equal to London or Cairo in population, and its inhabitants as acquainted with the art of writing, and other civilized attainments. The country along the banks of the Niger, between Houssa and Tombuctoo, was also described as fertile, and well inhabited. All the native travellers, with whom Park conversed, assured him that Houssa was larger and more populous than Tombuctoo; and that the state of trade, police, and government, were nearly the same in both places. The recent Narrative of Adams, the American sailor, enables us to estimate the amount of this comparison, and to form some idea of Houssa, when he tells us, that Tombuctoo, to which it bears so near a resemblance, covers about as much ground as Lisbon with houses irregularly scattered; that it contains no shops for its boasted commerce, but that the imported goods are deposited in the king's palace, till they are disposed of; that this royal residence and warehouse is constructed of mud, and altogether mean in its appearance; and that the principal food of the king and queen consists, like that of the people, of Guinea corn, boiled like burgoo, and eaten with goat's milk, to which, in the case of their majesties, is added the luxury of a little butter. See Park's *Travels* and *Appendix*; Adams' *Narrative*; and Tombuctoo. (*q*)

HOWARD, John, the celebrated philanthropist, was born at Enfield, about the year 1727. His father was originally an upholsterer in Long-lane, Smithfield; but, having acquired a handsome fortune, had retired from business several years before his death. He was a strict Protestant dissenter; and, wishing that his son should be educated in the same principles, placed him under a preceptor at some distance from London, who seems to have been more distinguished by his religious character than literary qualifications. Under the tuition of this person, young Howard continued for the space of seven years, without being thoroughly instructed in any one branch of knowledge; and, though he was afterwards removed to the academy of Mr Eames, he never surmounted the deficiencies of his early education. He was not able to write his native language with grammatical correctness; and, excepting the French, his acquaintance with other languages was very superficial. His father died when he was young, and directed, in his will, that his son should not come to the possession of his property till the twenty-fifth year of his age. In conformity, also, it is supposed, to the wishes of his parent, he was bound apprentice to a wholesale grocer in the city; but he found this employment extremely irksome; and, as soon as he came of age, bought up the remainder of his time, and set out on his travels to France and Italy. Upon his return to England, he lived in the style of other young men of fortune; but had acquired a taste for the arts, and an attachment to the study of nature. The delicacy of his bodily health required him to take lodgings in the country, and to follow a rigorous regimen of diet, which laid the foundation of his future extraordinary abstemiousness. About the 25th year of his age, he married Mrs Sarah Lardeau, as a return of gratitude for her kind attention during his invalid state while he lodged in her house at Stoke-Newington; but she was twice as old as himself, as well as of a sickly habit, and died at the end of three years after their marriage, in the year 1756. After the death of his wife, he set out upon another tour, which he designed to have commenced with a visit to Lisbon, which had been recently overthrown by an earthquake; but the packet, in which he sailed, was taken by a French privateer, and he endured for some time all the hardships of a prisoner of war in France. The sufferings of his countrymen in the same situation made a strong impression on his mind, and first directed his attention to the condition of those unhappy persons who are doomed to inhabit the cells of a prison. Having remained abroad only a few months, he fixed his residence, after his return, on his estate at Cardington, near Bedford; and, in 1758, was united in marriage to the eldest daughter of Edward Leeds, Esq. of Croxton in Cambridgeshire. In this connexion and situation he spent the most tranquil and happy years of his life, occupying his leisure and his wealth in executing plans of beneficence for the more indigent part of mankind. But his domestic felicity was fatally interrupted by the death of his wife in the year 1765, soon after the birth of her only child; and, for many years afterwards, he cherished her memory with the most affectionate sorrow. For some time he was attached to his home, by an anxious attention to the education of his son; but the child was sent to school at an early age, and Mr Howard began to assume a more public character. In 1773 he was nominated High-Sheriff of the county of Bedford; and entered upon his office with a resolution to perform its duties with his accustomed punctuality. In the inspection of the prisons within his jurisdiction, his humanity became deeply engaged by the distresses which he witnessed; and, in the progress of his enquiries, he was led to extend his investigation to all the places of confinement and houses of correction throughout the kingdom. He pursued his object with so much assiduity, that, in the beginning of 1774, he was desired to communicate his information to the House of Commons; and, in consequence of his representations, two bills were brought forward for the relief and health of prisoners. Being desirous, before he should publish his account of English prisons, to suggest remedies, as well as to point out defects, he resolved to examine personally the practice of the continental kingdoms in this branch of police. For this purpose, in 1775, he visited France, Flanders, Holland, and Germany; repeated his visit in 1776, extending his tour to Switzerland; and, during the intervals of these travels, made a journey to Scotland and Ireland, and most of the counties of England. In 1777, he published the information which he had collected with so much risk, toil, and expence, and dedicated his work to the House of Commons. Anxious to diffuse the knowledge of facts so interesting to humanity, and, at the same time, desirous to obviate any suspicion of his wishing to repay his benevolent labours by the profits of bookmaking, he not only presented copies of his work to the principal persons in the kingdom, and his particular friends, but insisted upon fixing the price of the volume at a lower rate than the original expence of publication. In the conclusion of the work, he pledged himself, if a thorough parliamentary enquiry were instituted for the improvement of prisons, to undertake a more extensive journey into foreign countries, for the purpose of obtaining additional information. The House of Commons having zealously entered upon the business of regulating places of confinement, Mr Howard, agreeably to his promise, which he was well inclined to fulfil, began a new tour in 1778. In his progress, he revisited the establishments of a penitentiary kind in Holland; directed his course through Hanover and Berlin to Vienna; went to Italy by way of Venice; proceeded as far south as Naples, returning by the western coast to Switzerland; pursued the course of the Rhine through Germany; and, crossing the Low Countries, returned to England in the beginning of the year 1779. During the spring and summer of the same year, he made another complete tour of England and Wales, besides taking a journey through Scotland and Ireland. In the year 1780, he published the results of this extensive research, as an appendix to his former work; and also a new edition of that publication, in which all this additional matter was incorporated. Still intent upon the farther improvement of his plans, he resolved to explore those countries of Europe which he had not yet visited; and, in 1781, he set out on a tour to Denmark, Sweden, Russia, and Poland, from which he returned about the end of the year. In the year following, he made another complete survey of the prisons in England, and another journey into Scotland and Ireland. In 1783, he examined the prisons of Spain and Portugal, and returned through France, Flanders, and Holland. In the summer of the same year, he again travelled into Scotland and Ireland, and visited many of the English prisons. In 1784, he communicated to the public the fruits of the preceding three years investigations, in the form of another appendix, with a new edition of the main work, comprising all the additions. With the view of acquiring information respecting the means of preventing contagion in general, and the formation of establishments for guarding against pestilential infection, he resolved to visit the principal Lazarettos in Europe, and to extend his researches to those countries which are most subject to the ravages of the plague. Aware of the hazards which he should have to encounter in this most perilous of all his journeys, he would not permit any of his servants to partake of these dangers, but determined to travel without attendants. About the end of the year 1785, he entered upon this tour, taking his way through Holland and Flanders to the south of France. His former visits, however, had so much alarmed the jealousy and excited the displeasure of the government in the last mentioned country, that he was apprehensive of his personal safety; and travelled with the greatest secrecy under the character of an English physician. From Nice, he went to Genoa, Leghorn, and Naples; thence to the islands of Malta and Zante; and next to Smyrna and Constantinople. Determined to obtain, by personal experience, the fullest information of the mode of performing quarantine, he returned to Smyrna, where the plague then was, for the purpose of going to Venice in a vessel with a foul bill of health, which would necessarily subject him to the utmost rigour of the process. In the course of his voyage, the ship in which he was a passenger was attacked by a corsair from Tunis, which was beaten off after a smart skirmish, in which he rendered essential service, by pointing some of the guns. After leaving his quarters in the Lazaretto of Venice, in which his health and spirits suffered considerably, he proceeded, at the close of the year 1786, to Vienna, where he had a private conference with the Emperor Joseph II.; and, returning through Germany and Holland, arrived safe in England, in the beginning of the year 1787. During his absence on this journey, he received the afflicting intelligence of his son having fallen into a state of decided insanity; his only child, of whom he used to speak with all the pride and affection of a parent, and whose hopeless calamity it required all the fortitude of his mind, aided by the consolations of religion, to sustain. At the same time he was informed of a public subscription having taken place among his countrymen, to express their esteem and veneration for his character, by erecting a statue or monument to his honour. This design, instead of tending to console his wounded spirit, only added to his distress; and he instantly exerted himself to prevent its being carried into execution. In corresponding with his friends, he expressed, in the strongest terms, his aversion to the proposed honour; and, in a letter to the subscribers, while he acknowledged his grateful sense of their approbation, he displayed so determined a repugnance to the measure, that the matter was dropped during his life. In 1787 and 1788, he made several visits to the prisons, bridewells, infirmaries, &c. of England, Ireland, and Scotland, and, in 1789, he put to the press an account of his observations in these various journeys, abroad and at home; containing an account of the various Lazarettos in Europe, papers relative to the plague, with additional remarks on prisons and hospitals. After the printing of this work, he remained but a short time at home; and prepared to revisit Russia and Turkey, and to extend his tour to Asia Minor, Egypt, and the coast of Barbary. In this new journey, he is understood to have had no peculiar object in view; and to have been actuated chiefly by a conviction, that, in such researches, he was pursuing the path of his duty; that, in those countries where he had formerly travelled, he might be still farther instrumental in relieving human suffering; and that, in exploring new regions, he might discover farther subjects of observation connected with his main pursuit. He had resolved to undertake this journey also without an attendant; and it was only in consequence of most urgent entreaties, that a faithful servant obtained permission to accompany him. Arriving in Holland, in the beginning of July 1789, he proceeded through the north of Germany, Prussia, Courland, and Livonia, to Petersburgh; thence to Moscow, and finally to the extremity of European Russia, on the shores of the Black Sea, where he fell a lamented victim to one of those infectious diseases, the ravages of which he was exerting every effort to restrain. While residing at Cherson, he was earnestly requested to visit a young lady, about sixteen miles from that place, who had caught a contagious fever; and it was his own opinion, that from her he received the disease. During his illness, which from its commencement he considered as likely to prove fatal, he received a letter from a friend in England, containing favourable accounts of his son. He was greatly affected by the intelligence; and often desired his servant, if ever his son should be restored to reason, to tell him how much he had prayed for his happiness. Except during the fits, with which he was occasionally seized in the course of the distemper, he retained his faculties till within a few hours of his death, which took place on the 20th January 1790. He was buried, according to his own request, at the villa of M. Dauphine, about eight miles from Cherson; where, instead of a sun-dial, which he had desired to be erected over his grave without any inscription,* a rude pyramid surrounded by posts and chains, was raised by the inhabitants of the neighbourhood.

Mr Howard, though frequently requested, would never consent to sit for his picture; and the various portraits, which have been given of him, are said by his intimate friends to be totally unlike. The nearest resemblance, is said to be a head sketched by an artist in London, and copied for Dr Aikin's *View of his Character;* which, though considered as somewhat of a caricature, is said to have exactly the expression of his countenance, when in a very serious and attentive mood. His eye was lively and penetrating, and his features strong and prominent; his gait quick, and his gestures animated. In his youth, his constitution was delicate, and his habit supposed to be consumptive; but he afterwards attained (probably in consequence of his abstemiousness in diet and application to exercise) a power of enduring, without inconvenience, the greatest corporeal privations and fatigues. The strict regimen in point of food, which he had originally adopted from a regard to health, he afterwards continued from choice. He made no use of animal food, or of fermented and spirituous drinks. Water and the plainest vegetables sufficed for his ordinary diet, and milk, tea, butter and fruit, were his luxuries. He was sparing in the quantity of his food, and indifferent as to the stated times of taking his meals. He was equally tolerant of heat, cold, and all the vicissitudes of climate; and could without difficulty dispense with the ordinary seasons and proportions of sleep. When he travelled in England or Ireland, it was generally on horseback, and he rode regularly about forty English miles a day. He was never at a loss for an inn; but, in Ireland or the Highlands of Scotland, could accommodate himself with a little milk at any of the poor cabins in his way. When he came to the town where he was to sleep, he bespoke a supper like other travellers, but made his servant remove it, while he was preparing his bread and milk. When he travelled on the continent, he usually went post in his own chaise, in which he slept as occasion required; and has been known to travel twenty days and twenty nights without going to bed. He used to carry with him a small tea-kettle, some cups, a little pot of sweet-meats, and a few loaves. At the post-house he would get some water boiled, send out for milk, and make his repast, while his servant went to the inn. He was remarkably attentive to the perfect cleanliness of his whole person; and water was always an indispensable necessary for his ablutions. His peculiar habits of life, and his exclusive attention to a few important objects, made him appear more averse to society than he really was. He assiduously shunned all engagements, which would have involved him in the irregularities of general intercourse; but he received his select friends with the truest hospitality, and was often extremely communicative in conversation, enlivening a small circle with the most entertaining relations of his travels and adventures. He was never negligent of the received forms of polite life; and, however much he might be charged with singularities, no one could refuse his title to the character of a gentleman. He was distinguished especially by his respectful attention to the female sex; and nothing afforded him so much pleasure as the conversation of women of good education and cultivated manners. His own voice and demeanour were so gentle as to be almost denominated feminine; and furnished a striking contrast to the energy of his mind and the extent of his exertions. His language and manners were invariably pure and delicate; and it must have been no small triumph of duty over inclination, which brought him to submit, in the prosecution of his benevolent designs, to such frequent communications with the most abandoned of mankind. Yet the nature of his errand appears to have inspired the most profligate with respect; and he has himself recorded, that he never met with a single insult from the prisoners, in any of the jails which he visited. He possessed an elegant taste for neatness in his house and furniture; and employed much of his leisure time in the cultivation of useful and ornamental plants. In the course of his various travels, he brought home many curious vegetables; and his garden became an object of curiosity, both for the elegant manner in which it was planned, and for the excellent productions which it contained. He was elected a Fellow of the Royal Society in 1756; and contributed a few short papers which have been published in its Transactions.† His philosophical researches were chiefly directed to meteorological observations, and he seldom travelled without some instrument for that purpose. He applied himself, likewise, with considerable assiduity, to the prosecution of experiments on the effects of the union of the primary colours in different proportions. In his intellectual character, he discovered less of the faculty of extensive comprehension than of laborious accuracy. By his talent of minute examination and detail, he was peculiarly qualified for the patient investigations in which he engaged; and in his modest estimates of his own abilities, he was used to say of himself, "I am the plodder, who goes about to collect materials for men of genius to make use of." His liberality with respect to pecuniary concerns, was early and uniformly displayed; and he appears never to have considered money in any other light than as an instrument of procuring happiness to himself and others. Contented with the competence which he inherited, he never thought of increasing it; and made it a rule with himself to lay up no part of his annual income, but to expend in some useful or benevolent scheme the surplus of every year. Moderate in all his desires, and untainted by the lust of growing rich, he was elevated above every thing mean and sordid. He expended much in charities, and displayed in all his transactions

* He had a strong dislike of monumental honours, and had once given directions before he set out on a journey, that in case of his death his funeral expences should not exceed ten pounds; that his tomb should be a plain slip of marble placed under that of his wife in Cardington church, with this inscription, "John Howard died ——, aged ——. My hope is in Christ."

† See the *Phil. Trans.* vols. liv. lvii. lxi.

a spirit of the utmost honour and generosity. He imbibed from his earliest years a devout principle of religion, which continued steady and uniform through every period of his life. The body of Christians, to whom he particularly attached himself, were the Baptists; and the system of belief, to which he adhered, was what has generally been called moderate Calvinism. But he was always less solicitous about modes and opinions, than the internal spirit of piety and sincerity; and though always warmly attached to whatever interests he espoused, he possessed that true spirit of catholicism, which led him to honour virtue and religion wherever he found them. It was his constant practice to join in the service of the established church, when he had not the opportunity of attending a dissenting place of worship; and he often dwells in his works, with great complacency, on the pure zeal and genuine Christian charity, which he frequently discovered among the Roman Catholic clergy. But the peculiar feature of his character certainly consists in that decisive energy, and unshaken perseverance, with which he prosecuted the great work of benevolence, to which he seemed to have devoted his life. He was distinguished by decision and dispatch in all his proceedings; and this was rather the predominant habit of his mind, than the occasional result of any excited feeling. "At no time of his life," says his friend and biographer Dr Aikin, "was he without some object of warm pursuit; and, in every thing he pursued, he was indefatigable in aiming at perfection. Give him a hint of any thing he had left short, or any new acquisition to be made; and, while you might suppose he was deliberating about it, you were surprised with finding it *was done*." Nor was it during a short period of ardour, that his exertions were thus awakened. He had the still rarer quality of being able, for any length of time, to bend all the powers and faculties of his mind to one point, unseduced by every allurement, which curiosity or any other affection might throw in his way, and unsusceptible of that satiety and disgust, which are so apt to steal upon a protracted pursuit."—"Impressed with the idea of the importance of his designs, and the uncertainty of human life, he was impatient to get as much done as possible within the allotted limits. And in this disposition consisted that enthusiasm, by which the public supposed him actuated; for, otherwise, his cool and steady temper gave no idea of the character usually distinguished by that appellation. He followed his plans, indeed, with wonderful vigour and constancy, but by no means with that heat and eagerness, that inflamed and exalted imagination, which denote the enthusiast." Neither was he moved, as some supposed, by mere sternness of principle, or rigidity of habit, or insensibility of feeling. "I have equally," says the last quoted author, "seen the tear of sensibility start into his eyes on recalling some of the distressful scenes to which he had been witness, and the spirit of indignation flash from them, on relating instances of baseness and oppression. Still, however, his constancy of mind and self-collection never deserted him: He was never agitated, never off his guard." His coolness and intrepidity proceeded both from nature and principle; and when marching in the path of duty, he was fearless of consequences. This resolute temper neither originated in any idea of his being moved by an irresistible impulse, or a persuasion of his being secured from the natural consequences of the dangers which he encountered; but from a steady sense of religious obligation and pious confidence, which rendered him superior to mere worldly considerations. His own testimony sufficiently expresses the sentiments by which he was actuated. "My medical acquaintance," he says in a letter during his last journey, "give me but little hope of escaping the plague in Turkey. I do not look back, but would readily endure any hardships, and encounter any dangers, to be an honour to my Christian profession." So heroic a philanthrophist, (though not devoid of some singularities and foibles, which have sometimes drawn the sneer of contempt from trivial and selfish minds, unworthy and incapable to pronounce upon a character so far above their sphere of judgment,) could not fail to attract the admiration of every friend of humanity. The sublimest strains of poetry and eloquence have been frequently devoted to the celebration of his exertions; and his name is become indissolubly associated with every idea of pure and elevated benevolence. The following tribute to his fame, which burst, in all the enthusiasm of genius, from the lips of Mr Burke, though probably familiar to the reader, can bear to be reperused, and may suitably close our feeble sketch of this extraordinary character.* "I cannot name this gentleman without remarking, that his labours and writings have done much to open the eyes and hearts of mankind. He has visited all Europe,—not to survey the sumptuousness of palaces, or the stateliness of temples; not to make accurate measurements of the remains of ancient grandeur, nor to form a scale of the curiosity of modern art; nor to collect medals, or collate manuscripts;—but to dive into the depths of dungeons; to plunge into the infection of hospitals; to survey the mansions of sorrow and pain; to take the gauge and dimensions of misery, depression, and contempt; to remember the forgotten, to attend to the neglected, to visit the forsaken, to compare and collate the distresses of all men in all countries. His plan is original: it is as full of genius as it is of humanity. It was a voyage of discovery; a circumnavigation of charity." See *various lives and anecdotes of Howard;* and particularly Dr Aikin's *View of his Life and Character.* (*q*)

HOWDEN, or HOVEDEN, a town of England, in the east riding of Yorkshire, is situated upon an inlet of the Ouse, named Howden Dike, which may be considered as the harbour of the town. Howden consists principally of two considerable streets, extending in the direction of north-east and south-west, intersected by three or four lesser ones. The town has of late years undergone very considerable improvements; and, though the houses are ancient, yet they are neatly built and commodious. The principal public buildings are, the moot-hall, a large edifice in the market, where the courts, &c. are held; a work-house, built by subscription in 1791, which contains from 20 to 30 paupers, who are maintained at an annual expence of 300*l.*; and the old Gothic church. This church is a large building in the form of a cross, and, excepting the chancel, which is of more recent date, it appears to have been built during the first period of the pointed arch style. The tower, which is quadrangular and well proportioned, is 135 feet high, and is said to have been built in 1390, by Walter Skirlaw, Bishop of Durham, as a place of refuge from the inundations of the Ouse and the Derwent, which were formerly very frequent. The chapter-house, which is now unfortunately in ruins, is reckoned a most beautiful specimen of the pointed style. The chancel, particularly the east end of it, is greatly admired. A peal of eight bells was cast for this church in 1775. The ruins of the palace of the bishops of Durham are situated almost close to the church-yard, and are now converted into a farm-house. One of the greatest horse fairs in the kingdom is held here on the 25th of September, and continues till the 3d of October. Besides the church and its two chapels of ease, there is an Independent and Methodist meeting-house.

* See also Darwin's *Botanic Garden;* Cowper's *Poem on Charity;* Hayley's *Ode to Howard;* and Foster's *Essay on Decision of Character.*

The celebrated historian Roger de Hoveden, who was monk of the abbey, and chaplain to Henry II. was born here.

The township of Howden contained in 1811,

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|---|---|
| Inhabited houses | 314 |
| Families | 409 |
| Do. employed in trade and manufactures | 230 |
| Total population | 1812 |

See Savage's *History of Howden Church;* Hutchinson's *Durham;* and the *Beauties of England and Wales*, vol. xvi. p. 562.

HOWITZERS. See ORDNANCE.

HOY. See ORKNEY ISLES.

HUAHEINE. See SOCIETY ISLANDS.

HUDDERSFIELD, or HUTHERSFIELD, a town of England, in the west riding of Yorkshire, is situated on the river Colne, and on the Huddersfield canal. This town is chiefly celebrated for its woollen manufactures, which consist of narrow and broad cloths, serges, kerseymeres, frize, &c. The buyers and sellers of these goods formerly met in an open square; but in the year 1765, Sir John Ramsden, who possesses all the land which the town covers, and also a great many of the houses, built a commodious cloth-hall. It is a circular building of two stories, and is divided by a diametrical range into two semicircular courts, into which all the windows open. It is subdivided into ranges like streets; and the cloths are laid close together upon their edge on benches or stalls. Over the entrance, is a bell placed in a handsome cupola. The Huddersfield canal (see INLAND *Navigation*) extends 8 miles to the river Calder. Ruins, supposed to be the ancient city of *Cambodunum*, are to be seen on the castle hill, about two miles south of the town, and west of Almonsbury; but Mr Watson thinks they are of Saxon origin. The Roman road, however, passed near Almonsbury. There are several medicinal springs in the neighbourhood.

In 1811, the township of Huddersfield contained,

| | |
|---|---|
| Inhabited houses | 1871 |
| Families | 1881 |
| Do. employed in trade and manufactures | 1842 |
| Males | 4824 |
| Females | 4847 |
| Total population | 9671 |

See the *Beauties of England and Wales*, vol. xvi. p. 767.

HUDSON'S BAY, lying between 55° and 65° of North Latitude, is about 250 leagues in length, and 200 at its greatest breadth. It is 140 fathoms deep in the middle, and is navigable during four months in summer, but is filled, all the rest of the year, with shoals of ice. Numerous rocks, sand-banks, and small islands, are dispersed through it, of which may be mentioned; Southampton island, in 64° north latitude, stretching about 100 leagues from north to south, but of very inconsiderable breadth; Marble island, in 62° north latitude, about 6 leagues long and two broad, composed of white marble, variegated with green, blue, and black patches; Carleton isle, in the south-east corner of the bay, covered with trees, moss, and shrubs. The entrance of the bay is a strait, of dangerous navigation, more than 200 leagues in length, and in some places of considerable breadth. It stretches from south-east to north-west, in 62½° north latitude, bounded on the north by the isle of Good Fortune, and on the south by Labradore. Its eastern extremity is formed by Cape Elizabeth on the north, and Cape Chudley on the south, between which is situated Resolution island, about 15 leagues in length, and a little westward Savage and Grass islands, almost uninhabited. In the north-west extremity, between Point Anne on the north, and cape Walsingham on the south, are several small islands, named Salisbury, Nottingham, Mill Diggs, and Mansfield. The principal bays of this inland sea are, James's Bay in the south-east corner, containing many islets; Button's Bay on the western coast; Chesterfield Inlet on the north-west coast, stretching far inland, and terminating in a large fresh water lake; Roe's Welcome, a deep inlet of the sea on the north coast; and Repulse Bay, still farther north. The most remarkable rivers which flow into it are, Great Whale river, East Main or Slude; Rupert's, which has its origin in lake Mistassins; Abbitibbe, flowing from a lake of the same name; Moose, and Albany, which all empty their streams into James's Bay; the Severn, which is supposed to proceed from lake Winipig; Nelson or Bourbon river, from a lake of the same name; and Missin-ni-pi,* or Churchhill river, which loses itself in the bottom of Button's Bay. The north coast of Hudson's Bay is yet imperfectly explored. The country on the east is part of Labradore, called East Main. The tract which stretches southwards below Button's Bay is called New South Wales, bounded on the south and east by Canada. The regions to the north-west are in like manner called New North Wales, and very little known; and on the west, is a vast tract of country, extending across the American continent to the Pacific Ocean, separated from the territories of Canada by a mountainous ridge in 49° north latitude, which covers the sources of the rivers flowing north and south.

Hudson's Bay was discovered in 1610 by Henry Hudson, who had been sent out, by the English Russia Company, in quest of a north-west passage round the American continent; but his crew having mutinied, left him, with his son and other seven persons, to perish in those seas, which now bear his name. It was afterwards more thoroughly explored by successive navigators employed by the same enterprising Company, particularly by Button in 1612; by Lucas Fox, and Thomas James, in 1631, the former equipped by government, and the latter by a company of Bristol merchants; and by Zacharias Gillam, in 1668, who was sent out by Charles II. at the solicitation of Prince Rupert, and was assisted by two French merchants of Canada, named de Grosseliers, who had previously made a voyage from Quebec to the scene of the present expedition. Gillam passed the winter in Rupert's river, where he built the first stone fort erected in the country, which he named Fort Charles, and provided it with a sufficient garrison. Before his return, the king had granted to Prince Rupert, and divers lords, knights, and merchants, associated with him, a charter, dated May 2d, 1669, in which he styled them "The Governor and Company of Adventurers trading from England to Hudson's Bay;" and, in consideration of their having, at their own costs and charges, 'undertaken an expedition to Hudson's Bay, in the north-west parts of America, for the discovery of a new passage into the South Sea, and for the finding of some trade for furs, minerals, and other considerable commodities, and of their having already made, by such their undertakings, such discoveries as did encourage them to proceed farther in pursuance of the said design; by means whereof, there might probably arise great advantages to the king and his kingdom,' absolutely ceded to the said undertakers, the whole trade and commerce of those seas, &c. in whatsoever latitude they might be, which are situated within the entrance of Hudson's Straits, together with all the countries upon the coasts

* A word signifying "Great Waters."

and confines of the said seas, straits, &c. so that they alone should have the right of trading thither; and whosoever should infringe this right, and be found selling or buying within the said boundaries, should be arrested, and all their merchandize be confiscated, so that one half should belong to the king, and the other half to the Hudson's Bay Company." Of this extensive grant the Company have enjoyed uninterrupted possession from the year 1669 to the present day, except during the space of 17 years, from 1697 to 1714, when the settlement was occupied by the French; but the charter, instead of promoting the progress of discoveries, is understood to have produced the opposite effect. The Company have been charged with having rather endeavoured to conceal, as much as possible, the situation of the coasts and seas connected with their territories; and even to influence those who had any knowledge of these quarters, to withhold it from the world. The few feeble attempts which they did make, to save appearances, between 1720 and 1730, rather excited the displeasure than satisfied the expectations of the public; and, by the exertions of Mr Dobbs, Capt. Middleton was sent out by government in 1741, and Capt. Moor in 1746, the former of whom discovered Repulse Bay, and the latter explored Wager's Strait and Chesterfield Inlet, so as to ascertain with sufficient certainty, that no passage existed in that direction.*

The Company's settlements around the whole extent of Hudson's Bay are only four, viz. Prince of Wales, or Churchhill Fort, the most northern of the factories, situated at the mouth of Churchhill river, in 59° N. Lat.; York Fort, formerly called Bourbon by the French, a square building, flanked with bastions, standing on an island between two branches of Nelson's river, in 57½° N. Lat.; Albany Fort, called by the French St Anne, or the river Albany, in 52° 18′ N. Lat.; and Moose Fort, or Monsipi, or St Louis, at the mouth of a small river on the south border of James's Bay, in 51° 28′ N. Lat. Besides these, are several smaller establishments, particularly Severn House, dependent on York Fort, in 56° 12′ N. Lat. and East-main, or Prince Rupert's, in 53° 24′, connected with Moose Fort.

The climate around the Bay is extremely severe, especially at Churchhill Fort. From the middle of October to the middle of May, the country is buried under frost and snow. In the year 1775, one of the severest seasons remembered by the oldest residents, the snow at the latter end of May lay level with the wall of the west curtain of the fort; and the ice in the river and bay did not break up till the end of June. Even at York Fort, though two degrees farther south, Fahrenheit's thermometer has frequently stood at 50° below zero in the month of January; and brandy, or strong brine, exposed to the air for a few hours, will freeze to solid ice. In the cellars, eight or ten feet deep, and below the guard rooms, where a daily and almost perpetual fire is kept up, London porter has been so frozen, that only a few gallons could be got out of a whole hogshead; and the remainder, converted to ice, was found, upon being thawed, to have no strength remaining. The lakes and rivers, which are not above 10 or 12 feet deep, are frozen to the ground; and the springs are uniformly bound by the frost to the greatest depth that has been dug. The most piercing cold is felt at sun-rising; and is particularly intolerable during the prevalence of the north wind. The air is frequently filled with particles of ice, sharp and angular, and sufficiently perceptible to the eye, which, in blowing weather, occasion a most painful sensation of cold; and, if driven upon the face or hands, raise the skin in little, hard, white blisters, which, if not immediately rubbed, or warmed, are apt to break out into hot watery issues. The utmost precautions against the effects of the cold are necessarily employed by the European residents. The windows of the factories are very small, and provided with thick wooden shutters, which are closely shut 18 hours of the day in winter. As soon as the wood in their large fires is burnt down to a coal, the tops of the chimnies are stopped with an iron cover to keep the heat within the house; and, three or four times a day, red hot iron shot of 24 pounds are suspended in the windows of the apartments. Yet all this will not preserve the beer, wine, and ink, from freezing; and after the fires go out, the insides of the walls and bed-places are found covered with ice two or three inches thick, which is every morning cut away with a hatchet. For a winter dress, they use three pair of socks of coarse blanketing or Duffield for the feet, with a pair of deer-skin shoes over them; two pair of thick English stockings, and a pair of cloth stockings over them; breeches lined with flannel; two or three English jackets, and a fur or leather gown; a large beaver cap, double, to come over the face and shoulders, and a cloth of blanketing under the chin; yarn gloves, and a large pair of beaver mittens, hanging down from the shoulder, ready to receive the hands as high as the elbows. Yet, with all this covering, they are frequently severely frost-bitten, when they stir abroad during the prevalence of the northerly winds; and many of the natives even fall victims to the severity of the climate. Watery vapours, ascending from the open sea-water, and condensed by the cold, occasion thick fogs, which are carried to a considerable distance along the coast, and which obscure the sun completely for several weeks together. But, during the intense cold of winter, the atmosphere is commonly remarkably clear and serene; and the stars shine during the night with extraordinary lustre. The aurora borealis particularly is seen almost every night during winter, darting with inconceivable velocity over the whole hemisphere, exhibiting the greatest variety of colours, and often completely eclipsing the stars and planets by its brightness. Parhelia and paraselenæ, or mock suns and moons, as they are commonly called, appear very frequently during the colder months; and, at the same time, coronæ of different diameters and various colours are seen around the sun for several days together, from his rising to his setting.† The frost is never out of the ground; and even in summer, when the heat is oppressive, and the thermometer frequently at 90 degrees of Fahrenheit, the earth is thawed only to the depth of three or four feet below the surface. The climate, nevertheless, is extremely salubrious throughout the whole year; and Europeans, with the exception of accidental injuries from exposure to the cold, enjoy in general an excellent state of health in the country.

On the eastern coast of Hudson's Bay, the soil is completely barren; and about Lat. 60° vegetation entirely ceases. The surface of the country is extremely rugged, covered with enormous masses of stone; and in many places are seen the most frightful mountains of an astonishing height. Its barren vallies are watered by a chain of lakes, which are supposed to be formed merely by rain and snow, and of which the water is so cold, as to be pro-

* The recent history of the Hudson's Bay Company, particularly as connected with its disputes with the North-west Company, will be found in Lord Selkirk's Pamphlet, entitled *A Sketch of the British Fur Trade in North America, with Observations relative to the North-west Company of Montreal.* London, 1816.

† See our article GREENLAND, and HALO.

ductive only of a few small trout. A little moss, or a blighted shrub, may be seen here and there on the mountains, and a few stunted trees in the lower grounds. The soil about Churchhill Fort is extremely rocky and barren, and bare of vegetable productions. There are no woods within seven miles of the shore; and those which are found at that distance consist only of a few stunted junipers, pines, and poplars, scarcely capable of affording a sufficiency of winter's fuel to the Factory. Upon advancing northward from that settlement, the earth becomes gradually more unproductive and desolate, till at length not the least herb is to be seen, nor any trace of human step observed in the frigid waste. The produce of a few garden seeds, put into the ground about the middle of June, and shooting up with surprising rapidity, is all that the residents are able to gather from the adjoining soil. At York Fort, the soil, which is of a very loose and clayey nature, is nearly equally unfit for agriculture, even though the climate were favourable. Cresses, radishes, lettuce, and cabbage, are raised by careful culture, and, in some propitious seasons, peas and beans have been produced, but they rarely come to perfection. The face of the country is low and marshy; and the trees, though superior to those at Churchhill Fort, are still very knotty and diminutive; but, after proceeding inland towards the south, about Moose and Albany Forts, the climate is more temperate, and the trees of considerable size; potatoes, turnips, and almost every species of kitchen garden produce, are reared without difficulty; and it is supposed that corn also might be cultivated by proper attention. Upon advancing inland towards the west, the climate becomes still milder, and the soil more productive. Wild rice and Indian corn are produced in considerable quantities in the plains; various kinds of animals abound in the woods; the rivers and lakes are stored with the most delicious kinds of fish; and iron, lead, copper, and marble, have been found in the mountainous parts. In the woods of the more northern tracts, the only trees are, pines, junipers, small scraggy poplars, creeping birch, and dwarf willows. The ground is covered with moss of various sorts and colours, upon which the deer principally feed. Grass is not uncommon; and some kinds, especially rye-grass, are so rapid in growth, as frequently to rise, during the short summer at Churchhill Fort, to the height of three feet. Another species of grass, adapted for the support of the feathered tribes, is very abundant on the marshes and banks of lakes and rivers. Vetches, burrage, sorrel, coltsfoot, and dandelion, one of the earliest salads, are plentiful in some parts around Churchhill river. A herb called Wee-suc-a-pucka grows abundantly in most parts of the country, of which the leaves, and especially the flowers, make a very agreeable kind of tea, much used both by the Indians and Europeans, not only for its pleasant flavour, but also for its salutary effects. It is of an aromatic nature, and considered as serviceable in rheumatism, for strengthening the stomach, and promoting perspiration. It is likewise applied outwardly in powder to contusions, excoriations, and gangrenes; but in this view does not appear to possess any medicinal quality. Another herb, named by the natives jack-ashey-puck, resembling the creeping boxwood, is mixed with tobacco, to make it milder and pleasanter in smoking. Several small shrubs are found in the country, which bear fruit; of which the chief are, gooseberries of the small red species, which thrive best in rocky ground, and spread along the ground like the vine; currants, both red and black, are plentiful around Churchhill river, and grow best in moist swampy soils. The blackberries particularly are large and excellent; but in some persons both kinds occasion severe purging, unless when mixed with cranberries, which completely correct that tendency. Hips of a small size are found on the coast, but large and abundant in the interior of the country. Upon a bush, resembling the creeping willow, grows a berry similar in size and colour to the red currant, but of very unpleasant taste and smell. Cranberries are very abundant every where; and, when gathered in dry weather, and carefully packed with moist sugar, may be preserved for years. Heath-berries are also produced in great quantities, and their juice makes a pleasant beverage. Juniper berries are frequently seen, chiefly towards the south, but are little esteemed, either by the natives or the Europeans, except for infusion in brandy. Strawberries and raspberries, of considerable size and excellent flavour, are found as far north as Churchhill river, and are often most plentiful in those places where the underwood has been set on fire. The eye-berry, resembling a small strawberry, but far superior in flavour, grows in small hollows among the rocks, at some distance from the woods. There are also the blue-berry, which grows on small bushes, and resembles the finest plum in flavour; the partridge-berry, growing like the cranberry, but of a disagreeable taste; and the bethagotominick, or dewater-berry, which grows abundantly in swamps on a plant like the strawberry, with a high stalk, each bearing only one berry, and is accounted an excellent antiscorbutic.

The principal animals around Hudson's Bay are, the Moose-deer, rein-deer, buffaloes, musk oxen, and beavers; polar or white bear, black bear, brown bear, wolves, foxes of various colours, lynxes, or wild cats, wolverins, which are remarkably fierce and powerful animals, able to withstand the bear itself; otters, pine-martins, ermines, a smaller otter called jackash, which is very easily tamed, but, when angry or frightened, apt to emit a most disagreeable smell; the wejack and skunk, the last of which is remarkable for its insupportably fœtid smell; musk beavers, porcupines, hares, squirrels, castor-beavers, and mice of various kinds, one species of which, the hair-tailed mouse, is nearly as large as a common rat, and capable of being speedily tamed even after they are full grown. Amphibious animals frequenting the coasts of the Bay are, the walrus, or sea-horse, some of which have been killed of so enormous a size as to exceed the weight of two tons; seals of various sizes and colours; and sea-unicorns in the northern parts. Of the feathered race, there are eagles and hawks of various kinds, white and gray owls, ravens, cinereous crows, which are very familiar and troublesome birds, frequenting the habitations of the natives, and pilfering every species of provision; woodpeckers, ruffed grouse, pheasants, partridges, pigeons, thrushes, grosbeaks, buntings, finches, larks, titmice, swallows, martins, cranes, bitterns, earlows, snipes, plovers, gullemels, divers, gulls, pelicans, goosanders, swans, geese of different kinds, and ducks in great variety, particularly the mallard, long-tailed, wigeon, and teal. There are several kinds of frogs, as far north as the latitude of 61°, which in winter are generally found in a completely frozen state, yet capable of reviving when thawed. Grubs, spiders, and other insects, are found in the same icy condition, from which they can be recovered by exposure to a gentle heat. Several kinds of shell fish are found on the shores of the Bay, particularly muscles, periwinkles, and small crabs. The empty shells of cockles, wilks, scallops, and other sorts, are frequently thrown upon the beach; but none of these have been seen with the fish in them. There are few fish in Hudson's Bay. White whales are found in considerable numbers at the mouths of the principal rivers; and the Company's servants, in the settlements on the west coast of the Bay, have been known to send home in some years from eight to thirteen tons of fine oil. A small fish, called kepling, about the size of a smelt, and very excellent for eating, resorts in some years to the shore in great numbers, but at other times is extremely scarce. No other salt water fish is found in the country, except salmon, which are also very plentiful at some seasons, and equally rare at other times. It has been observed, in short, that every species of game, whether quadruped, fowl, or fish, is remarkably variable at different periods; and it thus becomes necessary to provide in plentiful seasons a quantity of such provisions as are most capable of being preserved. The geese are said to be particularly useful for this purpose, when properly salted; and it is nothing uncommon for 10,000 to be killed during a winter at the factories.*

The natives who inhabit the countries around Hudson's Bay may be distributed under these three general denominations,—the Southern Indians, the Northern Indians, and the Esquimaux. The Southern Indians occupy the country lying between the south coast of Hudson's Bay and the territories of Canada, and that part of the western coast of the Bay which is situated to the south of Churchhill river, and extends inland to the lake of Athabasca or Athapuscow. They are the same as the Indian tribes who occupy the regions to the north of Upper CANADA; and we refer to the account of that country for a general description of the leading nations. The principal tribes who reside in the interior to the south-west of Hudson's Bay, and who used formerly to repair to the Company's forts, but now find their wants supplied at the trading houses nearer their own homes, are the Ne-heth-a-wa, and Assinne-poetuc Indians. The latter are the same as the Assinipoils or Stone Indians, originally a branch of the Naudowessies, but latterly incorporated with the Knisteneaux or Killistinoes. They are a numerous tribe, who extend over a considerable tract of country, and bring many peltries to the traders. The former, the Nehethawas, or Neheaways, are supposed to spring from the same stock as the Chipawas or Chepewyans. From being scattered over an immense extent of country, they appear to be less numerous than they are in reality. They have been longest acquainted with the fur traders, and are the most debauched and corrupted in the southern tribes. The Southern Indians, in general, who have become known to the Hudson Bay traders, are of a middle size and copper complexion; their persons generally well formed, and their features regular and agreeable. Their constitutions are strong and healthy; and they are subject to very few diseases. They are chiefly affected with dysentery and a violent pain in the chest, which is ascribed to the intensity of the cold, but which is said rarely to prove fatal. The venereal disease is also common among them, but generally mild in its symptoms. They seldom live to a great age; but are observed to enjoy all their faculties to the last. They are capable of travelling on foot with great expedition, and for many days in succession, patiently enduring the utmost degree of cold, hunger, and fatigue. They excel in hunting, which is their sole mean of subsistence; and though long used to fire-arms, they are still remarkably expert in the use of their original weapons, the bow and arrow. When employed to procure provisions for the factories, at the rate of the value of a beaver skin for every ten geese, they frequently bring in 50 or 60 of these fowls a day, which they shoot readily on the wing. They are extremely artful, addicted to every species of fraud and pilfering, and ready to boast of their thefts when successfully executed, so as to escape detection. At the same time, nothing can exceed their honesty and fidelity when entrusted with a charge. They are frequently employed by the Hudson Bay traders to take packages into the interior parts, and to bring down the articles which are procured in return. An Indian with his wife will embark in his canoe packs of 60 or 70 lbs. each, containing articles which would enable him to live in affluence for many years, and with which it would be easy for him to abscond, without the possibility of being traced. Yet this valuable property, so completely in their power, they will convey hundreds of miles, through unfrequented lakes and rivers, and deliver at the place appointed, with the utmost punctutuality, for the reward of the value of six beaver skins for each pack. They are humane and charitable to the widows and children of their departed relatives, and are naturally mild, affable, and friendly in their manners; but, in their moments of intoxication, they are invariably roused by the slightest provocation to the fiercest quarrels and most barbarous murders. Even when the women have taken care to remove their weapons, they rarely fail, on such occasions, to mutilate one another with their teeth and nails. They are also extremely licentious in their sexual intercourse, and give themselves up without restraint to every species of incestuous debauchery, with mothers, sisters, and daughters. They have no manner of regular government or subordination; but choose a temporary leader when they go to war, or form a party for trade. By the use of spirituous liquors, which they drink to the greatest excess, and with which they are too readily supplied by the Europeans as the most alluring article of traffic, they are debased in their minds, enervated in their bodies, dejected in their spirits; and are daily becoming a more emaciated, puny, indolent, and worthless race.

The Northern Indians occupy the extensive tract of country which reaches from the 59th to the 68th degree of North Latitude, and which is upwards of 500 miles from east to west. Their territories are bounded by the Churchhill river on the south, by the country of the Athabasca Indians on the west, by Hudson's Bay on the east, and by the country of the Dog-ribbed and Copper Indians † on the north.

The Northern Indians are generally above the middle size, robust, and well proportioned; but have less of that activity of body and liveliness of disposition, which commonly distinguish the Indian tribes of the western coast of Hudson's Bay. Their features are of a peculiar cast, and different from those of any other race in those countries. Their foreheads are low, their eyes small, their cheek bones high, their noses aquiline, their cheeks fleshy, and their chins generally long and broad. Their complexion is of a copper colour, but rather inclining to a dingy brown; and their hair, like that of the other tribes, black, straight, and strong. Few of the men have any appearance of a beard till they arrive at middle age, and then it is very small in quantity, but exceedingly bristly. They endeavour to pull out the hairs by the root, though they seldom effect this very completely. They have no hair under their arm pits, or on any other part of the body, except in those places

* A French governor at Fort Bourbon affirmed, that his garrison of 80 men consumed in one winter 90,000 grouse and ptarmigans, and 25,000 hares, which, for 200 days, allows about $5\frac{1}{2}$ grouse and $1\frac{1}{2}$ hares to each man per day.

† These are, in every respect, the same people as the Northern Indians, and speak a dialect of the same language. They never visit the Hudson's Bay factories; but used to supply the Northern Indians with the greater part of the furs which these last bring to the Company's traders. They appeared, when visited by Mr Hearne, to be a hospitable and harmless tribe; and a gainful traffic might have been opened between them and the factories; but, about the end of the last century, a war broke out between the Dog-ribbed and Copper Indians, which terminated in the destruction of the latter people, except a small remnant, who found their way to the Canadian houses among the Athabasca tribes, where they are cheaply supplied with the European articles which they require, and for which the Northern Indians used to make them pay almost a thousand per cent. dearer than the Company's rates.

which nature directs them to conceal. The skins of the women are soft, smooth, and polished; and, when they are dressed in clean clothing, they are entirely free from any offensive smell. All the tribes of the Northern Indians have three or four parallel black strokes on each cheek, which are produced by introducing an awl or needle under the skin, and rubbing powdered charcoal into the wound after the instrument is drawn out. As almost the whole of their country is little better than a mass of rocks and stones, scarcely producing any other vegetable food than moss for the deer, they have few opportunities of collecting furs, and subsist chiefly by hunting and fishing. A few of the more active or restless among them, who have acquired a taste for European articles, collect the furs from the rest, or from the Dog-ribbed and Copper Indians, or from their own hunting excursions towards the inland districts, where the proper animals abound; and, after carrying these to the factories with great risks and fatigues, barter, on their return, the fruits of their traffic with their less ambitious countrymen for necessary food and clothing. But the greater part, though they may have visited the factories once in their lives, lead a happier life, and enjoy a more comfortable subsistence in their own country. Their real wants are easily supplied; and a hatchet, ice-chisel, file, and knife, are almost all that is requisite to enable them, with a little industry, to procure a plentiful supply of food and clothing. They subsist chiefly on venison, and generally spend the whole summer in hunting the deer on the open plains, or catching fish in the rivers and lakes. As they have no dogs trained to the chace like the Southern Indians, and as they seldom have powder and ball in sufficient abundance for the purpose, they make use of their bows and arrows in killing the deer, as they pass through the narrow defiles, into which they drive the herds in the following manner. Upon seeing the deer, they betake themselves to leeward, lest they should be smelled by the animals; and then search for a convenient place for concealing the marksmen. They next collect a number of sticks, like large ramrods, with a small flag at the top of each, and these they fix upright in the ground above fifteen or twenty yards from each other, so as to form two sides of a very acute angle, terminating in the defile, where the huntsmen are concealed behind loose stones, heaps of moss, &c. The women and boys then divide into two parties, and going round on both sides, till they form a crescent behind the herd, drive them straight forward between the rows of sticks into the place of concealment, where they are shot as they run along. The same mode is employed, in the winter season, to drive the deer into a pound or inclosed space fenced round with bushy trees. These pounds are of various sizes, according to circumstances, and are sometimes about a mile in circumference. The door or entrance is not wider than a common gate, and the inside of the space inclosed is so crossed with hedges as to form a kind of labyrinth, at every opening of which also are placed snares made of thongs. As soon as the deer are driven into the pound, the gateway is blocked up with trees and brushwood, prepared for the purpose; and while the women and children walk round the outside of the fence, to prevent the imprisoned animals from breaking through or leaping over, the men are employed in shooting those which run loose, or in spearing those which have been entangled in the snares. About the end of March, or beginning of April, when the snow, slightly thawed during the day, is frozen during the night into a thin crust, which easily bears the Indian on his snow shoes, but sinks under the hoof of the deer, it is a common practice to kill the moose deer, by literally running them down. The hunters, lightly clothed, and armed only with a bow and arrows, a knife, or broad bayonet, generally tire the deer in less than a day, though sometimes they continue the chace for two days before they can come up with the game. These animals, however, when incapable of running farther, make a very desperate defence with their head and fore-feet, and unless the Indians are provided with a short gun, or with bows and arrows, they find it necessary to fasten their knives or bayonets to the end of a long pole, in order to stab the deer, without coming within reach of their feet. The flesh of the animals killed in this manner is so over-heated by the long run, that it is never well tasted. In taking fish they make use of nets and hooks at all seasons of the year. Their fishing nets are made of thongs cut from raw-deer skins, (much inferior to those of the Dog-ribbed Indians, which are made of the inner bark of the willow tree,) and are furnished with various appendages, such as the bills and feet of birds, toes and jaws of otters, &c. which the superstitiously consider as essential to their success. These nets are always used separately, and placed at a distance from each other; and on no account would they unite them together, for the purpose of stretching across the channel of a narrow river; because they imagine that one net would become jealous of its neighbour, and would not catch a single fish. In fishing with hooks, they are equally influenced by superstitious notions; and all the baits which they use are compositions of charms, inclosed within a piece of fish-skin, so as to resemble a small fish. These charms are bits of beavers' tails, otters' teeth, musk-rats' entrails, squirrels' testicles, curdled milk taken from the stomachs of sucking fawns and calves, human hair, &c.; and almost every lake and river is supposed to require a peculiar combination of different articles. A net or hook that has taken many fish is valued accordingly; and would be taken as an equivalent for a number of new ones, which had never been tried, or which had not proved successful. In winter the hooks are let down through round holes cut in the ice, and are kept in constant motion, both to allure the fish, and to prevent the freezing of the water. From want of fuel, they are frequently obliged to eat their victuals in a raw state; and this they occasionally do from choice, especially in the case of fish, which they seldom dress so far (even where fire is at hand) as to warm it thoroughly. A few of them purchase brass kettles from the European factories; but the greater part still prepare their food in large upright vessels made of birch bark. As these vessels will not admit of being exposed to the fire, the water is made to boil by a succession of hot stones being introduced; a method which effects the purpose very expeditiously, but mixes much sand with the victuals, in consequence of the stones frequently mouldering down in the kettle. They employ also the ordinary methods of broiling their food, or roasting it by a string. They make a favourite dish, by boiling in a deer's paunch or stomach a mixture of minced meat, blood, and fat; but the fat is chewed by the men and boys, to prepare it for mixing more intimately with the other ingredients, and the half-digested food, found in the animal's stomach, is carefully added to the mess. In winter, when the deer feed upon a species of fine white moss, the contents of their stomach is accounted so great a delicacy, that the Indians frequently eat it warm out of the paunch, as soon as the animal is killed. In like manner, they pull out the kidneys of the deer or buffalo, and eat them warm from the newly slaughtered animals, without any dressing. They often drink the blood, as it flows from the wound in the carcase, and account it a most nourishing sort of food, as well as an excellent quencher of thirst. They are remarkably fond of the womb of the buffalo, elk, deer, &c. even when they are some time gone with young; and are not desirous of cleansing the bag very completely before boiling it for use. The young calves, fawns, beavers, &c. taken out of their mothers' bellies, are reckoned most delicious articles of food; and all the parts of generation, belonging to any animal which they kill, whether male or female, are carefully eaten by the men and boys, partly as a dish which they relish, and partly as a superstitious observance, which they consider essential to their success in the chace. The deer skins also, freed from the hair, and well boiled, are frequently used as food. Even the worms, which infest them after the rutting season, are squeezed out and eaten alive as great delicacies. When animal food is scarce, the natives boil a kind of hard crumply moss which grows upon the larger stones, and which forms a very palatable gummy preparation, sometimes used to thicken other kinds of broth, and particularly esteemed when cooked in fish liquor. All the Indians around Hudson's Bay, Southern, Northern, and Esquimaux, constantly swallow the secretion which comes from the nose; devour the maggots which are produced by the flesh fly; and delight in a handful of lice as much as a European epicure is known to relish the mites in a decayed cheese.

The clothing of the Northern Indians consists chiefly of deer skins, with the hair inwards; but, for summer use, they prepare from these skins a fine soft leather, with which they make their stockings, jackets, &c. To make a complete winter dress for a grown person requires the principal parts of eight or ten deer skins; and all these must, if possible, be procured in the month of August, or beginning of September, when the fur is thickest, and the skin least injured by worms. Each person is calculated to require annually ten more of these skins for the lighter parts of summer clothing, for thongs, lines, and other domestic purposes, besides what is needed for tents, bags, &c. The coverings of the tents are always formed of skins with the hair; and by the Northern Indians are commonly composed (differently from the practice among the Southern tribes) of separate pieces, containing about five skins in each. At the commencement of the winter season, they frequently sew a few of the skins of the deer's legs together in the shape of long portmanteaus, which they use as a kind of temporary sledge, till they reach a situation where wood can be procured. They then construct proper sledges of thin boards of larch fir; and make them of various sizes, according to the strength of the persons by whom they are to be dragged. In general they do not exceed eight or nine feet in length, and twelve or fourteen inches in breadth; but sometimes they are not less than twelve or fourteen feet long, and fifteen or sixteen inches wide. The boards, of which they are made, are only about a quarter of an inch thick, and five or six inches broad. They are sewed together with thongs of parchment deer skin, and several cross-bars are fastened on the upper side to strengthen the vehicle, and secure the ground lashing. The head or fore part of the sledge is turned up, so as to form a semicircle of fifteen or twenty inches diameter, to prevent the carriage from diving into light snow, and enable it to rise over the inequalities of the surface. The trace is a double line or slip of leather fastened to the head of the sledge, and attached to a collar, which is put across the shoulders of the person who hauls it, so as to rest upon the breast. They are sometimes dragged by dogs, but too commonly by the women. The snow shoes of the Northern Indians differ from all others in that country, in being made so as to be worn always on the some foot, having a large sweep or curve on the outside, but nearly straight in the inside. The frames are usually made of birch wood, and a netting of thongs from deer skin fastens the toes and heels to the bottom or sole. They are four feet and a half in length, and about thirteen inches broad.

The canoes of the Northern Indians are smaller and lighter than those of the Southern nations, so as to be carried by a single person on the longest journies; and are chiefly employed for crossing the rivers and lakes, with which they meet in their progress. These canoes are flat bottomed, and sharp at each end, so as to bear some resemblance to a weaver's shuttle. They seldom exceed twelve or thirteen feet in length; and are from twenty to twenty-four inches broad at the widest part. The forepart is unnecessarily long and narrow, and is all covered over with birch bark, so as to admit of nothing being laid into it. The hinder part is much wider, for receiving the baggage, or a second person, who must lie along the bottom, that the vessel may not upset, while the rower sits on his heels in the middle space, impelling the vessel with a single paddle. A hatchet, a knife, a file, and an awl, are all the tools which these Indians employ in making their canoes, snow-shoes, bows, arrows, and other kinds of wooden work. These few instruments they use with the utmost dexterity, and execute every thing in the neatest manner. In tanning their leather also, they use a very simple, yet efficacious process. The skins are first well soaked in a lather made of the brains, marrow, and soft fat of the animal; then dried before the fire, and even hung in the smoke for several days. They are next thoroughly steeped and washed in warm water, till the grain of the skin is perfectly open and moistened; after which they are carefully wrung, and dried before a slow fire, being in the meantime repeatedly rubbed and stretched as long as any moisture remains. Last of all, they are scraped smooth with a knife, and are extremely soft and beautiful, almost equal to shamois leather. The women of the Northern Indians, as in most other tribes, are more the slaves than the companions of the men; and are held in a state of unmitigated subjection. They are commonly rather of low stature and a delicate shape; but being inured to labour from their infancy, they are able to sustain all kinds of drudgery, and to carry very heavy loads on their journies. It is nothing unusual to see them bear on their backs a burden of eight or ten stone of fourteen pounds each, or haul in a sledge a much greater weight. They are expected also to dress the deer skins, make the clothing, cook the victuals, pitch the tents, carry home the game when killed, and perform all the work of splitting, drying, and preserving it for use. When the meal is prepared, they are not allowed to partake, till all the males, even the servants of their fathers or husbands, have eaten what they think proper; and, in times of scarcity, it is not unfrequently their lot to be left without a single morsel. They possess little beauty even in youth; and become old and wrinkled before they reach the age of thirty. But they are remarkably chaste, mild, and obliging creatures, making the most faithful servants, affectionate wives, and indulgent mothers. A plurality of wives is customary among all these Indians, and every man takes as many as he is able to maintain, or has occasion to employ in his service. It is not uncommon to see six or eight in one family; and they are changed or increased in number, at the pleasure of the husband. From the early age of eight or nine years, the girls are kept under the greatest restraint, and are not permitted to join in any amusements with the children of the other sex; but are obliged to be constantly beside the old women, learning their domestic labours. They are betrothed at an early period of life, without any choice of their own, but entirely at the will of their relations, who are chiefly anxious to connect them with men able to maintain them. No ceremonies attend their marriages, or divorces; and they are taken or dismissed as the husband chooses. When he suspects any of them of incontinency, or is not pleased with her accomplishments, he administers a beating and turns her out of doors, telling her to go to her lover or relations, as the case may be. It is also a daily occurrence among them to take by force the wives of others whom they may happen to fancy; and all that is necessary to decide the claim is to vanquish the former husband in wrestling. On these occasions, the by-standers never attempt to interfere; nor will one brother even offer to assist another, except by giving his advice aloud, which being equally heard, may be equally followed by both the parties engaged. In these contests, there is properly nothing like fighting; and it is very rarely that either of the combatants receives any hurt. The whole affair consists in pulling each other about by the hair of the head, or, if they should have taken care to cut off their hair and grease their heads before beginning the contest, they endeavour to seize each other around the waist, and struggle to prove their superior strength and title, by throwing their antagonist to the ground. When one of them falls or yields, the other is entitled to carry off the woman, who was the cause of contention; but as the children usually go with the mother, it is chiefly for the younger wives that these contests take place. It is a common custom among them to exchange wives for a night, as one of the strongest ties of friendship between the two families; and, in case of the death of either husband, the other considers himself bound to support the children of the deceased. The women among the Northern Indians are less prolific than the females of more civilized nations; and their children are commonly born at such intervals, that the youngest is usually two or three years old before another is brought into the world. The wife, when taken in labour, is removed to a small tent erected for her separate accommodation, at such a distance from the other tents that her cries cannot be heard; and no male above the age of childhood approaches the place. No assistance is offered by the other women to facilitate the birth, which is generally easy, and the recovery of the mother not less speedy. A woman after delivery, however, is accounted unclean for a month or more, and continues to occupy a separate tent with one or two female acquaintances; nor does the father, during all that time, even see the child, in the apprehension that he might dislike its appearance, before its countenance is duly formed. At certain monthly periods, also, the women are not permitted to remain in the same tent with their husbands, and are obliged to make a small hovel for themselves at a little distance from the rest. When these periods arrive, they creep out of the tent at the side where they happen to be sitting, as on such occasions they are not permitted to go out or in by the door; and it is said, that, upon any disagreement with their husbands, they often make a pretence of being in that situation, as a reason for a temporary separation. During these periods, a woman is restricted from walking on the ice of rivers or lakes, or where a fishing net is placed, or from crossing a path where the head of any animal has been carried, or from eating of any part of the head; and all this from a superstitious notion that by so doing she would impede their success in hunting. The children are not put in cradles as among the Southern Indians, but merely have a small bundle of dry moss placed between their legs, and are thus carried on the mother's back next her skin, till they are able to walk. Though managed in this awkward manner, very few deformed persons are seen among them. The children are named by the parents or near relatives; and the names of the boys are generally taken from that of some animal, place or season. Those of the girls are most frequently expressive of some quality or part of the martin, such as White Martin, Black Martin, Summer Martin, Martin's-head, Martin's-foot, Martin's-tail, &c. The men, though very indifferent about their wives, express much affection to their children, especially to the youngest; apparently actuated by no other principle than mere natural instinct.

When two parties of these Indians chance to meet, their mode of salutation is rather singular, and quite different from all European practices. When about twenty or thirty yards distant from each other, they make a full halt; and sit or lie down upon the ground, without speaking, for some minutes. At length the oldest on one side breaks silence, by relating to the other party all the misfortunes which have befallen him or his companions, since they had last seen or heard of each other, and also all the deaths or calamities of any of their countrymen, as far as may have come to his knowledge. A similar communication is made in reply; and, should any of the two companies be nearly affected by any of the bad news announced, they begin to sob and cry, in which all the rest unite with the utmost vehemence. They then advance by degrees, and mix together, the two sexes, however, always associating separately. The pipes are passed freely, if any tobacco can be found among them; conversation becomes general; the good news circulate; cheerfulness appears on every countenance; and small presents of provisions, ammunition, or other articles, are made, sometimes as gifts, but more frequently as speculations, to draw forth a greater present in return. Their principal amusements are, shooting at a mark with the bow and arrow; playing a game resembling that of quoits, in which they make use of short clubs sharpened at one end; or shifting a button, or small bit of wood from hand to hand, as in "which hand will you take?" in which the player, whenever he guesses rightly, receives a counter or chip of wood from his antagonist, and he who first gains all the sticks, is winner of the stake, which is usually an arrow, or a single load of powder and shot, or something of inconsiderable value. At times they amuse themselves with dancing, which is always performed during the night; but in which they have nothing peculiar to their own nation, and always imitate the songs and dances of the Southern tribes, or more commonly of the Dog-ribbed Indians. These dances are very simple, and are performed by three or four persons at a time, who stand up naked, or nearly so, close to the musician; and, with their hands close upon the breast, their heads inclining a little forwards, and their bodies kept quite stiff, lift their feet alternately in quick succession, and as high as possible. The music is produced by a drum or tabor, and sometimes a rattle made of buffalo's hide, shaped like an oil-flask, and filled with pebbles or small shot. These instruments are accompanied with the voice, repeating in a monotonous kind of tune, the words *hee, hee, hee, ho, ho, ho*, &c. The women are never allowed to join in these diversions, but sometimes dance by themselves, out of doors, to the music which serves the men within the tent. Their mode of dancing has still less meaning and motion than that of the men; and is performed by a number of them crowding close together in a straight line, shuffling themselves a little from right to left and back again on the same ground, without lifting their feet; and making, when the music stops, a kind of awkward curtsey, with a shrill cry of *he-e-e, ho-o-o-o-e*.

Few of the Northern Indians live to a great age; and the extreme fatigues which they undergo from their youth, in procuring their subsistence, is supposed to have no small effect in shortening their lives. Their most fatal disorders are fluxes and consumptions, which carry off great numbers of both sexes and of all ages. But the most prevalent diseases is, a kind of scurvy resembling the worst stage of the itch. It is seldom known to prove fatal, unless when conjoined with some internal affection; but it is extremely troublesome and obstinate, resisting all the medicines which have yet been applied at the Company's factories; and, when left to the power of nature, as is always the case among the natives, seldom removed in less than twelve or eighteen months. They make no use, indeed, of medicine, either for external or internal diseases, and attempt to cure them solely by charms. The modes most commonly employed are, sucking the part affected, blowing and singing to it, laughing, spitting, and uttering a multitude of unmeaning sounds and vocables. In the case of some internal complaints, such as colic, strangury, &c. the operator frequently blows into the anus or the adjacent parts, whatever be the sex of the patient, and continues the process as long and as violently as his lungs can act. The consequence of such an accumulation of wind is not unusually precisely the same as the effect of a clyster; and the reaction is sometimes so sudden, as to lodge the contents full in the face of the doctor; a scene which, however ludicrous to Europeans, never discomposes the gravity of any of the Indian parties or spectators. The medical practitioners are a class of conjurors, who no doubt impose upon the credulity of their countrymen, but who seem to have themselves a real belief in the efficacy of some of their operations. In cases of great danger, besides the usual modes of cure, they pretend to appease the power of death, and to procure a respite for the sufferer, by swallowing hatchets, ice-chisels, broad-bayonets, knives, &c.; and these feats they are described as performing, or rather appearing to perform, with wonderful dexterity. Some of their exertions are sufficiently real and laborious, as particularly described in a case witnessed by Mr Hearne. After one of them had performed the feat of swallowing a long board, he took with him other five men and an old woman into the house where the patient lay; and, having stripped themselves completely naked, began to suck, blow, sing, and dance around the sick man, "continuing so to do for three days and four nights, without taking the least rest or refreshment, not even so much as a drop of water. When these poor deluding and deluded people came out of the conjuring-house, their mouths were so parched with thirst, as to be quite black, and their throats so sore, that they were scarcely able to articulate a single word, except those that stand for *yes* and *no* in their language. After so long an abstinence, they were careful not to eat or drink too much at one time, particularly for the first day; and, indeed, some of them, to appearance, were almost as bad as the poor man they had been endeavouring to relieve. But great part of this was feigned; for they lay on their backs with their eyes fixed as if in the agonies of death, and were treated like young children. One person sat constantly by them, moistening their mouths with fat, and now and then giving them a drop of water. At other times, a small bit of meat was put into their mouths, or a pipe held for them to smoke. This farce only lasted for the first day; after which they seemed to be perfectly well, except the hoarseness, which continued for a considerable time afterwards." These conjurors profess to accomplish their cures by the aid of certain spirits or fairies, with whom they pretend to converse, and whom they often describe as appearing to them under the shapes of beasts, birds, clouds, &c. They are supposed to be equally able, by means of those supernatural allies, to take away as well as to prolong any one's life; and when they chose to threaten such a malign influence to any individual or family, the imaginations of their victims are so possessed by the conviction of their power, that the consequence is affirmed to have often proved fatal, without any apparent molestation being offered to the objects of their vengeance. Indeed, when any of their principal people die, their death, in whatever way it has taken place, is usually ascribed to some conjuring influence, either of their own countrymen, or of the Esquimaux, or of the Southern tribes. They never bury their dead, but always leave the bodies on the spot where they expire. They are understood to be generally devoured by beasts and birds of prey; and for this reason these Indians will not eat the flesh of foxes, wolves, ravens, &c. unless they be pressed by absolute necessity. Though thus neglectful of the mortal remains of their friends, they are deeply affected with grief for their loss; and express their sorrow by tearing off their clothes, and wandering about naked, till their neighbours or relatives come to their relief. After the death of a father, mother, husband, wife, son, or brother, they mourn for the space of a whole year, indicating their affliction, not by any particular dress, but by cutting off their hair, and crying almost perpetually. But the greatest calamity that can befal any of these Indians is old age. When any one is incapable to labour, he is treated, even by his own children, with the greatest neglect and disrespect, being always last served at meals, and then only with the worst of the victuals; being clothed in the clumsiest manner, with what the rest of the family despise to wear; and finally, when no longer able to walk, deliberately abandoned to perish of want. This practice is so general, that one half at least of the aged people of both sexes are supposed to die in this miserable manner. The absolute necessity of moving from place to place in quest of subsistence, and the want of any easy mode of conveyance among them, may be considered as the original causes of this unnatural custom.

The notions which these Indians entertain in religion are so extremely vague and limited, that they may almost be said to have no ideas at all on that subject. With regard to the origin of the world, they have a tradition, that the first person on earth was a woman, who, after being some time alone, found an animal like a dog, which followed her to the cave where she lived, and transforming itself during the night-time into the shape of a handsome youth, rendered her the mother of a family. Some time afterwards, a person, of such gigantic stature as to reach the clouds with his head, came to level the land, which had been hitherto a confused heap, and this he effected merely with the help of his walking stick, marking out, at the same time, the lakes, ponds, and rivers. He then took the dog, and, tearing it in pieces, threw its intestines into the waters, commanding them to become fishes; dispersed its flesh over the land, with a similar charge to form the different kinds of beasts; threw the pieces of its skin in the air, to give origin to the feathered tribes; commanded the woman and her offspring to kill, eat, and never spare, as he had charged these creatures to multiply for her use; and then returning to the place whence he came, has never been heard of since. They believe in the existence of several kinds of spirits, whom they suppose to inhabit the different elements, and to whose influence they attribute every change in their lot, whether favourable or adverse. They have no fixed creed, however, in these matters; but are continually receiving new fables from their conjurors, who profess to receive intimations in dreams from these invisible beings. They have no practical religious observances whatever, except perhaps speaking with reverence of certain beasts and birds, in which they imagine these spirits to reside. But they restrict the influence of these beings upon their welfare entirely to the present life, and have no idea whatever of a future state.* They have indeed a multitude of superstitious customs, some of which have already been mentioned, respecting success in hunting, fishing, &c. but which seem to partake more of the nature of civil than religious institutions. One of the most remarkable of these is that which they observed after having put to death any of their enemies in war. All those who have shed blood are, for many months afterwards, in a state of uncleanness, and obliged to perform a number of strange ceremonies. They are prohibited from cooking any kind of victuals for themselves or others; required to paint their faces with red earth before every meal; restricted to the use of their own pipe and dish; forbidden to eat various parts of animals, particularly the head, entrails, and blood; precluded from having their food prepared in water, so that, if they could not have it broiled on the fire or dried in the sun, they must eat it in a raw state; and finally denied the privilege of saluting any of their wives and children. When the appointed time is expired, they kindle a fire at some distance from the tents, into which they throw all their ornaments, pipe-stems, and dishes; and then partake of a feast, consisting of all those articles of food which they had been prohibited from using.

The Northern Indians are an indolent, improvident race; and are frequently in danger of starving from mere want of exertion and foresight, especially in their trading excursions to Prince of Wales Fort, the only one of the factories which they frequent. They are seldom guilty of stealing from one another, but are ready to pick up every kind of iron work which falls in their way at the Company's settlements. They excel in all the arts of defrauding and overreaching, and especially in playing the part of feigned want and distress. They are continually pleading poverty even among themselves; and, at the factory, they may be said to practise begging more than traffic. They are generally of a morose and covetous disposition, and remarkably deficient in gratitude. They are by no means a warlike people, and are not inclined to acts of cruelty, except towards their enemies the Esquimaux. Whatever losses or injuries they may sustain from one another, their revenge rarely extends beyond a wrestling match with the offender. Murder is almost unknown among them; and the perpetrator of such a crime would be treated by universal consent as an outlaw from their tribe. At the same time, they testify little humanity to the sufferings of others beyond the circle of their immediate relatives; and are known rather to ridicule, in the most unfeeling manner, the most afflicting cases of distress. They are not at all addicted to the use of spirituous liquors; and though some, who have intercourse with the factory, may learn to take them freely enough, when given gratis, they never think of them as an article of purchase. They are thus always sober, and are guilty of no greater rioting than what consists in abusive language. They are apt to become insolent and uncomplying when treated with indulgence; but nevertheless are by far the mildest tribe of Indians to be found on the borders of Hudson's Bay.

The Esquimaux who inhabit the northern coasts of Hudson's Bay,† (to whom alone the following particulars apply,) seldom approach the Company's fort at Churchhill River; but a sloop is regularly sent to trade with them at Knapp's Bay, Navel's Bay, and Whale Cove. It is only since the middle of last century, that the Company's servants could venture to land among them, (partly, perhaps, because they were considered by the Esquimaux as the allies of their most inveterate enemies, the Northern Indians,) but they have of late become so much civilized, and reconciled to the Europeans, as readily to welcome their arrival, and to treat them with every mark of hospitality. They have long been persecuted by their more powerful neighbours the Northern Indians with the most savage barbarity. No quarter is ever granted on either side; and the strongest party never fails to massacre every creature of the vanquished, without sparing even the women and children. Of late years, however, the company's servants have extended their protection to the oppressed Esquimaux, and have succeeded in establishing a peace between the two nations, so far at least that parties and individuals of both tribes can meet each other in a friendly manner, or rather without any disposition to plot each other's destruction. But the more distant Esquimaux, who reside so far to the north as to have no intercourse with the Europeans, are still exposed and often fall a sacrifice to the fury of their enemies. They are tolerably well protected in winter by their remote situation; and, in summer, they guard as much as possible against surprise, by residing chiefly on islands and peninsulas; but with all these precautions, they are often so harassed and closely pressed by their pursuers, as to be obliged to leave behind them those goods and utensils upon which they depend for procuring subsistence, and the loss of which they cannot replace without a great expence of time and labour. These more northern Esquimaux are of low stature and broad figure, but neither strong nor well proportioned. Their complexion is of a dirty copper colour, but some of their women are considerably fairer. They have a singular custom which distinguishes them as a peculiar tribe, namely, that all the men have the hairs of their heads pulled out by the root; but in most other respects, they resemble the Esquimaux of Hudson's Straits and Labradore. Their arms and utensils, from the want of proper tools, are very inferior in workmanship to those of the more southern tribes of their nation; yet even with the imperfect instruments in their possession, many of their articles of furniture are formed and ornamented with wonderful ingenuity, especially their stone kettles. They are made of a grey porous stone, of an oblong square shape, wider at the top than the bottom, with strong handles of solid stone left at each end, for the purpose of lifting them more conveniently, and are sometimes large enough to contain five or six gallons. They are all ornamented with neat mouldings around the rim, and occasionally with a kind of fluted work at the corners; and all this is executed with no other instruments than such as are made of a harder kind of stone. Their arrows, spears, darts, &c. are generally pointed with a triangular piece of black stone, or sometimes a piece of copper. Their tools for wood work are entirely of this metal, namely, hatchets, broad bayonets, and women's knives. The hatchets are made of a thick piece of copper, about five or six inches long, and from one and a half to two inches square, bevelled away at one end like a mortice chisel, and fastened at the other to a wooden handle about twelve or fourteen inches in length, so as to resemble an adze; but they have neither weight nor sharpness to act like an adze or hatchet, and are generally applied in working like a chisel, being driven into the wood with a heavy club. The bayonets resemble an ace of spades, and are fastened to a handle of deer's horn about a foot long. During summer, they live in cir-

* The Southern Indians consider the aurora borealis as the assembled spirits of their departed friends dancing in the clouds; but the Northern Indians have no belief of this nature, and merely speak of that phenomenon by the name of Deer, in consequence, it is said, of observing, that a hairy deer-skin, when briskly stroked with the hand in the dark, emits electrical sparks like these lights in the atmosphere

† For an account of the other tribes of that people, see Greenland and Labradore.

cular tents covered with deer skins, and employ themselves principally in fishing; but in winter they occupy small huts, the lower half of which is sunk below the surface of the earth, and the upper part formed with poles which meet at the top in a conical form. Those who reside near Churchhill river travel, in winter, from lake to lake, or from river to river, where they have magazines of provisions, and heaps of moss for fuel; but as those stations are often far distant from each other, they frequently pitch their tents on the ice, and cut holes in the ice within the tent, where they sit and angle for fish, which, for want of fire, they eat in a manner alive as they come out of the water, and are altogether a miserable starving race of beings.

The original Hudson's Bay Company appear to have acted upon the most liberal and benevolent principles. Their instructions to their factors contain the most explicit directions, to use every mean in their power for reclaiming the Indians from a state of barbarism, and inculcating on their minds the principles of Christianity. They were, at the same time, admonished to trade with them equitably, and to take no advantage of their native simplicity; to explore the country, and to study to derive such benefit from its soil and produce, as might redound to the interest of the mother-country, as well as to their own emolument; to watch over the behaviour of the European servants, especially as to sobriety, temperance, and veneration for the services of religion. The chief person in command at each settlement is called the governor of the fort, and sometimes there is one appointed to act under him, termed the second. These, with the surgeon and the master of the sloop attached to the place, constitute a council, who deliberate together in all matters of importance, or cases of emergency. The governors are appointed for a period of 3 or 5 years, and have from 50*l.* to 150*l.* per annum as fixed salary, with a premium upon the trade, which consequently fluctuates according to its amount.* The labouring servants, who are chiefly procured from the Orkney islands, are generally engaged for three, four, or five years, and, about twenty years ago, received six pounds per annum as wages, independent of maintenance. Their employments consist principally in carrying fuel, sledging the snow out of the avenues of the factory, and hunting. The company export muskets, pistols, powder, shot, brass and iron kettles, hatchets, knives, cloth, blankets, baize, flannels, gunworms, steels and flints, hats, looking-glasses, fish-hooks, rings, belts, needles, thimbles, glass-beads, vermilion, thread, brandy, &c. with which they purchase from the natives skins, furs, whalebone, train oil, ivory, eider-down, &c. The trade was understood, in its original flourishing state, to be the most profitable in the world; and the proprietors of the stock were generally supposed to gain about 2000 per cent. It has been denounced, however, as proportionably detrimental to the mother-country; and it has been affirmed, that, if laid entirely open, the number of persons employed, and the quantity of wares exported, might easily be increased ten fold. The company are charged, at the same time, with transacting all their affairs with the greatest secrecy, and always shewing the utmost reluctance to expose the details of their trade to public view. On the other hand, during a parliamentary inquiry into their proceedings in 1749, they produced documents to prove, that their profits were sufficiently limited, as appears from the following summary of their expenditure and returns, in the space of ten years, from 1739 to 1748, inclusive:

| | |
|---|---|
| Charges of shipping, factories, &c. in ten years . . . . . . . | *L.* 157,432 14 4 |
| Exports during that period . . | 52,463 9 0 |
| Total expences . . | *L.* 209,896 3 4 |
| Amount of sales . | 273,542 18 8 |
| Clear profits from the trade in ten years | *L.* 63,646 15 4 |
| Dividends in one year among 100 shares of *L.*100 each . . . | *L.*6364 13 6 |
| For each proprietor of *L.*100 stock . | *L.* 63 12 11 |

The following account of imports and sales for one year, from Michaelmas 1747 to Michaelmas 1748, may afford a more detailed view of the articles of the trade, and their respective values:

| Articles. | Number. | | *L.* | *s.* | *d.* | |
|---|---|---|---|---|---|---|
| Beaver skins . . | 52,716 | at | | 7 | 6 | per skin |
| Martins . . . . | 8,485 | at | | 6 | 8 | do. |
| Otters . . . . . | 1,445 | at | | 9 | 7¼ | do. |
| Cats . . . . . | 1,199 | at | | 10 | 10½ | do. |
| Foxes . . . . . . | 527 | at | | 8 | 1¼ | do. |
| Wolverins . . . | 977 | at | | 5 | 0 | do. |
| Bears . . . . | 371 | at | 1 | 2 | 7 | do. |
| Wolves . . . . | 1,663 | at | | 9 | 6¾ | do. |
| Woodshocks . . | 32 | at | | 10 | 7 | do. |
| Elks . . . . . | 50 | at | | 6 | 7 | do. |
| Deer . . . . | 105 | at | | 2 | 3 | do. |
| Bed-feathers . . | 5,838 lbs. | at | | 1 | 2 | per lb. |
| Castor . . . . | 308 | at | | 6 | 2¼ | do. |
| Whale fins . . . | 226 | at | | 2 | 0½ | do. |
| Minks . . . . | 33 | at | | 3 | 1 | per skin. |
| Racoons . . . . | 26 | at | | 1 | 7 | do. |
| Goose quills . . . | 43,000 | at | | 15 | 0 | M. |
| Musquash . . . | 268 | at | | 0 | 9¼ | per skin. |
| Badger . . . . | 80 | at | | 1 | 1 | do. |
| Total value . | *L.* 30,160 | | | 5 | 11 | |

The Company's establishments in the Bay, in the year 1790, may be seen at one view in the following Table.

| Settlements. | Number of Servants. | Indian Settlements. | Ships consigned to. | Sloops in the country. | Trade on average. |
|---|---|---|---|---|---|
| | | | Ships. Tons. | Sloops. Tons. | |
| Churchhill Fort . . . . | 25 | | 1 of 250 | 1 of 70 | *L.*10,000 |
| York Fort } Severn-house } . . . | 100 | 4 | 1 of 250 | 1 of 60 | 25,000 |
| Albany Fort . . . . | 50 | 2 | | | 5,600 |
| Moose Fort . . . . | 40 | 2 | 1 of 280 | 1 of 70 | 7,000 |
| East Main . . . . | 25 | | | 1 of 70 | |
| Total . . | 240 | 8 | 3 780 | 4 270 | *L.*47,600 |

* The Second has about 40*l.*; an assistant, 25*l.*; and a clerk, 15*l.* per annum.

In forming a standard of trade with the natives, the beaver skin is taken as the universal measure; and a comparative valuation made of the other kinds of peltry, &c.

| | | | |
|---|---|---|---|
| A full grown moose | skin | 1 as | 2 beavers. |
| Cub ditto | | 1 | 1 |
| Old bears | | 1 | 3 |
| Cub ditto | | 1 | 1 |
| Foxes, black | | 1 | 4 |
| Ditto, grey | | 1 | 3 |
| Ditto, white | | 2 | 1 |
| Ditto, red | | 1 | 1 |
| Ditto, brown | | 2 | 1 |
| Wolf | | 1 | 2 |
| Wolverins | | 1 | 2 |
| Cats | | 1 | 2 |
| Otter, old parchment | | 1 | 1 |
| Ditto, cub and drest | | 2 | 1 |
| Martins, prime | | 2 | 1 |
| Ditto, ordinary | | 3 | 1 |
| Deer, buck | | 1 | 1 |
| Ditto, doe | | 2 | 1 |
| Musquash | | 6 | 1 |
| Goose feathers | lb. | 10 | 1 |
| Ditto quills | No. | 2000 | 1 |
| Castor | lb. | 2 | 1 |

With these the trading goods are bartered, or rather directed to be bartered, at the following rates:

| | | | |
|---|---|---|---|
| Glass beads | lb. | 1 as | 1 beaver. |
| China ditto | | 1 | 6 |
| Kettles, brass | | 1 | 1½ |
| Coarse cloth | yard | 1 | 3 |
| Blankets | No. | 1 | 7 |
| Tobacco, Brasil | lb. | ¾ | 1 |
| Ditto, leaf | | 1 | 1 |
| Ditto, English roll | | 1 | 1 |
| Shirts, check | No. | 1 as | 2 |
| Ditto, white | | 1 | 2 |
| Stockings, yarn | pair | 1 | 2 |
| Powder | lb. | 1 | 1 |
| Shot | | 4 | 1 |
| Duffels | yard | 1 | 2 |
| Knives | No. | 4 | 1 |
| Guns | No. | 1 | 14 |
| Combs | | 1 | 1 |
| Flints | | 16 | 1 |
| Vermilion | lb. | 1 | 16 |
| Pistols | No. | 1 | 7 |
| Small burning glasses | | 1 | 1 |
| Gartering | yard | 1½ | 1 |
| Orrice lace | | 1½ | 1 |
| Rings, brass | No. | 3 | 1 |
| Files | | 1 | 1 |
| Tobacco boxes | | 1 | 1 |
| Awl blades | | 8 | 1 |
| Boxes, | barrel | 3 | 1 |
| Hawks-bells | pair | 12 | 1 |
| Sword blades | No. | 1 | 1 |
| Ice chisels | | 1 | 1 |
| Gun worms | | 4 | 1 |
| Hats, coarse | No. | 1 | 4 |
| Trunks, small leather | | 1 | 4 |
| Needles | | 12 | 1 |
| Hatchet | | 1 | 1 |
| Brandy, English | gallon | 1 | 4 |
| Medals | No. | 12 | 1 beaver. |
| Thimbles | | 6 | 1 |
| Collars, brass | | 1 | 2 |
| Fire steels | | 3 | 1 |
| Razors | | 2 | 1 |
| Thread | lb. | 1 | 1 |

Out of this standard, however, which is in itself sufficiently hard upon the Indians, the factors are allowed, for their own emolument, to raise a surplus-trade; so that the natives often pay at the rate of one-third, or even one half, more than the preceding rates. In consequence of this griping traffic, and the alleged supineness of the company, the trade has been gradually decreasing, though the articles procured have been bringing a higher price at home. This is partly ascribed to the competition of the Canadian traders since 1773, who penetrate into the interior, and establish trading ports nearer the abodes of the natives, who often collect more skins than they are able to convey to the settlements on the coast, and are glad also to find a market without needing to seek it through a long and laborious journey. By these enterprising competitors under Mr Joseph Frobisher, the company's trade suffered so severely, that, in 1775, it fell short nearly one half of what it had been in 1774. They immediately commenced pursuit of the retreating trade, by erecting trading houses in the interior. In 1775, they formed a settlement at Sturgeon Lake, in north latitude 53° 56′, and west longitude 102° 15′; in 1793, their traders repaired to the south-east of Portage de Traite, among the Knisteneaux, whom they term their home guards; and, about the beginning of the present century, to Athabasca river, in north latitude 56° 42′, among the Chepewyans. Since the establishment of these trading houses, which are maintained at a great expence, the Indians have in a great measure ceased to visit the factories on the coast of Hudson's Bay, which have thus become little better than storehouses for the articles of the trade. Still, however, in spite of these endeavours to secure the *traffic* of the natives, they have found the adventurers from Canada in every respect an overmatch for their people in the business; a circumstance for which it is difficult to account, when it is considered how much nearer to the Indian hunters is the residence of the Hudson's Bay traders, and in how much shorter a time they can procure a return upon their goods. The directors of the Company appear to have readily authorised their agents to pursue the inland trade since the encroachments of the Canadians, of which a proof may be adduced from the following manuscript notes in a copy of Mackenzie's Voyages, by one of their factors at that period.* "When chief factor at York Fort, I sent inland several young men with the Indians, to observe the movements of the Canadian adventurers. They found bands of them, with servants and coureurs des bois, pursuing the fur trade with more spirit than their predecessors the French. From that date, 1762 to 1764, I yearly sent inland, and repeatedly informed the directors of what was going forward. The Company's trade at York Fort increased for two or three years after the conquest of Canada; but decreased after Findlay, Currie, &c. penetrated to Saskatchiwine river. Anno 1774, I advised the directors to establish settlements inland, with which they readily complied; and have continued to do so at an enormous expence. I do affirm, the Company spare no cost to promote trade in every branch. This I say from my own experience, having been 26 years in their service, greater part of that time governor and chief factor; and since I left the employment, have been highly honoured

* The late Andrew Grahame, Esq. Prestonpans.

with their esteem, and application for advice on the subject. But our countrymen from Canada are bold adventurers, and far superior to the Company's servants: the former work for their own benefit, while the latter do not." "I repeatedly advised the Directors to prosecute the trade to Athabasca; but the servants never would venture, making as excuse, that they would be in want of food." The company, however, have been loudly and publicly charged with making only the most languid exertions, with failing from an ill-judged parsimony to animate their servants by adequate salaries, and with injudiciously employing in the carrying part of the inland trade the native Indians, who are so much less active than the Canadian servants, and who are thus withdrawn from their more profitable service as hunters. It has been affirmed, in short, that were they to prosecute the trade with spirit, the Canadian associations would be obliged to relinquish it entirely; and it has been consequently urged, that so inefficient a monopoly should be thrown open to the exertions of the public. These charges, however, are made chiefly, and rather inconsistently, by the rival fur traders from Canada, who have certainly been the greatest gainers by the remissness of those from Hudson's Bay; and who must be convinced, that, if the trade were thrown open, it would naturally be prosecuted rather through the more favourable stations on Hudson's Bay, than through the circuitous route of the St Lawrence. See Foster's *History of Voyages and Discoveries in the North*; Hearne's *Travels to the Northern Ocean*; Mackenzie's *Voyages through the Continent of North America*; Umfreville's *State of Hudson's Bay*; and Long's *Travels in Canada*. (*q*)

HUET, Peter Daniel, Bishop of Avranches in France, an eminent scholar, was born of a good family at Caen in Normandy, on the 8th of February, 1630. His parents died while he was but an infant, and left him to the care of guardians, who neglected him; but his natural abilities and innate love of learning overcame all disadvantages, and before he was thirteen years of age he had finished his studies in the *belles lettres*. Having entered into the study of philosophy, he found an excellent guide in father Maimbrun, a Jesuit, who directed him to begin by learning a little geometry. Huet, however, went farther than his tutor desired, and contracted such a relish for the mathematics as had almost induced him to abandon his other studies.

Having finished his elementary studies, it was his object to apply himself to the law, and to take his degrees in that faculty; but from this pursuit he was diverted by two books which were then published. These were, "The Principles of Descartes," and "Bochart's Sacred Geography." To the philosophy of Descartes, of which he was a great admirer, he adhered for many years; but afterwards abandoned it, when he discovered the fallacy of its principles. The immense erudition displayed in Bochart's work made a great impression on him, and inspired him with a strong desire to become conversant with Greek and Hebrew learning. To assist his progress in these studies, he contracted a friendship with Bochart, who was minister of the Protestant church at Caen.

At the age of twenty, he was emancipated, by the custom of Normandy, from the tuition of his guardians; and soon after made a journey to Paris, with the view of purchasing books, and becoming acquainted with the learned men of the times. About two years afterwards, he accompanied Bochart to the court of Christina, queen of Sweden, and had thus an opportunity of introducing himself to the learned in other parts of Europe. The queen, it is said, wished to have engaged him in her service; but owing to the jealousy and intrigues of Bourdel, another physician, Bochart's reception had not been very gracious; and Huet, being aware of the fickle temper of Christina, declined all offers, and returned to France after an absence of three months. The principal advantage which he derived from this journey, besides the acquaintance he formed with the learned men in Sweden and Holland, consisted in the acquisition of a copy of a manuscript of *Origen's Commentaries upon St Matthew*, which he transcribed at Stockholm. While engaged in translating this work, he was led to consider the rules of translation, as well as the different manners of the most celebrated translators; and in 1661, he published his thoughts upon this subject at Paris, under the title *De interpretatione libri duo*; a work written with great vigour and elegance, in the form of a dialogue between Casaubon, Fronto Ducæus, and Thuanus. In 1664, he published, at Utrecht, an elegant collection of Greek and Latin poems, which was afterwards enlarged in several successive editions. At length, in 1668, he published at Rouen his *Origenis Commentarii*, &c. *cum Latina interpretatione, notis et observationibus*, in 2 vols. folio; to which was prefixed an ample preliminary discourse, containing all that antiquity relates concerning Origen.

In 1659, Huet was invited to Rome by Christina, who had abdicated her crown and retired thither; but he again declined the invitation. About ten years after, when Bossuet was appointed preceptor to the Dauphin, Huet was chosen for his colleague, with the title of sub-preceptor. He accordingly went to court in 1670, and remained there till 1680, when the dauphin was married. It is to this appointment, probably, that the learned world is indebted for the editions of the classics *in usum Delphini*; for although the first idea of the commentaries for the use of the dauphin was started by the Duke de Montausier, it was Huet who digested the plan, and directed the execution of this useful undertaking. Although necessarily much occupied with the duties of his situation, he found leisure, at this period, to compose his *Demonstratio Evangelica*, which was published at Paris in 1679, in folio, and has since been reprinted in various forms. He was admitted a member of the French Academy in 1674.

At the age of forty-six, Huet entered into orders; and in 1678 he was presented by the king to the abbey of Aunay in Normandy, whither he retired every summer after he had left the court. In 1685, he was nominated to the bishopric of Soissons, which, with the consent of the king, he exchanged with the Abbé de Sillery for the see of Avranches. In 1689, he published his *Censura philosophiæ Cartesianæ*; and in 1690, his *Questionis Alnetanæ de Concordia Rationis et Fidei*, which work is written in the form of a dialogue, after the manner of Cicero's Tusculan Questions.

In 1699, he resigned his bishopric of Avranches, and was presented to the abbey of Fontenay, near the gates of Caen. Soon after, he removed to Paris, and lodged among the Jesuits in the Maison Professée, to whom he bequeathed his library, reserving to himself the use of it while he lived. Here he resided during the last twenty years of his life, and employed himself chiefly in writing notes on the vulgate translation of the Bible; for which purpose he is said to have read over the Hebrew text twenty-four times, comparing it, as he went along, with the other Oriental texts. In 1712, he was seized with a severe illness, from which, contrary to the expectation of his physicians, he gradually recovered, and applied himself to the writing of his life, which was published at Amsterdam in 1718, under the title of *Pet. Dan. Huetii, Episcopi Abricensis, Commentarius de rebus ad eum pertinentibus*. The critics have wondered how such a master of the Latin language as Huet should have been guilty of so great a solecism in the very title of his book, by using the pronoun *eum* instead of *se*. This performance, although composed in an amusing style, is by no means equal to his other works, his faculties being then a good deal impaired. He died on the 26th of January, 1721, in the 91st year of his age. The Abbé Olivet relates a most remarkable singularity of Huet, viz. that for two or three hours before his death, he recovered all the vigour of his genius and memory.

Besides the works we have mentioned in the course of the preceding narrative, Huet published a variety of other treatises upon literary and philosophical subjects. He had been, throughout the whole of his long life, a hard student; and he left behind him the reputation of one of the most learned men of the age. See *Eloge Historique de M. Huet, par M. l'Abbé Olivet*, prefixed to his *Traité Philosophique de la foiblesse de l'Esprit humain*; Aikin's *Life of Huet*, London, 1810; and *Gen. Biog. Dict.* (z)

HUGUENOTS, a name of uncertain origin, given to the Protestants of France. A full account of their history will be found in our article FRANCE.

HULL, or KINGSTON-UPON-HULL, is a seaport town of England, in the east riding of Yorkshire, situated on the west side of the river Hull, and on the northern side of the river Humber, about twenty miles from its mouth.

The town, which lies on a level tract of ground, extends nearly in a direct line along the river Hull, from the Humber bank to very near the church of Sculcoates, a space of about two miles. It stretches nearly as far in another direction, from the High Street on the river Hull towards Beverly, Anlaby, and Hessle. The dock, or artificial harbour, divides the town into two principal divisions. The one to the north of the dock belongs to the parish of Sculcoates, and is without the original boundaries of Hull. It consists of several very spacious streets, which have been built chiefly within the last thirty years. The principal streets of Hull are clean and spacious, and the whole town is paved, flagged, and lighted.

The public buildings of Hull are numerous, but by no means elegant. The Trinity church, which was partly built about the year 1312, is a magnificent and beautiful structure, built in the Gothic style. It occupies a space of 20,056 square feet. It extends 279 feet from the west door to the east end of the chancel. The nave is 144 feet long, the breadth of the transept 28, and the length of the chancel 100. The breadth of the nave is 72 feet, and the breadth of the chancel 70 feet. St Mary's church, commonly called the Low church, was built a few years later than the preceding. Its length is 74 feet, and the height of the steeple is 74 feet. St John's church, a neat and simple brick building, was erected at the sole expence of the Rev. Thomas Dikes, and finished in 1792. It is 86 feet long, and 59 broad. It is wholly built upon arches, raised seven feet above the surface, and contains more than 70 vaults for burying the dead. The town contains several places of worship belonging to the three denominations of dissenters, to the Methodists, and other sectaries. The Methodist chapel in Waltham Street is spacious and elegant.

Among the charitable institutions of Hull, that of the Trinity-house is the most ancient. It was established in 1369, for the reception of decayed seamen who have been admitted members of the institution; but it has, for many years past, been set apart for the widows of such seamen as have attained the age of fifty. In 1787, the Trinity-house built an hospital for decayed seamen and their wives; and in the same year they founded a marine school, for preparing boys for the sea service. Thirty-six boys are now educated at this seminary, each member of the corporation appointing one. They continue at school three years, and are annually clothed in a neat uniform. The present house was erected in 1753, and is of a quadrangular form, inclosing a spacious area. The different apartments, and the curiosities which they contain, are well worthy of being examined.

The Charter-house Hospital was founded by Michael de la Pole in 1384, for the support of poor pensioners, under the superintendance of a master. It is a plain building, with two projecting wings, and is built of handsome brick, covered with blue slate. It contains 44 apartments, well fitted up for the accommodation of the pensioners, who are allowed 3s. 6d. per week each, besides coal, turves, and occasional payments. The chapel, which is spacious and neat, is in the body of the building. The minor charities are, Lister's Hospital, for the reception of 12 paupers; Gregg's Hospital; Crowle's Hospital, for 12 paupers; Watson's Hospital, for 14 poor; Gee's Hospital; Harrison's Hospital; and Ratcliffe's Hospital.

The Charity Hall or Work House was established in the reign of King William III. The house is decent and commodious, and has a house of correction adjoining to it.

The public charities supported by voluntary contribution are very numerous. The General Infirmary was established in 1782 upon the most liberal and humane principles. The building is of brick, ornamented with stone, and is neat and handsome. It is situated in a healthy spot, and can accommodate seventy in-patients. The ranges of wards open into a long, wide, and airy gallery, for the purpose of obtaining a perfect ventilation. The total number of patients admitted between 1782 and 1816 is 15,129, of whom 11,248 have been cured, and 193 greatly relieved. The total number of persons vaccinated, up to January 1, 1816, is 5,566.

The Lying-in Charity appears to have been established about 1802. More than 4,281 patients have been admitted since the 5th April 1802, and the number of children born 4,314. The Hull Female-Penitentiary was opened in July 1811. More than 100 females have been admitted, and a great proportion of these have been restored to their friends. The Hull and Sculcoates Dispensary has been recently established, and a Humane Society, for the recovery of persons apparently dead, was founded in 1800.

The *Grammar School* of Hull was founded and endowed in 1436 by John Alcock, Bishop of Ely. The School Room is esteemed one of the best in England. The *Vicar's School* is a free institution, founded in 1734 by William Mason, vicar of the parish, and the father of the poet, for the education of 60 scholars. Coggan's Charity School educates 20 poor female children. Besides these, there are subscription schools in Salthouse Lane, which originated in 1786. They consist of two day schools for girls, each containing 30, and four Sunday schools for boys. The buildings are capacious, and no fewer than 250 boys and 150 girls are educated here on Bell and Lancaster's system.

The other public buildings at Hull are, the citadel, the exchange, the custom-house, the theatre, the gaol, the Hull subscription library, &c. The *citadel*, intended for the defence of the harbour and town, is situated on the east bank of the river. The ancient castle, called the Magazine, is a mere storehouse for arms and ammunition. A battery of 21 guns faces the Humber, and the embrasures on the mounds are well furnished with cannon. The citadel is surrounded with a ditch palisadoed in the middle. The garrison generally consists of a few companies of invalids. The exchange was opened on the 1st of January 1794. It is a brick building, on a most substantial plan, with a spacious flagged area in front of it. The public subscription news room is above the exchange. The custom-house is a spacious and handsome building, situated in White Friar Gate. The theatre, erected in 1809, is a large building in Humber Street. The present gaol, which contains very healthful accommodations, was erected in consequence of an act of parliament passed in 1789. The Hull subscription library was instituted Dec. 6, 1775; and the foundation stone of the present building in Parliament Street was laid on the 21st of June 1800. The library possesses a spacious reading-room, which is open to the subscribers every day. The collection of modern books is excellent, and the number of subscribers is nearly 500.

The avenue from the market-place to the Humber was widened some time ago, by removing the guildhall, on the site of which the most elegant and well ventilated shambles were erected in 1806. The east end of Trinity church is thus exposed to the market-place, in the centre of which is a beautiful equestrian statue of King William III. erected in 1734 by subscription, and executed by Mr Sheemaker.

Hull may be considered as one of the first commercial towns in the united kingdom. It carries on a great intercourse with the Baltic, and sends an immense number of ships annually to the whale fishery.

The wet dock, which was originally intended to receive all the ships engaged in the trade of Hull, was begun in virtue of an act of parliament passed in 1774. The foundation stone was laid on the 19th Oct. 1775, and the whole was completed in four years instead of seven, as required by the act. Government gave a grant of the ground, and of 15,000*l*. It occupies the place where the walls and ramparts once stood, and it enters immediately from the river Hull, about 300 yards from its mouth. It is 700 yards long, 85 wide, 22 deep, and is capable of containing 130 vessels of 300 tons. Including the wharfs and quays, it covers an area of 13 acres, the area of the dock being 48,188 square yards, and that of the quay 17,479. The subscribers are incorporated under the title of the "Dock Company at Kingston-upon-Hull." The number of shares was originally 120; but acts were passed in 1802 and 1805, empowering the Company to raise them to 180. The money arising from this increase in the number of shares, amounting to 82,390*l*., was appropriated to the construction of another wet dock, called the Humber Dock.

The foundation stone of the Humber Dock was laid on the 13th April 1807, and it was completed in 1809, at the expence of 220,000*l*. The area of the dock is 7 acres and 18 perches, and that of the road and wharfs is 3 acres and 33 perches, amounting in all to 10 acres 1 rood and 11 perches. It opens into the Humber by a lock, which will admit a fifty gun ship, and which is crossed by an iron bridge. By extending the dock a little farther to the north, to the extremity of White Friar Gate, the old town may be completely insulated. Hull possesses also several dry docks for repairing vessels. The following Table, shewing the amount of the customs in different years, will exhibit a correct view of the progress of the trade of Hull:

| | | | |
|---|---|---|---|
| 1701 | *l*. 26,287 | 1805 | *l*. 386,070 |
| 1778 | 78,229 | 1806 | 374,907 |
| 1785 | 91,366 | 1807 | 340,825 |
| 1792 | 199,988 | 1808 | 198,487 |
| 1802 | 438,459 | 1809 | 276,811 |
| 1803 | 379,675 | 1810 | 311,780 |
| 1804 | 287,210 | | |

The following Table exhibits the state of the Greenland fishery, from 1806 to 1811 inclusive:

| Years. | Ships. | Whales. | Seals. | Unicorns. | Bears. | Sea Horses | Tons Oil. |
|---|---|---|---|---|---|---|---|
| 1806 | 37 | 239 | 1804 | 10 | 3 | 6 | 3382 |
| 1807 | 35 | 377 | 722 | 24 | 9 | | 4253 |
| 1808 | 27 | 467 | 552 | 13 | 4 | 2 | 4330 |
| 1809 | 26 | 419 | 311 | 9 | 7 | | 4230 |
| 1810 | 34 | 449 | 1238 | 8 | 13 | | 4912 |
| 1811 | 42 | 552 | 993 | 2 | 2 | | 4782 |

The inland trade of Hull exceeds that of any other English port. In the year 1792, merchandise, stores, coals, &c. to the value of 5,156,998*l*., were conveyed to and from the Aire and Calder navigation alone.

The following Table contains the number of ships that entered inwards and cleared outwards, from 1804 to 1810, inclusive.

| Years. | With Cargoes. | | In Ballast. | | Coasting Vessels. | |
|---|---|---|---|---|---|---|
| | Inw. | Outw. | Inw. | Outw. | Inw. | Outw. |
| 1804 | 728 | 279 | 51 | 380 | 1560 | 1547 |
| 1805 | 658 | 232 | 47 | 327 | 1626 | 1602 |
| 1806 | 513 | 226 | 29 | 272 | 1576 | 1636 |
| 1807 | 525 | 158 | 9 | 335 | 1484 | 1614 |
| 1808 | 207 | 67 | 109 | 135 | 1557 | 1733 |
| 1809 | 473 | 256 | 55 | 223 | 1806 | 1938 |
| 1810 | 622 | 193 | 30 | 427 | 1786 | 2033 |

Various manufactures are carried on in Hull. One of the principal is, the expressing and refining oil from lintseed, and preparing the residue for feeding cattle. Many of the mills for this purpose, and for grinding corn, are from about 80 to 100 feet high, and contain excellent machinery. The other manufactories are, an iron foundery, a large soap-work, two sugar-houses, several white lead manufactories, several breweries, and several ropeworks and shipbuilders yards.

The civil authority of the county of Kingston-upon-Hull, which includes a district of more than 18 miles, comprehending the villages of Hessle, Anlaby, Kirk Ella, West Ella, Swanland, and North Ferriby, is vested in the corporation, consisting of the mayor, the recorder, the sheriff, two chamberlains, and twelve aldermen. The town sends two members to parliament, who are elected by the burgesses.

The following is an abstract of the population returns for the town of Hull in 1811:

| | |
|---|---|
| Number of inhabited houses | 4611 |
| Do. of uninhabited houses | 306 |
| Do. of families | 6541 |

| | |
|---|---|
| Number employed in agriculture, . . . | 305 |
| Do. employed in trade and manufactures . | 2608 |
| Do. not included in any of these classes . | 3628 |
| Males . . . . . . . . . . . . | 11,998 |
| Females . . . . . . . . . . . | 14,794 |
| Total population . . . . . . . . | 26,792 |

See the *Guide to Hull*, published by Mr Craggs, who has favoured us with the proof sheets of it before it was published; Tickhill's *History of Hull*; and the *Beauties of England and Wales*, vol. xvi. p. 447—537.

HUMBER, the *Abus* of Ptolemy, is a large river or estuary in England, which runs into the German Ocean after separating the counties of York and Lincoln. Below the confluence of the Ouse with the Trent, the former of which carries off almost all the waters of Yorkshire, the united streams receive the name of the Humber. It is gradually enlarged to the breadth of two or three miles, and below Hull it swells into an estuary about six or seven miles broad. The Humber has been compared to the trunk of a vast tree, spreading its branches in every direction, and commanding the navigation and trade of a very extensive and commercial part of England. See ENGLAND.

HUME, DAVID, an eminent historian, metaphysician, and general literary character, was the younger son of a very respectable Scottish family, and was born at Edinburgh on the 26th of April 1711. He lost his father when an infant, and the care of his education devolved on his mother, whom he describes as a woman of great merit, who performed in a most exemplary manner the duties of an only parent. In his youth he made a creditable appearance as a scholar, and acquired a high ardour for literature. This did not, as often happens, subside as soon as those more serious occupations to which, in the common calculations of mankind, literature is reckoned preparatory and subservient, were presented to his mind. His fortune being slender, he was destined to the profession of the law. But this pursuit, with all the prospects of honour and wealth which it presents to an aspiring mind, had not for him sufficient charms to eclipse the attractions of classical literature and philosophy. Nor was Mr Hume even content to cultivate the two pursuits in conjunction, the one as the means of his future livelihood, and the other as having a more immediate relation to man as a thinking being. The contrast of their intrinsic character had the effect of disgusting him with the study of law, which he wholly neglected in order to devote himself to literature. He therefore renounced entirely these professional pursuits. Not entertaining the hope, however, of supporting himself comfortably by literary occupations, he was prevailed on, at the age of twenty-three, to make a feeble attempt to enter on a mercantile employment in the city of Bristol. This he soon relinquished, as totally unsuited to his turn of mind; and at last, combining a regard for his favourite studies with the dictates of prudence, he formed a plan for leading the life of a literary man. He resided for two years in France, first at Rheims, and afterwards at La Fleche in Anjou, where he practised a strict economy, and prosecuted with much industry his literary studies. In this retreat he probably had not access to extensive libraries, and depended chiefly on a small collection of his own, with such assistance as was furnished by the convents of the country. Here he was chiefly occupied in the composition of that ingenious, but singular and somewhat paradoxical work, his *Treatise on Human Nature*. He acknowledges that, in the midst of these studies, he was not certain of the utility of his labours, and was in some measure puzzled by the interminable problems which his own ingenuity had raised; yet he gave himself up to the bent of an inquisitive mind, regardless of conclusions, trusting that investigation, if free from bias, could not be too keen or persevering, and that all its apparent disadvantages must be accidental and temporary. He studied human nature in a point of view which was in a great measure his own, without consulting the prevailing taste, either in the choice of his subject, or in the style and manner in which he chose to handle it. He has been accused of a passion for singularity; but we find him in this instance regretting, that opinions which he found inevitable were so different from those which prevailed around him. He published his treatise in London in 1738, and then returned to his friends in Scotland. But all the visions of a sanguine author were now severely mortified. He had been prepared to encounter opposition and outcry. These he expected, and he seems to have pleased himself with contrasting his own unanswerable theorems with the shallow replies which would be zealously and from numerous quarters elicited. But his work excited no interest; it was neither known nor read, and, as he himself expresses it, "fell dead-born from the press." He continued, however, to value the opinions which it contained; and endeavoured, by various persevering efforts, to conciliate to them the public attention. The admirers of his metaphysics reckon it the most profound of his works, and consider his subsequent writings on the same subject as losing in depth what they gained in popularity of manner.

His disappointment, though keenly felt, was surmounted by a cheerful and sanguine temper; and he prosecuted, with renewed industry, his literary labours in the country. In 1742, he published the first part of his *Essays*, which met with a reception sufficiently favourable to console him for his first disappointment. In 1745, he resided as a companion to the Marquis of Annandale in England for twelve months; and, from his appointments during that time, acquired a considerable accession to his small fortune. About this time the professorship of moral philosophy in the university of Edinburgh becoming vacant by the resignation of Dr (afterwards Sir John) Pringle, Mr Hume became a candidate for that situation; but the sceptical principles which he had advanced in his first work were too offensive to allow the magistrates, who were the patrons, or those learned persons whom they consulted, to receive him as a public instructor of youth, and that application was consequently ineffectual.

In 1746, he accompanied General St Clair, as his private secretary, in an expedition destined for Canada, which terminated in an incursion on the coast of France. In 1747, he attended the same gentleman in his military embassies to the courts of Vienna and Turin. From this cause his literary occupations were suspended for two years; but he enjoyed with much relish, that polished society which he highly ornamented, and in which he was a general favourite. At this time he attempted to give a more popular form to his first speculations, in a work entitled *An Inquiry concerning the Human Understanding*; which, however, had little better success than the original *treatise*. A new edition of his *Essays* was also published, which met not with a much better reception. Mortified in some degree, but not discouraged, by these miscarriages, he continued his efforts to rouse the attention of the world to his favourite subjects. He had now returned to his brother's house in Scotland, where he composed his *Political Discourses*, and his *Inquiry concerning the Principles of Morals*. His opinions had gradually worked themselves into notice; an effect which the plausibility of his reasonings, the charms of his language, and the importance of the subjects, could not fail to produce. Being adverse to the prevailing philosophy, as well as bearing strongly on the religion of the age, and considered by many persons as alarming in their tendency, they could not, of course, be permitted to extend their influence, without having their validity subjected to the most rigid scrutiny. Mr Hume, either unalterably confident in the justness of his views, or considering them as less important than his fame, was principally disposed to look on the appearance of a succession of replies, as flattering symptoms of his rising reputation, and derived from them encouragement to proceed in his career. In 1752, his *Political Discourses* were published. This was the first of his works which gained immediate attention, and general approbation. He also now published his *Inquiry concerning the Principles of Morals*, a work which met with little notice, though more highly valued by the author than any other. It appeared to correspond too much with the sceptical principles of his other writings on moral subjects, by referring all moral distinction to utility. It certainly, however, displayed much acuteness of research, and contributed to remove much of the rubbish by which questions of this nature had been encumbered. The dangerous character which Lord Kames, and some others of his opponents, attached to a theory which reduced all moral differences to utility, as leaving them to the arbitrary decisions and varying judgments of individuals, is more or less applicable to every theory on the subject. The agreement or disagreement of mankind on particular moral questions, is rather matter of fact than of theory. The apprehensions of any dangerous tendency attached to the theory of Mr Hume, imply, in their most obvious sense, a contradiction in terms. Utility is, in itself, real and precise, however obscurely understood; and in its very essence excludes all idea of danger. We have, indeed, heard particular acts represented as inculcated by utility, while their danger was capable of being painted in the most convincing terms. These arguments only prove, that the character of utility may be rashly applied, while some circumstances essential to it are omitted. Utility, indeed, is not a simple original principle. It is a general feature, applicable to a variety of phenomena, among which human actions are to be numbered; and even with those who grant that there are prior principles of our nature which serve to suggest moral distinctions, all such suggestions must be allowed to become the subjects of computation; and in all discussions of the propriety of particular actions, utility is the ultimate test to which we are referred, and is necessary to stamp them with the character of rectitude.

In the same year, he was made librarian to the Faculty of Advocates of Edinburgh, a situation which not only gave him command of the invaluable library belonging to that body, but forcibly directed his attention to the character of the works which it contained. It was now that he began to write his *History of England*, that highly pleasing performance, which, however censured in some of its parts and tendencies, is read with delight by all classes of persons, and does high credit to the country which gave birth to its author. The first volume that was published, commenced with the accession of the house of Stuart, and contained the reigns of James I. and Charles I. It appeared in 1754. The public, however, were not so easily won by the splendour of his narrative, and that air of easy philosophy which dictated the remarks of the historian, as to give any quarter to his obnoxious sentiments. He offended the Christian world, by treating religious systems too lightly, and even the advantages which this characteristic might at first seem to promise to the spirit of toleration, were found to be coldly withheld. His displeasure is chiefly directed against the complaints, and even the non-conformity, of the people; and he palliates in the conduct of princes all deviations from patriotism and law, as well as that offensive arrogance which set at nought the object of general satisfaction. He construes the slightest incongruity in the complaints of the nation, which was capable of being turned to ridicule, into a vindication of the most arbitrary and intolerant conduct on the part of the sovereign. The party questions relating to the rights which king or people respectively derived from precedent and law, were of much less moment than the spirit in which the contending parties maintained their point. Appeals to the original and universal rights of man are reckoned dangerous, as being subject to the widest differences of opinion, and therefore *precedents* in favour of liberty had been chiefly appealed to by the Whigs. Precedents, however, were to be found on both sides; and Mr Hume points out the shallowness of any pretence to make the ultimate decision of great and general questions in politics depend on them. It is with the degree of correctness and generosity of the spirit in which the king and the people approached to one another for the adjustment of their differences, that an unbiassed historian is chiefly concerned in measuring to each party his share of approbation and of censure. This was certainly so offensive and unconciliating on the part of the Stuarts, as to amount to a forfeiture of all submission, and even of all sympathy, from the party which they laboured to crush. That the dissensions of the times rendered the duties of a sovereign arduous, must be acknowledged, and strong measures might have been on some occasions necessary. But the measures of these princes had neither the merit of strength, nor the inoffensiveness of total inactivity. They were both irritating in their tendency, and destitute of efficiency. The exertion of a despotic authority, if evidently directed to ends substantially good, might have saved the country, and preserved the dynasty. But the Stuarts made their right of power a matter of ostentation, rather than an instrument of good government, and thus insulted the nation, instead of ruling it. There were errors on all sides. The people were often fanatical, and their complaints were sometimes inconsistent. All these facts should come alike under the scrutiny of the historian. But the plausible coolness of Hume degenerates into a cavalierly insensibility: his sarcasms are directed only against the great mass of the nation, while his sympathetic feeling and indulgence are reserved for kings and their ministers.

Dr Herring and Dr Stone, the one primate of England and the other of Ireland, were the only persons from whom the author heard favourable sentiments of his work. Both of these gentlemen wrote to him not to be discouraged. The impression made on his mind by the unfavourable reception of his work, was however very deep. Although on looking to the periodical publications of that day, we find the due tribute repeatedly and even liberally given to his merits as a writer, he seems not to have been at all prepared to meet with any opposition or neglect. He showed on this occasion, the overweening importance which authors are disposed to attach to their own powers, and how little they calculate on the difficulty of making any impression in opposition to the general sentiments of the public. He confesses that his mortification would have now determined him to retire to a corner of France, to change his name, and never more revisit his native country, had not a war breaking out between the two nations, prevented the execution of any such scheme.

He next published his *Natural History of Religion*, which was attacked with considerable acrimony by Dr Hurd, and, though otherwise not much attended to at the time, produced, at a subsequent period, no slight sensation in the religious world, as tending to reduce the general principles of religion to an uncertain and even a frivolous origin in the human mind.

A second volume of the History of England, which brought it down to the revolution, was published in 1756. This, containing fewer obnoxious sentiments, was better received than the first, and even served to impart to it a degree of adventitious character.

In 1759, he published his *History of the House of Tudor*. In this publication he displayed considerable address in supporting his Tory principles. While he details facts which demontrate the duplicity of the character of Elizabeth, he gives her a character far higher than these facts can warrant. At the same time he describes her conduct, as well as that of her predecessors of the same family, as so offensively harsh, that the maxims of the Stuarts, reckoned by many tyrannical, must on the contrast appear mild and liberal. He neglects to give the due weight to the beneficial tendency and the magnanimous justice which marked some of her most arbitrary acts, and the activity which she displayed in managing the vital interests of the state. These characteristics were widely different from the vexatious and idle exaction of reluctant homage which the Stuarts delighted to make from their subjects. Habit had now rendered Mr Hume callous to the impressions of public opinion, which he affected to despise; yet he owed his equanimity in some measure to the increased forbearance of his opponents, and the tribute of admiration which some of his qualities as a writer extorted from all. In 1761, he published the two volumes which contain the earlier part of the English history. The copy money given to him by the booksellers much exceeded any thing of the kind formerly known in England, and his circumstances were in consequence rendered opulent.

At this time a storm of ecclesiastical censure was preparing by some members of the church of Scotland, directed against Mr Hume, and intended to include Lord Kames, and various other writers, who, though differing in their opinions, agreed in treating religious subjects with coolness, and subjecting them to metaphysical analysis. A motion was made in the *committee of overtures* of the General Assembly, in which Mr Hume was named as the most obnoxious author. It was proposed to call him before that court, to answer a list of accusations, on the tendency of the principles which he had published. This, however, was afterwards abandoned, as it was supposed that the influence of such discussions was limited to a narrow circle, and that there could be no propriety in extending them to the common mass of readers, who might, from the sympathy naturally felt for a man subjected to violent opposition, be led to an undue bias in favour of his opinions.

In 1763, he attended the Earl of Hertford on his embassy to Paris, where he was loaded with great civilities. He expresses himself highly pleased with the politeness and information which characterised the society of that metropolis.

In 1766 he returned to England, and then to Edinburgh. On this occasion he brought with him the celebrated Rousseau, who was exposed to some trouble in Switzerland and France, for the opinions which he had published on religious subjects, and had it in contemplation to take up his abode in a retired situation in England. Mr Hume, admiring his genius, and attached to him by fellow feeling as a free-thinker, exerted himself to provide for his comfort. But the morbid sensibility of Rosseau disappointed every scheme of kindness that could be adopted. He conceived himself to be neglected by the world, and was prone to suspect his best friends of intending to undermine his interests, and subject him to ridicule and scorn. Mr Hume soon perceived the troublesome temper of his friend; yet he treated him with great tenderness, making allowance for an excess of natural irritability, heightened by a severe bodily disorder under which he laboured. He even found that one of his complaints, that of extreme poverty, was an entirely false pretence, held out for exciting the interest of others. These frailties Mr Hume deplored, but did not cease to do what lay in his power to serve him. At last Rousseau suspected Mr Hume of being the author of a very improper sarcastic letter, which was circulated in the name of the King of Prussia, as addressed to Rousseau, and was the work of Mr Horace Walpole. Suspicions of all kinds accumulated in his gloomy mind, till they burst forth in a storm of invective in the form of a long letter to Hume. To this Hume published a reply by the advice of the Parisian literati, though contrary to that of Mr Walpole, who thought Rousseau's letter a sufficient answer to itself, and the whole business unworthy of notice. Nothing could have rendered it necessary to answer an effusion so absurd, and so evidently the offspring of disease, except the celebrity of Rousseau, the interest which his admirers took in every thing he did and felt, and their disposition to vindicate the most far-fetched of his insinuations as the dictates of sentiment and sagacity, as to reiterate with zeal his reproachful complaints against other less favourite characters. This friendly connection was thus inevitably dissolved. Every part of it bore testimony to the humanity, tenderness, and sincere friendship of Mr Hume, who, far from neglecting to make due allowances, seems to have exceeded the ordinary limits of human patience.

In 1767, he was invited by Mr Conway to be under secretary of state; a situation which he accepted and held till 1769, when he returned to Edinburgh.

In 1775, his health began to decline. He was attacked with a disorder in his bowels, which gradually increased, and which he perceived at last, at the time that he drew up his short account of his life, to be mortal and incurable. But he continued his former occupations and amusements, and enjoyed unabated good spirits both in his private studies and in company. He lived in a house in James's court in Edinburgh, surrounded by the friends whom he most highly valued. The literary society of Edinburgh at this time contained a few men of the first genius and talent, along with many other persons who made the various objects of liberal study their principal delight. Dr Robertson, principal of the university, the historian, was one of the most eminent, and notwithstanding the wide difference of opinion which existed between him and Hume on the most important subjects, yet as all hope of proselytism on either side was cut off, they avoided all disputes which tended to agitate the passions, and by mutual consent enjoyed the pleasure and improvement, which in other respects they were fitted to impart to one another. The zeal of Dr Blair prevented him from being equally circumspect; and Hume found himself obliged to intimate to that worthy clergyman the necessity of abstaining from all topics which implied serious differences of sentiment, if they were ever to enjoy one another's society. This is decidedly, though delicately, expressed in the letter which he wrote to him, after the perusal of the work of Dr Campbell on Miracles, which Dr Blair had sent to him. Dr. Joseph Black, the celebrated professor of chemistry, and Dr Adam Smith, were among the most intimate of his friends. The latter, however, was now engaged in the composition of that work which has associated his name, in an indelible manner, with the great interests of society, his *Inquiry into the Nature and Causes of the Wealth of Nations*, and lived in a state of retirement with his mother at Kirkcaldy, a town on the opposite shore of the Frith of Forth. This separation was vexatious to Hume, who often ineffectually urged his friend to take up his residence in Edinburgh. They had both written on the origin of moral ideas; they had embraced different opinions, and found it interesting to make the discussions implied in them part of the subject of their conversation. They were both ready to enter on any subject to which the ingenuity of either was directed, and a delightful diversity of topics was undoubtedly suggested by the fates, characters, and all the *memorabilia* of many literary friends, whom, on former occasions, and in different parts of the country and of Europe, they had known. Lord Kames, Mr Smellie, Allan Ramsay the painter, (son of the Scottish poet,) were also among the number of the literati who, in the days of Hume, adorned the circle of this metropolis. The manners of literary men were particularly easy, and they had the character of great frankness and ready accessibility. No cause of political enmity operated as a source of division; differences of religious opinion were tempered in their expression by good manners; the facility of intercourse was not obstructed by affectation, or a harsh incommodious etiquette; literary controversies and private debates were managed without occasion of offence. If any excess existed, it seems to have been on the side of familiarity, which admitted of an indulgence in a coarse species of raillery. From this school issued the following curious sentiment, to be found in Lord Kames's *Art of Thinking:* "You are a fool, you dream, and such like, are expressions we may easily bear from friends. Among free spirits I love freedom. Let the words go the full length of the thought. In a manly society, familiarity is agreeable, because it has nothing effeminate or ceremonious." These manners may be consistent with correctness when of spontaneous origin; but when recommended and studied, they become flat and unmeaning. Familiarity degenerates into insipidity, and those who have indulged it begin to envy the ceremony which, though at first stiff and forbidding, preserves mutual respect, and obviates the cloying influence of extreme freedom. Men oscillate from one inconvenient bias to another, and those who can do it without going far into either extreme are the most happy. Such, in general, is the literary society of Edinburgh. Sober convivial clubs of men of taste and genius have at different times been formed, some of which have been supported with much greater steadiness than the precarious nature of such institutions renders generally practicable. They are soon broken up by the admittance of unaccommodating characters, and on the other hand, they are apt to lose the stamp of liberality, when conducted on a principle of fastidious selection. It is therefore chiefly by a quick succession of them, formed by the buoyant spirit of liberal sociality readily surmounting occasional causes of separation, that they prove agreeable and useful.

The philosophical opinions of Mr Hume subjected him to many controversial attacks. To these he never published any formal reply, but satisfied himself with making occasional private observations, and availing himself of public criticism for amending his works in subsequent editions.

In the manner in which he expressed himself towards those who wrote against him, he shewed himself extremely sensible to the pleasing influence of civility, and the galling effects of disrespect or rudeness. He was pleased with Dr Campbell's *Essay on Miracles*, with an anonymous tract, entitled *A Delineation of Morality*, written by Mr Balfour, an advocate and professor of moral philosophy. But such severities as those of Hurd, Warburton, and Beattie, teeming with petulance and abuse, produced in his mind the strongest feelings of alienation and contempt. His good humour probably too much depended on the cultivation of that radical hauteur which sometimes forms the man of fashion, and was too little cherished by that steady forbearance, and that system of universal allowances, which would have better suited the character of a philosopher.

The progress of his bodily disorder was rapid. In April 1776, he set out for London at the intreaty of his friends, who hoped that a long journey might improve his health. At Morpeth he met with Dr Adam Smith, and Mr Home, the author of the tragedy of Douglas. The latter remained with him in England, while Dr Smith returned to the north. Mr Hume finding himself seemingly improved when he arrived in London, went next to Bath to drink the waters, which contributed still farther to a temporary recovery. But his complaint relapsed with additional violence, and he returned to Edinburgh under a deliberate expectation of soon finishing his days. He employed himself in correcting his works, reading books of amusement, and conversing with his friends. He encouraged his friends to speak to him in the frankest manner as to a dying man. It is evident that he did not entertain a belief in any future state. Yet the constant expressions of a hope of this sort which a man is accustomed to hear in the course of early education, and in the common intercourse of life, render the mind familiar with an imagery founded on that hope to which the most sceptical occasionally recur for amusement, even while they reject a belief which appears to them incongruous. Some of them playfully indulge in supposing themselves to have been imbued with the belief of a mythology belonging to a different age or country, and thus balance the influence of present systems against that of others. Mr Hume had too much respect for society to indulge in any open scurrility directed exclusively against the religious sentiments of the age: but he playfully retailed the conversations which were likely to take place between himself and Charon, the ferryman of the river Styx, at the moment of his transit from the present to the unknown world. He did not affect any great wish to speak on the subject for the purpose of displaying his indifference or his courage, and only touched on it occasionally in reply to the enquiries of his friends. His strength very gradually declined. When no longer able to converse, he continued to read in a state of composure; and after four or five days passed under this degree of debility, he died on the 25th of August 1776.

In stature Mr Hume was above the ordinary size. His countenance was open and free, a just picture of his benevolent and cheerful temper. His features were large, and were exempt from that trifling smartness and habitual intensity of expression which characterise a bustling fashionable ambition. Lord Charlemont, on this account, considered them as blank and unmeaning, and wondered that the ladies at the court of Turin valued so much his company and conversation. His attractions seem to have consisted in the liberality of his mind exhibited in the jolly openness of his countenance. See Hardy's *Memoirs of Lord Charlemont*, and the critique on them given in the *Edinburgh Review*.

The manner in which he died has sometimes been made the theme of injudicious comment, for the purpose of elucidating the merits of particular views of philosophy or religion. The equanimity displayed in his last moments has been boastfully represented as a triumph to infidelity, and a proof that a philosopher may die in tranquillity. Such were the sentiments inculcated in a tract, entitled *An Apology for the Life and Writings of David Hume.* But the eagerness with which a single instance of this kind is grasped at might be plausibly construed into a presumption of the general fallacy of the remark. On the other hand, it is equally unfavourable to candour to embrace, with exclusive keenness, those anecdotes, whether well or ill supported, which represent persons of these sentiments as doomed to the agonies of remorse in the hour of death. This spirit has given rise to some misrepresentations of fact, which fall under the character of pious frauds. We are told, that though a man may lead the life of a fool, by advocating the cause of Deism, yet a fool he cannot die; and then an anecdote is told of some noted infidel, which bears the marks of evident fabrication. That this direction of zeal is wholly superfluous and insufficient in the support of religion, we may be satisfied, when we reflect, that such anecdotes are only circulated concerning those who are infidels by profession. It is maintained that many who, from motives of policy, apparently acquiesce in the religion of the age, do not believe it in their hearts. Such persons might be supposed to labour under the double weight of infidelity and hyprocisy; yet we hear nothing of their death-bed agonies. Allowing, therefore, facts of that kind to which we have alluded to be as general as they have been sometimes represented, they must be otherwise accounted for than by being considered as the unmingled effects of the power of truth on the human conscience. They will be explained in a more satisfactory manner, if ascribed to the influence of that contrariety which an individual of solitary professions feels between himself and the rest of society, oppressing a mind bereft of its energy by the decay of nature. Weak man, even in his most vigorous moments, needs company to support him in the enjoyment of his opinions; and the influence of this principle enters much deeper into the private comfort of individuals than most men are willing to allow. We should always beware of resting questions of so grave moment on data thus precarious.

The character of David Hume as a man has been variously estimated. About his agreeable qualities there could be no difference of opinion; and those who abhorred his principles allowed that he possessed as much worth as was compatible with infidelity. The chief difference, therefore, depends on the amount of that degree of praise. One tells us that he was a pattern of good humour, benignity, and self-command; and as near to perfection as the lot of humanity will admit. Such is the character assigned him by his friend Dr Smith. Another writer says, we may find fault with the measure of his faith, but we cannot deny him the credit of good works. To this Bishop Horne replies, that the promotion of religion is the best of works; and a conduct the reverse of this the worst and most infamous. As for religious principles, and every quality that is strictly implied in them, Mr Hume's character must be given up: and if such terms as virtue, morality, and goodness, are to be so restricted, he cannot be allowed the credit of them. But if we take such words in the sense in which they have been used by the world at large, and by men who scarcely entertain any religious knowledge or sentiment, we must acknowledge Mr Hume to have been honourably distinguished from the great mass of mankind, whether infidel or religious. Some have remarked, that, by his own confession, his ruling passion was the love of fame, and that this is at best a selfish principle. The validity of this reflection involves a question concerning the comparative propriety of preferring the ends of self-love or the good of others in adjusting the motives of human conduct. We seldom object to a man's character because he has a ruling passion, although it should not be the most dignified in its nature. With regard to selfish ends, even a man who enters on holy orders is allowed to be possessed of real worth, though his chief motive is the procuring of a living, provided he is attentive to his professional duties: and some of our gravest and best moralists represent the cultivation of a fund of internal happiness as the first duty of a man, and a far more copious source of benignant conduct than could be formed by cultivating social feelings as the first and leading object of attention, and making personal happiness a subordinate consideration. With the amplest allowance for differences of opinion, and taking benevolence in the most accommodating acceptation which licentiousness itself could desire, possessing also the fullest conviction of Mr Hume's personal sincerity, we cannot consider the general strain of his philosophical writings as indications of a pure benignity, even though we should proceed on the hypothesis of the truth of his speculative views. They had an evident tendency to make many persons unhappy: hard struggles are required from an admiring reader to surmount this tendency,—struggles for which the author furnishes but feeble assistance. Though he entertained no belief in the most consoling doctrines which had been cherished among mankind, benignity would not have led him to begin with overturning them, but rather with showing that happiness might be enjoyed independently of them, and thus he might have been considered as contributing to the creation of habits of feeling which were more to be relied on for their permanence, and as labouring to prepare the mind more completely for the comfortable exercise of a curiosity free from control. Yet by persons whose reading on these subjects is extensive, the works of Mr Hume may be read with advantage. The German philosophers, whose conclusions are the most liberal and pious, look up to Hume as an author, who materially contributed to guide intellectual research, though his system stood in need of some ulterior steps to bring us to the truth; and they speak with great contempt of the data on which the British writers endeavoured to subvert his doctrines. We find such observations as these emanating from the school of Kant, which, though chargeable with obscurity, is not destitute of acuteness.

The censure which we have expressed is most of all applicable to two tracts published after his death, one *On the Immortality of the Soul*, and the other *On Suicide*. The former is little more than a compression of doctrines which he had advanced, or to which he had at least pointed in his other works, but expressed in more dogmatic language. His tract *On Suicide* contains an argument which he had not formerly touched upon; and it must be admitted to have a most pernicious tendency. We read without unpleasant emotions the sentiments which the Romans entertained on this subject, because they cultivated a species of manliness, mistaken indeed, but plausible, and apparently consistent. Mr Hume, on the contrary, encourages that temper which leads to suicide, not by cultivating a heroic contempt of death, but by laying the mind open to the most wretched discontent. He maintains, that those whose happiness is marred by the gloom of superstition have the most urgent motives to rid themselves of life, yet are cruelly prevented by the dread which their belief of future punishment inspires. This remark, inculcated with all the zeal of apparent sincerity, tends to generate the utmost degree of moral confusion; and the motive which could have prompted any writer to commit such a sentiment to paper cannot well be assigned, except by referring it to the perverseness which is so incident to the human mind. If the superstitious are deceived in the dread which they entertain of suicide, they must also be deceived in entertaining a belief in those gloomy opinions which render their lives miserable; and a philosopher, wishing to emancipate them from their errors, can have no reason for recommending suicide, since he relieves them from the evils which generated a weariness of life. The only tendency that such a sentiment can have is, by superadding a new doubt to their former perplexities, either to produce a still more wretched life, or give rise to an act of suicide, committed in a tumult of horror, and degraded by cowardice. Whoever the person was that published this posthumous piece, he could not have any motive that could bear examination.

It is as a historian that Mr Hume is most generally popular. The beauty of his diction, and the interest which his elegant turn of thought imparts to the course of events described, render it on the whole the most pleasing book of English history in our language. Many who are sensible of the faults formerly mentioned, do not substitute any other for it in their recommendations to general readers. It might perhaps be rendered less exceptionable in its tendency, and more valuable for common use, if accompanied with *corrective* notes, and references in the most faulty places, to other authors. It would require much delicacy, however, to do this without spoiling the effect, by a harsh interruption of the current of the narrative, and an interference with the general spirit of the historian. Fox's historical fragment, published uniform with some popular edition of it, would greatly contribute to render it worthy of general perusal, by correcting the distrust produced by the peculiar colouring of the author.

See *Hume's Life*, *written by himself*, prefixed to his History; Smellie's *Lives;* Ritchie's *Life of Hume;* and a variety of anecdotes scattered in different biographical tracts, as Professor Stewart's *Lives of Dr Robertson and Dr Smith*, Lord Woodhouslee's *Life of Lord Kames*, and the Memoirs of Mr Gibbon in his *Posthumous Works*. (*H. D.*)

HUMIDITY. See HYGROMETRY.

# HUNGARY.

THE Huns, from whom the kingdom of Hungary derives its name, are the Hiong-nau of the Chinese, and were a nation of Tartars, who had their ancient, perhaps their original, seat in an extensive barren tract of country, immediately on the north side of the great wall of China. But the valour of the Huns extended their dominions; and their chiefs, who assumed the appellation of Tanjou, gradually became the sovereigns of a formidable empire. Towards the east, their victorious arms were stopped only by the ocean. On the west, near the head of the river Irtish, their enemies were numerous: in a single expedition, twenty-six nations or tribes are said to have been subdued. On the side of the north, they are said, but on dubious authority, to have extended their empire to the ocean; it is more probable that the Lake Baikal was the limit of their conquests in this direction. Towards the south, they were most desirous of extending their empire; and, in the third century before the Christian æra, a wall of 1500 miles in length was constructed to defend the frontiers of China against the inroads of the Huns.

Their cavalry frequently consisted of 200,000 or 300,000 men, who managed their bows and their horses with matchless dexterity; they supported the inclemency of the weather with hardy patience; and marched with incredible speed, being seldom checked by any obstacle. The Chinese were unable to oppose them, or to protect their empire, notwithstanding the defence of the great wall. A regular payment of money and silk was stipulated as the condition of a temporary and precarious peace; and by a more disgraceful and degrading condition, a supply of women was annually given to the Huns; and the Tanjou was united in marriage with the imperial family of China. In the verses of a Chinese princess, who laments that she had been condemned by her parents to a distant exile under a barbarian husband, some particulars of the mode of life of the Huns at this period are given: she complains that sour milk was her only drink, raw flesh her only food, and a tent her only palace.

In the long reign of Vouti, the fifth emperor of the powful dynasty of the Han, which continued for the space of 54 years, from the year 141 to the year 87 before Christ, the Huns were frequently defeated by the Chinese. About the year 87, the camp of the Tanjou was surprised in the midst of sleep and intemperance, and though he cut his way through the ranks of his enemy, he left above 15,000 of his troops on the field of battle. But the power and empire of the Huns were not weakened so much by their defeats, as by the policy pursued by the Chinese emperors of detaching the tributary nations from their obedience; and these generally became their inveterate and formidable opponents. The Tanjou himself was at last obliged to renounce the character and privileges of an independent monarch, and to perform the duty of a respectful homage to the Emperor of China. The monarchy of the Huns after this gradually declined, till, about A. D. 48, it was broken by civil dissension into two hostile and separate kingdoms. One of the princes retired to the south with eight hords, which composed between 40,000 and 50,000 families: he fixed himself on the verge of the Chinese provinces, and attached himself to the service of that empire. The Huns of the north continued to languish about fifty years, till they were oppressed on every side by foreign and domestic enemies. The *Sienpi*, a tribe of oriental Tartars, retaliated upon them their former injuries; and, in the year A. D. 93, the power of the Tanjous, after a reign of 1300 years, was utterly destroyed. The emigrations of the Huns now began: above 100,000 persons, the poorest of the people, were contented to remain in their native country, to renounce their name, and mix with their conquerors. Fifty-eight hords, about 200,000 men, retired towards the south, and claimed and received the protection of the Chinese emperors. But the most warlike and powerful tribes of the Huns sought more distant countries, and moved westward in two great divisions. The first of these colonies established their dominion in the fruitful and extensive plains of Sogdiana, on the eastern side of the Caspian Sea. Here their manners were softened, and even their features were sensibly improved; and they obtained the appellation of *White* Huns, from the change of their complexions. The only vestige of their ancient barbarism was the custom which obliged all, or nearly all, the companions who had shared the liberality of a wealthy lord, to be buried alive in the same grave. Their vicinity to the kingdom of Persia involved them in frequent and bloody contests, in the course of which they gained a memorable victory, but, unlike their ancestors, they were moderate and mild in their use of it.

The second division of the Huns gradually advanced towards the north-west; and, by their intercourse with tribes more savage than themselves, their native fierceness was exasperated. As late as the 13th century, their transient residence on the eastern banks of the Volga was attested by the name of Great Hungary. In the winter they descended with their flocks and herds towards the mouth of that river.

It is impossible to give even an outline of the history of the Huns from this period till they became known to the Romans; but there is reason to believe that the same force which had driven them from their native seats, still continued to impel their march towards the frontiers of Europe. In their first irruption into the Roman empire, they are mentioned by ancient historians under a variety of appellations, all comprised under the general name of *Ugri* or *Hunni*. The more general distinction, however, was the Nephthalite or White Huns, who possessed a rich country on the north of Persia; and the Sarmatian or Scythian Huns. The latter are exhibited to us under the character of savages, without faith, laws, or any form of religion: living in the open air without houses, or huts, which they denominated the sepulchres of the living; quite unacquainted with the use of fire, their only food being roots and raw meat, and their only clothing the skins of animals. They were also distinguished by their broad shoulders, flat noses, small black eyes deeply buried in the head, and the want of beards. This race, inured to all manner of hardships and deprivations, and having no fixed settlements, were delighted with the first accounts which they received of the rich and fertile kingdoms of the west. Crossing, therefore, the Volga under Balamir, one of their chiefs, they overwhelmed the Alans and Goths, who inhabited the extensive country between the Volga and the Danube; and, having either driven them out, or forced them to submission, established themselves in Dacia in A. D. 376. Theodosius I. dreading their presence in the frontiers of the empire, and wishing to attach them to his service, encouraged many of them, by large sums of money, to enter into the Roman armies. They continued for some time in their new possessions without molestation to the empire, till A. D. 391, when they passed the Danube, and being joined by the Goths, committed dreadful ravages in Mœsio and Thrace.—They were soon stopped, however, by the army of Stilicho, the imperial general, who overthrew them with great slaughter, and would have completely destroyed them, had not Theodosius agreed to terms of reconciliation.

Not discouraged by their late disasters, they broke unexpectedly into the eastern provinces, penetrated as far as Antioch, destroying all with fire and sword, and committing everywhere unheard of cruelties. St Jerome, speaking of this irruption, says, "All the East trembled when the dismal news were brought, that swarms of Huns, coming from the far distant Mœotis, and dwelling between the frozen Tanais and the country of the savage Massagetes, flew up and down, and filled all places with blood and slaughter.—The cruel enemy roved without controul, where they pleased, preventing by their speed the report of their coming. They had no regard either to religion or dignity; no age they spared, nor were they softened by the tears of the crying infant; but put those to death who had scarce begun to live, and who, not apprized of their danger, smiled, when in their enemies' hands, at those very weapons that were immediately to destroy them." After having overrun and plundered several provinces, they returned home loaded with spoil, and carrying with them an immense number of prisoners. From this time they made regular incursions into the empire, always extending their settlements; and in 432, we find them in possession of Panonia, on the south side of the Danube. Their arms, however, were sometimes also employed in defence of the empire. They joined the army of Ætius against the Burgundians and Goths; but no sooner was their pay as auxiliaries withdrawn than they renewed their hostility, and Theodosius II. was compelled to buy a peace from Rouas their king, with an yearly pension of 350 pounds weight of gold.

Rouas was succeeded by his nephew Attila, the fiercest and most magnanimous of their kings. The countless nations between the Danube and the Volga obeyed his summons, and he became the terror alternately of the Eastern and Western Empires. The court of Constantinople complied with his demands with servile submission; but the court of Ravenna prepared to repel his inroads by force; and at the memorable battle of Chalons, Attila for the first time sustained a complete defeat, and was compelled to recross the Rhine before Ætius the Roman general. For the exploits of Attila, and the progress which the Huns made under his dominion, see Attila.

Some idea, however, of the manners and civilization of the Huns, during the reign of Attila, may be formed from the account which Gibbon has given us of the entrance of that monarch into his capital, and of the royal feast. "The entrance of Attila into the royal village was marked by a very singular ceremony. A numerous troop of women came out to meet their hero and their king. They marched before him, distributed into long and regular files: the intervals between the files were filled by white veils of thin linen, which the women on either side bore aloft in their hands, and which formed a canopy for a chorus of young virgins, who chanted hymns and songs in the Scythian language. The wife of his favourite Onegesius, with a train of female attendants, saluted Attila at the door of her own house, on his way to the palace; and offered, according to the custom of the country, her respectful homage, by entreating him to taste the wine and meat which she had prepared for his reception. As soon as the monarch had graciously accepted her hospitable gift, his domestics lifted a small silver table to a convenient height, as he sat on horseback; and Attila, when he had touched the goblet with his lips, again saluted the wife of Onegesius, and continued his march."——

"The Romans both of the East and of the West, were twice invited to the banquets, where Attila feasted with the princes and nobles of Scythia. Maximin (the Roman ambassador) and his colleagues were stopped on the threshold, till they had made a devout libation to the health and prosperity of the king of the Huns; and were conducted, after this ceremony, to their respective seats in a spacious hall. The royal table and couch, covered with carpets and fine linen, was raised by several steps in the midst of the hall; and a son, an uncle, or perhaps a favourite king, were admitted to share the simple and homely repast of Attila. Two lines of small tables, each of which contained three or four guests, were ranged in order on either hand; the right was esteemed the most honourable, but the Romans ingenuously confess, that they were placed on the left; and that Beric, an unknown chieftain, most probably of the Gothic race, preceded the representatives of Theodosius and Valentinian. The barbarian monarch received from his cupbearer a goblet filled with wine, and courteously drank to the health of the most distinguished guest, who rose from his seat, and expressed in the same manner his loyal and respectful vows. This ceremony was successively performed for all, or at least for the illustrious persons of the assembly; and a considerable time must have been consumed, since it was thrice repeated as each course was set upon the table. But the wine still remained after the meat had been removed; and the Huns continued to indulge their intemperance long after the sober and decent ambassadors of the two empires had withdrawn themselves from the nocturnal banquet. Yet before they retired, they enjoyed a singular opportunity of observing the manners of the nation in their convivial amusements. Two Scythians stood before the couch of Attila, and recited the verses which they had composed, to celebrate his valour and his victories. A profound silence prevailed in the hall; and the attention of the guests was captivated by the vocal harmony, which revived and perpetuated the memory of their own exploits: a martial ardour flashed from the eyes of the warriors, who were impatient for battle; and the tears of the old men expressed their generous despair, that they could no longer partake the danger and glory of the field. This entertainment, which might be considered as a school of military virtue, was succeeded by a farce, that debased the dignity of human nature. A Moorish and a Scythian buffoon successively excited the mirth of the rude spectators, by their deformed figure, ridiculous dress, antic gestures, absurd speeches, and the strange unintelligible confusion of the Latin, the Gothic, and the Hunnic languages; and the hall resounded with loud and licentious peals of laughter. In the midst of this intemperate riot, Attila alone, without a change of countenance, maintained his stedfast and inflexible gravity; which was never relaxed, except on the entrance of Irnac, the youngest of his sons: he embraced the boy with a smile of paternal tenderness, gently pinched him by the cheek, and betrayed a partial affection, which was justified by the assurance of his prophets, that Irnac would be the future support of his family and empire. Two days afterwards the ambassadors received a second invitation; and they had reason to praise the politeness, as well as the hospitality of Attila."

On the death of Attila, Ellac, by the will of his father, succeeded to an extensive empire, which, however, was soon embroiled in civil war by the ambition of his younger brothers. They insisted upon an equal division of their father's dominions, and immediately took up arms to support their demand. This afforded a favourable opportunity to the nations that had been subjected by Attila to throw off the yoke. Ardaric, king of the Gepidæ, accordingly declared that he would no longer obey the sons of Attila; and other nations, led by his example, hastened to join his standard. Ellac, who possessed both intrepidity and experience in war, marched against him with all his forces. The two armies met on the banks of the Netad in Panonia, where the Huns were utterly routed; and king Ellac fell in the field, after having performed prodigies of valour worthy of the representative of the great Attila. They afterwards received repeated defeats, both from the Goths and Romans, and were compelled to confine themselves to their own settlements for nearly sixty years.

In 539, however, the Cuturgurian and Uturgurian Huns united, broke into the empire, and laid waste Thrace, Greece, Illyrium, and all the provinces from the Ionian sea to the very suburbs of Constantinople. They then retired without molestation, with immense booty, and 120,000 captives. The Uturgurian Huns proceeded to their own country on the Euxine Sea; but the Cuturgurians received lands in Thrace, and an annual pension from the Emperor Justinian, upon condition of their serving when wanted in the Roman armies. Unable, however, to restrain them from committing continual depredations in the neighbouring provinces, Justinian had recourse to the Uturgurians; and by means of presents, and offers of pensions, embroiled the two nations in a bloody war, which lasted many years, and by which they were so weakened, that they were long prevented from offering farther molestation to the empire.

From this time, no credible historian makes particular mention of the Huns, till A. D. 776, when the remains of this nation, reinforced by the Avars, and other northern tribes equally barbarous with themselves, and with whom they are frequently confounded by historians, seem to have recovered their strength, and we find them masters of Dacia, Upper Mœsia, and the two Panonias. Two of their princes sent ambassadors to Charlemagne, desiring his friendship and alliance. Charles received them with extraordinary distinction, and readily agreed to their request; but a misunderstanding afterwards arising between him and them, he entered their territories with two numerous armies, ravaged the country with fire and sword, the Huns being unable to keep the field against so powerful an enemy. After a war of eight years continuance, he reduced them to complete subjection, and built strong fortifications along the Raab to repress their predatory irruptions into his territories.

They remained within this boundary for more than a century, when Arnolph, emperor of Germany, invited them to his assistance against the king of Moravia. Equally ferocious with their ancestors, and glad of an opportunity to renew their devastations, they ravaged Bavaria, Suabia, and Franconia. Germany afterwards became a prey to their fury; and Louis IV. submitted to an annual pension to get rid of them. In the reign of Conrad I. who also became their tributary, they again devastated Germany, penetrated into Lorraine and Languedoc, plundering and massacreing the inhabitants wherever they went.

The Huns were at this time subject to petty chiefs, whose precarious authority rested on no solid foundation, and were respected only because the choice fell on the bravest. Fear naturally attached them to the man whose vengeance they dreaded, or to whom they looked for protection in the continual wars in which they were engaged. Their last irruption into Germany was severely chastised by the valour of Otho the Great, and the united power of the German princes, who compelled them, after a dreadful slaughter, to retire within the limits of Hungary, and to fortify with a ditch and rampart the most accessible passes into their country.

In process of time, and by their intercourse with other nations, civilization began insensibly to spread among them; and in 997, under their first king *Stephen*, they assumed a place among the nations of Europe. This monarch established the Catholic religion in his dominions, and received from the Pope the title of *Apostolic*, which the sovereigns of Hungary to this day retain. From him also they date the origin of many of those institutions and laws by which the state is still governed. On his death, the respect in which his memory was held by his subjects, led them to choose his son as his successor to the throne; and, without renouncing their right of election, to maintain the royal dignity in his family for more than three centuries.

There were twenty-four kings of the dynasty of Stephen, few of whom, however, deserve to be drawn from oblivion. The most remarkable were: *Ladislaus*, surnamed the Saint, on account of the purity of his life, who added Dalmatia and Croatia to his dominions, and flourished near the end of the eleventh century. *Geicza* or *Geiza* II. expelled the Saxons, Austrians, and Bavarians, from Poland and a part of Hungary, where they had committed great ravages. *Bela* III. after having freed his territories from the brigands which infested it, employed himself in the internal administration of his kingdom. He instituted many judiciary regulations, which still remain in force, and was the first who divided the kingdom into counties, appointing a governor to each. His son, *Andrew* II. was one of the most renowned sovereigns of his age. He joined the Crusade in the beginning of the thirteenth century, with a numerous army, and acquired great glory by his bravery and skill in war; and the nobles, as a reward for their services on this occasion, received from him very extensive privileges. In his reign, the regulations of his father were perfected and formed into a national code, called the *Golden Bull*, which every king at his accession was obliged to confirm by a solemn oath. The famous clause, however, which granted to every noble the right of *veto* in the election of their monarchs, had been so often the occasion of civil wars, that it was abolished in the reign of Leopold I. in 1687. The reign of *Bela* IV. is remarkable for the invasion of the Scythians, who, after having overrun Russia and Poland, penetrated as far as Pesth, spreading terror and rapine throughout the kingdom. Bela, surprised in his camp, was compelled to fly. The Scythians continued in possession of the country for nearly three years; but Bela, with the assistance of the Knights of Rhodes, dispersed the invaders, and regained this throne. His son Stephen V. was celebrated for his victories over the kings of Bohemia and Bulgaria. His daughter Mary espoused Charles, king of Sicily, from whom sprung the famous Charles Martel, the father of Charles of Anjou, who afterwards became king of Hungary. Andrew IV. the last, and perhaps one of the most illustrious of the dynasty of Stephen, received the surname of *Venetian*, from his conquests over the Venetians. He died without issue at Buda in 1301.

Hungary then became a prey to all the calamities which anarchy brings along with it. Competitors for the crown appeared in the King of Bohemia and the Duke of Bavaria. The son of the former was elected by a party, and was kept upon the throne for six years, in opposition to the wishes of the nation, and amidst the greatest troubles. Being recalled to Bohemia by his father, the Duke of Bavaria was immediately crowned; but Ladislaus, waywode of the Jazyges, took him prisoner, and drove him from his throne and the kingdom. On the termination of these civil dissentions, Charles of Anjou was solemnly proclaimed king in 1310. Under his reign, Hungary, which had lately been regarded merely as a fief of the empire, became more powerful than the dominions even of the emperors. Dalmatia, Croatia, Servia, Transylvania, Bulgaria, Bosnia, Moldavia, and Walachia, received the laws of Charles. His marriage with the sister of Cassimir, king of Poland, who had no offspring, also secured a throne to his family. He died in 1339, beloved by his subjects and all his neighbours. The veneration which his memory inspired, and also the personal qualities of his son, fixed the choice of the nation on Louis. The reign of this prince was even more brilliant than that of his father. He pushed his conquests as far as Naples, to revenge the assassination of his brother Andrew, who had been strangled by his own wife Queen Jane; and appointed the waywode of Transylvania as governor of that kingdom, which however he afterwards restored. Part of Russia submitted to his dominion, and he drove the Tartars beyond the Euxine. He was acknowledged also as king of Jerusalem; but, while Hungary rose in power and estimation during his life, his death plunged her again into new calamities and dissentions.

Louis leaving no male issue, the Hungarians, as by a general impulse of admiration and enthusiasm, called his daughter Mary to the throne, under the title of Maria Rex. She had been married to Sigismund of Bavaria, who was as yet under age, and in the mean time she shared the cares of government with her mother Elizabeth. The tyranny, however, of Nicolas Gara the Palatine, who in her name actually governed the kingdom, soon made her subjects regret their imprudent homage to the memory of Louis. They therefore offered the crown to Charles, king of Naples, the nephew of Louis, and the son of the unfortunate Andrew. But scarcely had he entered Hungary, than he was assassinated by the Palatine, with the direction and countenance of Mary and Elizabeth. John Horvat, bann of Croatia, in revenge for the murder of a prince to whose interests he was attached, slew the assassin, and, after having made Mary and her mother be dragged as common criminals by the hair, cast Elizabeth into the river Bozota. Mary was reserved for the infamous brutality of Horvat, and then shut up in prison. Horvat, however, dreading the rage of Sigismund, who was approaching with an army to reclaim his crown, set the Queen at liberty, after making her promise upon oath that she would forget her injuries. These injuries, however, were too cruel to be erased from her memory, and repelling the oath which fear alone had extorted from her, she visited them upon the fierce avenger of Charles in a manner still more cruel and barbarous. Sigismund was twenty years of age when he ascended the throne; but the whole of his reign was only a succession of wars, troubles, and calamities to Hungary. Mary dying without children in 1392, new dissentions arose; and the Turks, taking advantage of these, seized upon Bulgaria. Sigismund was defeated and put to flight at the battle of Nicopolis; when his subjects revolt against him, seize his person, and confine him in prison. The conspirators then offer the crown to Ladislaus, king of Naples. But Sigismund seemed to triumph over fortune and all his enemies. Escaping from prison, and collecting a considerable army, he obliges Ladislaus to desist from his pretensions, and recovers his kingdom. In 1410, he was elected emperor of Germany. At his death, Albert, archduke of Austria, who had espoused the only daughter of Sigismund by a second marriage, inherits all his possessions, and ascends the throne of Hungary in 1437. This event forms the earliest basis of the Austrian claim to the Hungarian monarchy.

The reign of Albert, however, was very short, and his death was succeeded by civil wars, which continued to desolate this kingdom for another century. Ladislaus, king of Poland, was invited to the throne; but soon after perished in the battle of Werna against the Turks. The famous John Hunniades was then appointed regent; and on the decease of another Ladislaus, the posthumous son of Albert, in 1457, Mathias Corvinus, the son of Hunniades, receives the crown from the states assembled in the field of Rakos, near Pesth. Mathias seized Vienna and the other Austrian states, which he retained till his death; and is regarded as the greatest prince that ever held the Hungarian sceptre. He was brave, prudent, and generous, the friend of letters and arts, and a man of letters himself. He founded the magnificent library of Buda, which he furnished with the best Greek and Latin authors, and many valuable manuscripts.

The descendants of Albert again fill the throne; but upon the death of Louis II. the son of Ladislaus, who lost both the battle and his life in the plains of Mohats in 1527, the Hungarians were divided into two factions. John Zapolya, waywode of Transylvania, was proclaimed king by one party, while the nobles assembled at Presbourg, offered the sceptre to Ferdinand of Austria, who had conducted some succours to the Hungarians against the Turks. Zampolya was unable to resist the forces of his rival; and after his defeat at Tokay, was compelled to evacuate the kingdom, when Ferdinand was crowned at Stuhl-weissenbourg. Some time after, the waywode returned with the Sultan Soliman, at the head of a formidable army, who pushed his conquests as far as Vienna; but on the death of Zampolya, his partisans, indignant at the conduct of the Turks, and preferring the dominion of Austria to that of the barbarian, immediately joined Ferdinand, who was crowned a second time. This monarch was afterwards called to the empire; but he retained the crown of Hungary till

1563, when he resigned it to his son Maximilian. The Hungarians, however, bore the Austrian yoke with much impatience, and every new election called forth their aversion to their masters, who regarded them as their lawful inheritance. But their efforts were fruitless, and those who ventured to support the rights of the nation were silenced by the stroke of the executioner. In vain did Tekely raise all the provinces to revenge these outrages; and, supported by the Turks, to whom the Hungarians in their despair had surrendered themselves, laid siege to Vienna. All Germany immediately armed against the common enemy, the Turks, who were driven back into their own territories. Rakotzy, who, after Tekely, endeavoured to support their efforts of independence against tyranny, was equally unfortunate. The Archduke Joseph, son of Leopold I. was acknowledged king in 1687, and the crown was declared hereditary in the male descendants of the house of Austria. This line, however, failed at the death of Charles VI.; but the Hungarians, exhausted by continual wars, and fatigued by so many fruitless revolutions, had lost that ardent love of liberty for which they were so conspicuous, and which led them to brave so many dangers. They therefore submitted to the accession of Maria Theresa, the daughter of Charles, in 1741. She had gained and deserved their love and affection. Her husband, the emperor Francis, was associated with her in the government, and their descendants still hold the Hungarian sceptre. The preceding sketch of Hungarian history is all that our limits will allow.

## STATISTICS OF HUNGARY.

Hungary, properly so called, a kingdom in Europe, and under the dominion of Austria, lies in Latitude 44° 33′ 18″—49° 26′ 20″ North; and in Longitude 13° 45′ 2″—22° 46′ East of Paris. Nature herself points out the boundaries of this kingdom. The Carpathian or Krapak mountains separate it on the north and east from Moravia, Silesia, Galicia, Buckovina, and Transylvania: on the south, the Danube and the Drave divide it from Servia, Sclavonia, and Croatia; and on the west, the Morau, or Morava, with a range of mountains lying between the Drave and the Danube, form its boundary with the Archduchy of Austria. According to Captain Lipsky, it contains 4051 German square miles;* its greatest length from west to east being 136, and its greatest breadth from north to south 77 German miles.

The kingdom of Hungary is divided by modern geographers into four circles, comprehending forty six counties, besides the districts of *Jazyg*, *Great Cumania*, *Little Cumania;* the sixteen cities of the *Zips;* the six cities of *Heidukes*, which enjoy peculiar privileges; and the two frontier regiments of the Bannat, and the battalion of *Tschaikistes*. The whole, according to the following Table, contained, in 1805, 42 royal free cities, 8 episcopal cities, 590 towns, 9214 villages, 2338 *prædien*,† and 22 cities of Zips and Heidukes.

| Counties. | Royal Free Cities. | Episcopal Cities. | Cities of Zips and Heidukes. | Towns. | Villages. | Prædien. |
|---|---|---|---|---|---|---|
| I. The circle on this side of the Danube contains 13 counties: | | | | | | |
| 1 Presbourg, . . . . | 5 | | | 24 | 295 | 41 |
| 2 Neutra, . . . . . | 1 | 1 | | 38 | 418 | 46 |
| 3 Trentschin, . . . | 1 | | | 19 | 393 | 8 |
| 4 Thurotz, . . . . | | | | 6 | 96 | 9 |
| 5 Arw, . . . . . . | | | | 5 | 95 | 1 |
| 6 Liptau, . . . . . | | | | 10 | 121 | 2 |
| 7 Sohl, . . . . . | 5 | | | 8 | 147 | 3 |
| 8 Barsch, . . . . . | 2 | | | 11 | 201 | 21 |
| 9 Hont, . . . . . | 3 | | | 9 | 171 | 30 |
| 10 Neograd, . . . . | | | | 10 | 245 | 142 |
| 11 Gran, . . . . . | 1 | | | 5 | 44 | 8 |
| 12 Pesth, . . . . . | 2 | 2 | | 20 | 165 | 153 |
| 13 Baatch, . . . . . | 3 | | | 9 | 96 | 52 |
| The district of Jazyg, . | | | | 3 | 8 | 6 |
| Do. of Little Cumania, . | | | | 3 | 5 | 24 |
| II. The circle on the other side of the Danube contains 11 counties: | | | | | | |
| 1 Wieselbourg, . . . | | | | 13 | 37 | 7 |
| 2 Oedenbourg, . . . | 3 | | | 38 | 196 | 6 |
| 3 Eisenbourg, . . . | 1 | | | 43 | 607 | 51 |
| 4 Raab, . . . . . | 1 | | | 2 | 80 | 35 |
| 5 Komorn, . . . . | 1 | | | 5 | 85 | 69 |
| 6 Szalad, . . . . . | | | | 25 | 584 | 101 |
| 7 Schumegh, . . . | | | | 22 | 292 | 256 |
| 8 Veszprim, . . . . | | 1 | | 9 | 106 | 177 |
| 9 Stuhlweissenbourg, . | 1 | | | 12 | 65 | 115 |
| 10 Barany, . . . . . | | 1 | | 7 | 336 | 71 |
| 11 Toln, . . . . . | | | | 17 | 89 | 85 |
| III. The circle on this side of the Thiesse contains 10 counties: | | | | | | |
| 1 Abaujwar, . . . . | 1 | | | 11 | 230 | 41 |
| 2 Beregh, . . . . . | | | | 6 | 261 | 7 |
| 3 Boschod, . . . . | | 1 | | 11 | 167 | 68 |
| 4 Goemor, . . . . | | | | 13 | 257 | 74 |
| 5 Hewesch, . . . . | | | | 16 | 132 | 108 |
| 6 Scharosch, . . . . | 3 | | | 11 | 359 | 13 |
| 7 Zips, . . . . . . | 2 | | | 12 | 177 | 6 |
| Cities of the Zips, . | | | 16 | | | |
| 8 Torn, . . . . . | | | | 1 | 42 | 10 |
| 9 Unghwar, . . . . | | | | 4 | 201 | 14 |
| 10 Zemplin, . . . . | | | | 24 | 426 | 34 |

* In this Article, where English miles are not marked, German miles must be understood.

† By the laws of Hungary, the proprietors of the soil are obliged to let out to farm one half of their lands to their vassals; what they cultivate on their own account is called *Prædien*.

| Counties. | Royal Free Cities. | Episcopal Cities. | Cities of Zips and Heidukes. | Towns. | Villages. | Prædien. |
|---|---|---|---|---|---|---|
| IV. The circle on the other side of the Thiesse contains 12 counties: | | | | | | |
| 1 Arad, . . . . . | | 1 | | 18 | 171 | 24 |
| 2 Bekesch, . . . . | | 1 | | 4 | 15 | 71 |
| 3 Bihar, . . . . . | 1 | | | 19 | 458 | 55 |
| 4 Tschanad, . . . . | | | | 1 | 7 | 31 |
| 5 Tschongrad, . . . | 1 | | | 3 | 6 | 52 |
| 6 Kraschow, . . . . | | | | 8 | 221 | |
| 7 Marmarosch, . . . | | | | 5 | 141 | 1 |
| 8 Saboltsch, . . . . | | | | 14 | 131 | 35 |
| Cities of Heidukes, . | | | 6 | | 4 | 4 |
| 9 Szathmar, . . . . | 3 | | | 19 | 244 | 16 |
| 10 Temesch, . . . . | 1 | | | 6 | 178 | 3 |
| 11 Torontal, . . . . | | | | 7 | 115 | 48 |
| 12 Ugotsch, . . . . | | | | 3 | 63 | 3 |
| The district of Great Cumania . . . . . . | | | | 1 | 5 | 17 |
| 1st frontier regiment, . | | | | | 48 | 23 |
| 2d do. do. . . | | | | | 112 | |
| The battalion of Tschaikistes, . . . . . . | | | | | 14 | |
| Total, 2 military communes, and . . . . | 42 | 8 | 22 | 590 | 9214 | 2338 |

The configuration of this country presents to us the most opposite regions and climates; rugged and enormous mountains, where reign sterility and eternal snows, and which cover almost one-third of the whole kingdom; extensive flats, irrigated by numerous rivers and lakes, where winter is scarcely known; plains of sand driven by the wind, which threaten the traveller with instant death; fertile and smiling vallies, producing every necessary, and many of the luxuries, of life in the greatest abundance; numerous morasses, which cover the surrounding country with their noxious exhalations; and immense forests, where the foot of man has never penetrated.

On entering the Bannat of Temeschwar on the east, the country appears like Flanders, flat, and entirely destitute of wood, excepting in the vicinity of the villages. The soil is extremely fertile; and the prospect as we advance exhibits immense pastures covered with cows, sheep, and horses; or wide fields of corn without enclosures. Silk plantations, and orchards of peach, cherry, and plum-trees, are every where common. Proceeding westward, the country towards Szegedin becomes sandy; and after crossing the Thiesse low swampy plains, full of stagnant pools, where nothing is heard but the croaking of toads, fill up the distance to Ketschkemet. From thence the country, though well cultivated in some places, is flat and sandy, resembling the *steppes* of Russia; and, on approaching the Danube, a chain of mountains appears, which rise with grandeur on the western side of the river. From Buda, towards Gran, the country is rich, populous, and highly cultivated. The hills are covered with vineyards to their very summits; and every where are seen delightful villages filled with healthy inhabitants. On the north of the Danube, the mountainous district towards Schemnitz is agreeably picturesque; and as we approach that town, the scenery becomes sublime. "The appearance of this beautiful country," says Mr Cripps, "although surrounded by mountains, reminded us of the county of Kent. The cottages are remarkable for their great cleanliness; and there are numerous villages. The district between *Zeilitz* and *Lewa* is the most beautiful imaginable, being full of rich meadows and fields of corn, every where thick set with noble oaks." Dr Clarke also remarks, that "the road, although constructed in the midst of mountains, is not inferior, either in breadth or excellence, to any of the roads about London; and the traveller, surrounded by the sublimest natural scenery, sees to his surprise the greatest artificial labours accomplished with neatness, ornament, and economy; beautiful roads through recesses, and over steeps, that would otherwise be impassable; churches crowning the most elevated summits; towns and villages; gardens and vineyards; all decorating without diminishing the wild grandeur of the Hungarian Alps." Indeed, the whole of this district, as far as Presbourg, is exceedingly rich and beautiful.

The most prominent feature of the Hungarian landscape are the mountains, the principal of which is the Carpathian chain, or mountains of Tatra, which run in a semicircular direction from west to east, about 500 English miles; and its summit, which consists of huge naked rocks completely destitute of vegetation, at its greatest height, in the county of Zips, is about 1350 toises above the level of the Black Sea. The mountains situated in the east and south-east, are separated from the northern chain by a plain, which extends from Hungary into the grand duchy of Transylvania. They take their rise in the latter province; and, following the direction of the Marosch as far as Arad, strike towards the south by the Bannat upon the confines of Transylvania and Walachia; the highest of these are Szemenik and Montye le mare, or the high mountain. Those on the western part of the kingdom, run from the county of Eisenbourg in a crooked chain towards Stiria and Austria, as far as the Leitha; and some of them equal the Alps nearly in height. Besides these, there are other considerable mountains in the counties of Pesth, Gran, Veszprim, and Szalad, some of which are covered with impenetrable forests of oak.

The northern part of the Carpathians is composed chiefly of granite, and its summits are covered with limestone, or spread with a kind of brown freestone. Granite forms also an essential part of the mountains of Konigsberg, and of the rocks of Tatra, which are adjacent, and stretch into the southern part of the counties of Zips, Goemor, Sohl, Liptau, and into the western part of the counties of Arw, Thurotz, and Trentschin. It also abounds in the northern part of Zips, where the mountains of Fleischbank, Porte de Fer, Altendorf, and some others, are entirely composed of it. Near Altendorf it begins to disappear, and is replaced by a greyish free stone, which covers almost three leagues of country, and forms the great mountain of Babagura. This stone extends along the extremity of the western frontiers of Tatra, Godivilk, and towards the south the county of Arw. From the eastern extremity, it extends still more along the frontiers of Hungary, and into the counties of Zips, Scharosch, Zemplin, and Unghwar. There another kind of stone presents itself; clay slate covered with brown free-stone. It is likely that the clay-slate commences in the higher mountains of the north, as it begins to appear in the county of Goemor, near Rosenau, from whence it stretches into the southern part of the county of Zips, and into the northern part of the county of Abaujwar. The central mountains of the Carpathian chain and its promontories, produce limestone and porphyry. The other generations which are formed in the accessary mountains are, mica, clay-slate, trap, basalt, and breccia. There are also found volcanic stones, pumice stone, and different kinds of opals. The body of the Carpathians on the north-east, consist principally of clay-slate. The chain which stretches along the valleys of Marmarosch and the borders of the seven mountains, as far as the Theisse, and traverses the counties of Szathmar and Ugotsch, is composed chiefly of porphyry and grey free-stone. In the eastern mountains, and, in general, in those of the Bannat, there is a great deal of lime-stone; which prevails also in the interior mountains. The other stones that are found there are clay-slate, brown free-stone, and porphyry. The neighbouring mountains of Stiria and Austria contain lime-stone, free-stone and granite.

The mountains of Hungary, especially the Carpathian chain, abound with grottos of various dimensions, the principal of which are, *Mazarna* and *Dupna* in the county of Thurotz, *Drachenhole* in the county of Liptau, *Holgocz* in Zips, *Agtelek* in Goemor, and *Sziliacz* in Torn. Bones and skeletons, partly petrified, are found in these grottos, and the most beautiful stalactites of every size and form. Those of Drachenhole and Sziliacz are particularly curious, being filled during the summer with ice, which is formed in spring, and melts at the approach of winter. The grotto of *Veteranische Hole* is famous for the defence which General Veterani, with a few followers, maintained against the Turks, in 1694. It is situated on the left bank of the Danube, a little above the village of Ogradina. The rock of which it is formed is inaccessible on every side except at the entrance of the grotto, which is about four feet high and two broad, and secured by an iron gate. The interior is large enough to accommodate a thousand men; and, from the embrasures cut out in the rock, it has the complete command of the navigation of the Danube. Here also, in the last war of Austria against the Turks, the brave Major Stein, with a battalion of infantry, defied the whole power of the Turkish army, and after enduring for three weeks the most painful privations, made an honourable capitulation, and marched out at the head of his surviving followers with their arms and baggage.

The interior of Hungary consists of one almost continued flat, excepting a chain of mountains which, taking their rise near the Danube, run through Gran, Pesth, and the neighbouring counties, and divide the country into two immense plains, called the Upper Plain and the Lower Plain. The former is the smallest, and is of a circular form. It extends from the lake of Neusiedl for about twenty German miles, to the foot of the mountains on the north, and then streches as far as the Drave, upon the confines of Croatia. The Lower Plain is of much greater extent, and comprehends all the east part of the kingdom, as far as Transylvania; and where it approaches the mountains, is finely diversified with hills and vallies. The level is evidently higher in the upper than in the lower plain, as the rivers in the former almost uniformly direct their course towards the Danube; and the lowest spot in the whole country is at its south-eastern extremity, near Orsova.

The Carpathian chain gives rise to innumerable rivers, which flow in all directions, according to the declivity of the ground and the sinuosity of the vallies, but which eventually fall into the Thiesse or the Danube. The *Thiesse* has its source in the county of Marmarosch. Its course from its commencement is full and rapid while it continues among the hills; but when it reaches the plain its rapidity slackens, and, bending towards the west, receives innumerable tributary streams from the northern mountains. Taking a southerly direction, it is joined by the Marosch, near Szegedin, and, after a course of about 420 miles English, falls into the Danube not far from Belgrade. As the banks of this river are low, it often overflows them, and occasions extensive inundations, particularly in the neighbourhood of Tokay. Few rivers in Europe abound more with fish than the Thiesse; and it is a common saying in the country, that it contains two parts of water, and one of fishes. It is navigable as high as Szegedin. The *Waag* or *Woh* fertilizes the counties of Thurotz, Trentschin and Neutra. Circumscribed in its channel, it dashes its impetuous waters over frightful rocks, and forms during its course above a hundred whirlpools. It enters the plain at Sillein, and discharges itself into the left branch of the Danube, which forms the island of Schutt. Besides these, the other principal rivers which commence and finish their course within the boundaries of the kingdom are, the Gran, the Gollnitz, the Hernad, the Torisza, the Sajo, the Nera, the Temesch, and the Bega.

The rivers which have their sources in other countries, but which water, in some part of their course, the kingdom of Hungary, are the Danube, (of which a particular description will be found in vol. vii. p. 574.); the *Drave*, which rises in the Tyrol, and flows with such rapidity that its banks are neither so high nor so solid as to retain its waters. It is navigable during the whole of its course through Hungary, and falls into the Danube above Essek; the *Samosch*, the *Marosch*, and the *Korosch*, which take their rise in Transylvania, and fall into the Thiesse; the Morava, which gives its name to the province of Moravia, washes the western boundary of the kingdom; the Raab, which rises in Stiria; and the Leitha in Austria.

The lakes and marshes of Hungary are both numerous and extensive. In the Upper Plain the most considerable are, Lake *Balaton*. The Lake of *Neusiedl*, which the Hungarians call Tento, lies between the counties of Oedenbourg and Wieselbourg. Its western bank is formed by hills, which are covered with vineyards, woods, and cultivated fields, while the opposite shore is low and marshy, producing nothing but reeds. It is about thirteen miles (English) in length, by four in breadth, but so full of shallows and sand banks, that its navigation is both difficult and dangerous. In the Lower Plain, the principal is the lake of *Palitsch*, in the county of Batsch. It is about eight miles (English) long, having a hard bottom covered with alkaline salt. Its water is used in the neighbouring baths, and is considered very salubrious in nervous disorders. The most remarkable of the Carpathian lakes is the *Grune-See*, which is formed by an enclosure of rocks, and is about 300 paces in circumference. It takes its name from the green colour of its waters, which is produced by the reflection of the surrounding pines. Its banks are covered with gravel and blocks of granite, and its water is pure and transparent, and excellent for drinking.

Marshes of various extent pervade almost every quarter of the kingdom, and are in general formed by the inundations of the rivers. The most considerable are those of *Saretje*, *Mohatsch*, and *Etsed*. In the plain of Bannat, they cover more than a third of the county of Toronthal, almost the whole of Temeschwar, and the greatest part of the district of the frontier regiment of Bannat. The marsh of *Hansag*, which joins the lake of Neusiedl, is five miles long by three broad. The water appears only in the middle, the greatest part being covered with turf, and studded with trees. It produces plenty of hay; but it is dangerous to cross it, unless well acquainted with the particular direction of the paths.

It would be proper to notice also the sandy plains, which overspread many parts of this country, the most extensive of which are, *Ketschkemeten-Heide*, or the heath of Ketschkemet, lying between the Danube and the left bank of the Thiesse; *Debreczin*, in the county of Bihar; and the *Ager Romanorum*, near Delliblat. Besides these, there are others in the counties of Tolna, Stuhlweissenbourg, Baranje, and particularly in Schumegh, which is one continued ocean of sand moving with the wind.

The morasses and swampy plains which abound in this country are supposed to render the air damp and unwholesome, the cold of the night rivalling the heat of the day; but this evil is in some measure remedied by the wind from the Carpathian mountains; and the inhabitants in general are rather remarkable for health and vigour. In some of the counties on the north-west, the atmosphere is particularly pure and bracing; but in the Bannat, on the north-east part of the kingdom, it is quite the contrary. The transitions of temperature are extremely sudden. Agues and inflammatory fevers are very prevalent; and in Temeschwar, the capital, a healthy person is scarcely to be seen. Baron Born, when here, fancied himself in the realms of death, inhabited by carcases in fine tombs, instead of men; and at a dinner, to which he was invited, all the guests had a fit of the fever,—some shivering, and others gnashing their teeth.

If we except the barren heaths and the mountainous districts in the north, the soil of Hungary is equal to that of any other country in Europe. It contains 5,897,218 acres of arable land, and produces the finest grain, without manure, and almost without cultivation; and were the exertions of the husbandman to keep pace with the abundance of his crops, the produce of the kingdom would be doubled. After a very superficial ploughing, the seed is thrown into the ground; a few branches of trees tied together serve the purpose of harrows; and without farther care the harvest is luxuriant. But much of the grain is lost, by the manner in which it is separated from the straw and stored. It is allowed to stand in the field after it is cut until the tithe is gathered, by which time it has begun to vegetate. They afterwards tread it out with horses and cattle in the open air, by which operation a third of it nearly is destroyed; and then, instead of receiving it into granaries, of which they have none in Lower Hungary, it is put into pits dug for the purpose, and there kept for future use. These pits are lined in the bottom and sides with straw and reeds, and contain from 100 to 200 bushels each. They are then covered in with straw and earth.

This method of rural economy, however, applies only to the lower and central parts of Hungary, which are by far the most fertile. In the northern districts, and on the frontiers of Austria and Stiria, the soil requires all the industry of the inhabitants to make it produce even a tolerable crop; and were their exertions and method of culture (though still imperfect) transferred to the southern parts of the kingdom, Hungary would become the granary of Europe. An insuperable obstacle, however, to all improvement in this respect, lies in the tenure, by which the farmer holds his lands. The lands are parcelled out into farms, half farms, quarter farms, &c. A farm is measured by the seed it requires, being 48 bushels, and 12 *tagwerk* of meadow; if the soil is poor, the arable land is augmented in proportion. In Croatia they distinguish three kinds of land, good, middling, and bad. A farm of the first quality is 21,000 square toises; of the second 34,000; and of the third 40,000. The annual burdens attached to a farm in Hungary are, fifty-two days work with two horses, or four oxen, beginning at sun-rise, and finishing at sun-set; a fourth part of them must be performed during the winter, and, in the time of harvest, the proprietor can demand two in the week: a ninth part of the crop, and also of the sheep, goats, lambs, and bee-hives; and if the number is under nine, 4 kreutzers for every lamb, 3 kreutzers for every goat, and 6 kreutzers for every hive; 2 hens, 2 capons, a dozen of eggs, and half a pint of melted butter: 30 farms together pay a calf or a florin, and 30 kreutzers in money; every married peasant to give eighteen days work, and pay a florin for the rent of his house, and all others to give twelve days work: every vassal to beat the bushes three times a year in the hunting season: four peasants, each possesing a farm, to unite in forming a job with four horses at the distance of two days journey, excepting the time of harvest or vintage: two florins for permission to distil *aqua vitæ*, and to spin six pounds of lint. The proprietor furnishes his vassals with wood for fuel and building; and, in return, they must cut a *cord* of wood in the forest, and transport it to the castle. The respective rights and obligations of the noble and his vassals are regulated by a statute, which is called *urbarium*, and which was provisionally confirmed by the diet in 1791. The peasant, however, holds his lands only from term to term, and must resign them, when proper warning has been given by his lord.

Notwithstanding these disadvantages, the soil is so productive, that the annual exportation of grain to Italy and Germany is very considerable. Wheat is the principal object of cultivation; and in the mountainous parts of the country, where the soil is lighter and the climate colder, rye, barley, and oats, are produced of good quality, and in abundance. They have also plenty of maize, rice, peas, potatoes, turnips, melons, cucumbers, pumpkins, onions, and garlic. Lint and hemp are cultivated in many of the counties; also poppies, saffron madder, and woad. Tobacco forms a considerable branch both of agriculture and commerce; and in 1779, when American tobacco was very scarce, the city of Trieste alone exported Hungarian tobacco to the amount of 100,759 pounds in powder, and 3,263,136 pounds in leaves or carrots. The best tobacco is produced at Tolna, Kospalogh, and Szegedin.

The vineyards of Hungary are very extensive, and are general throughout the country, unless in seven of the northern counties, where the temperature is too cold. They occupy nearly 911,984 acres, and produce upon an average 18,239,680 *eimers* annually. The wine of Tokay is the most valuable, and is drunk by the rich in every country in Europe. The vines which furnish the real Tokay grow on the mountain of *Hegy-Allya*, in the county of Zemplin; but as this mountain produces a very inconsiderable proportion of what passes under the name of Tokay, they sell for it the wines of Mada, Tallya, Zumbor, Szegu, Zsadany, Toltschwa, Benye, &c. which few but a Hungarian palate can distinguish. Next to the wines of Tokay, the most esteemed are those of Rust and Œdenbourg, which are cultivated with great care and intelligence. The others of consequence are the wines of Erlau, Buda, Neustadtel, Menesch, Scohmla, Resmil, and Ratschdorf.

Although the climate of Hungary be very favourable for the cultivation of all kinds of fruit, very little attention is paid to them in the Lower Plain. The orchards are confined chiefly to Œdenbourg, Presbourg, Neutra, and the neighbouring counties, where chesnuts, almonds, apricots, peaches, apples, and pears abound, and are of the first quality. Entire forests of plumtrees flourish in the counties of Trentschin, Neutra, and some others; and their fruit, both fresh and dried, is exported in great quantities to Austria and Prussia.

The meadows and pasture grounds of Hungary are very much neglected. They cover 1,483,003 acres, and yield about 17,085,935 quintals of hay. The northern and western districts of Hungary abound in immense forests of fir, pine, and oak, interspersed with yews, ash, hazel, and linden, which overspread nearly nine millions of acres. In the district of the frontier regiment of Walachia, the forests cover 465,362 acres, and afford employment and profit to many of the inhabitants. In 1802, there were drawn from these woods the following articles, which will give the reader some idea of their value and importance.

| | |
|---|---|
| 58,446 | pieces for the construction of wheels. |
| 1,414 | cubic toises of ash. |
| 108,732 | staves for casks. |
| 2,725 | do. for scuttles. |
| 2,560 | do. of oak. |
| 30,920 | do. of beech. |
| 344 | cubic toises of oaken joists. |
| 702,800 | staves. |
| 2,363 | planks a foot square. |
| 900 | green poles. |
| 11,013 | planks for boat building |
| 5,293 | laths. |
| 1,704 | planks for scaffolding. |
| 40,624 | do. of linden and maple. |
| 1,099 | do. of hazel. |
| 196 | posts of do. |

The forests of Hungary produce an immense quantity of gall-nuts, which, from their exportation during ten years, (from 1777 to 1786,) yielded 516.679 florins of revenue. In the south, however, from Pesth to Debretzin on the one hand, and from the mines of Bannat in the county of Kraschow to Peterwardein on the other, a wood is scarcely to be seen. In this district the fuel, on account of the scarcity of timber, consists chiefly of reeds, and cow dung made into bricks with straw.

On the pastures of Hungary are reared a great number of cattle, which forms one of the principal sources of national opulence. The oxen are nearly equal to those in Kent, which are the finest in Europe. They are generally of a whitish colour, or light grey, and are valued for their great weight, and the fine flavour of their flesh. About the conclusion of the last century, there were reckoned in Hungary 797,540 fat oxen, 89,805 bulls, and 1,508,177 cows; and according to the commercial tables, during ten years of the same period, the exportation of oxen amounted to thirty millions of florins, when a pair of oxen sold only for 50 or 60 florins.

The horses in general are small, but are equal to any in Europe in elegance and swiftness. They have been, however, much neglected; and notwithstanding the many attempts that have been made by the government for their improvement, they are still far removed from that state of perfection of which they are capable. The royal studs at *Mezoehegyes* in the county of Tschanad, and *Babolna* in the county of Komorn, were established by the Emperor Joseph II.; and from them 60 stallions are regularly distributed every year throughout the country, to produce a more noble breed. In 1795, the stud of Mezoehegyes consisted of 10,000 horses, of which 1000 were mares, and 60 stallions. It is under the direction of a major, 12 officers, 50 sub-officers, and 200 soldiers, besides grooms and labourers; and is obliged to furnish annually 1000 horses for the army. There are also several private studs, of which the most considerable are those of the lordship of Holitsch, established by Francis I., of Prince Esterhazy at Uzor, and of Count Palfy at Dertrekoe. The small size of the Hungarian horses may be attributed to their being too young when brought to the yoke, and to their scanty nourishment. They seldom give them hay, but drive them out at all seasons to pasture; and even when on a journey, they are sent into the fields, to find at the same time food and rest.

The Hungarian sheep are very beautiful, especially those with forked horns, of which none are reared in any other country, except on Mount Ida, and in some of the islands in the Archipelago. Their wool, however, which is long and hairy, is used only in fabricating coarse stuffs, which are worn by the peasants. In 1773, the Austrian government attempted to improve the wool of the native sheep, by the introduction of Spanish rams; but it was long before this practice became general. At present, however, many of the nobles possess immense flocks of the improved breed, and draw from the sale of their wool a considerable revenue. Some of these flocks produce annually about 1500 quintals of wool, worth 274,000 florins. Flocks of every description pass the winter in the open fields. The shepherds, whom they call *juhasz*, are very little removed from savages. They burrow under ground with their dogs, and, except a boy or two, who assist them and bring their food from the village, and the merchants who in the beginning of summer come to make purchases, they seldom see a human face. Yet, retired as they are from the world, they are fond of ornaments in their dress; and though their clothes are of the coarsest description, and besmeared with grease, they trim their hats with ribbands of various colours, and have their leathern girdles thick studded with bright metal buttons.

As bacon is a favourite dish with the Hungarians, they rear an immense quantity of hogs; and the head of a family, who had not a piece of fat pork on his table at Christmas, would be regarded as a very bad economist. The consumption of this animal in the country is so great, that they have none of their own to spare for exportation; but they carry on a very lucrative traffic, by buying them in Turkey, and selling them to their neighbours. According to the Commercial Tables, they annually purchased in Turkey to the amount of 531,973 florins, which they sold for 895,337 florins.

Among the animals of this country may also be mentioned a race of shepherds' dogs, of a white colour and noble size, and also a breed of immense mastiffs. Bees and silkworms form considerable branches of industry in this country, and it abounds also in poultry and game. Fish are so abundant in Hungary, that they form an important branch of industry and commerce; and sturgeons, salmons, pikes, carps, perches, &c. are to be found in all the principal rivers. In 1803, they were exported to Austria to the amount of 98,230 florins.

Hungary abounds in minerals of every description, gold, silver, copper, lead, iron, mercury, cobalt, antimony, salt, slate, &c. which, in their exploration and manufacture, afford employment to a great proportion of its inhabitants. Native gold is found in the beds of many of the rivers; and in the Koeroes, pieces of the size of a nut are picked up by the inhabitants of the Bannat, who upon an average gather to the amount of 900 ducats. In general, however, it is extracted from the auriferous sand, which is not only taken from the channels of the rivers, but also from their banks, and from pits in the adjacent ground. In these pits, which are generally about four feet deep, the first stratum consists of vegetable mould; the second of loam, and an alluvial deposit of pebbles; the third, of the auriferous sand and pebbles; and the fourth of slate, clay, marl, and coal. The washing of the auriferous sand is practised by the gypsies, who, from long experience, are so expert that hardly a particle of gold escapes them. The operation is very simple, and is performed by means of a plank of lime-tree six feet in length, and about three in breadth, with grooves or furrows cut across. This plank is placed at an angle of about 45 degrees, and at the upper end is a trough where the auriferous sand is put. The sand is then washed down the sloping of the board by plenty of water, when the gold dust falls into the higher grooves, and is afterwards scraped or brushed off. Sometimes the plank is covered with woollen cloth, to which the gold adheres, or, when they cannot obtain cloth, they substitute a fleece in its place. Many thousands of florins of gold are produced in this manner.

The great emporium of the precious metals, however, are the mines, which surpass in richness those of any other country in Europe. The most valuable are those of Schemnitz in the county of Hont, and of Cremnitz in the county of Barsch. In these mines, the gold is always found united with silver; and they estimate the value of the ores, by calculating that one quintal (cwt.) of ore yields so many *lotos* of silver, and one mark of silver contains so many *deniers* of gold. At Schemnitz the metallic veins extend north and south, running parallel to each other; and their inclination or dipping from west to east is at an angle of about 60°. There are six principal veins, besides many smaller ramifications.

The first on the west is called *Theresa-schadt*, at an average about two fathoms wide. The matrix of the ore is principally *clay* and *red ferruginous jasper* or *sinople*, every where traversed by small veins and crystals of *quartz;* and the ore itself is for the most part *lead*. About 120 fathoms eastward is the *Hospital vein*, which is much broader, being 22 fathoms wide, although not pure throughout this width. It contains many foreign substances belonging to the mountain in which it lies. Both these veins lie near the surface; they are very rich, and were the earliest discovered. The third vein is called *Oberbiber-stohln*. It differs essentially in its nature from the others, the matrix of the ore being *clay*, but without any *sinople ;* and containing a great deal of lime, and a small portion of quartz. The next is *Johan-schadt*, about a hundred fathoms from *Oberbiber-stohln*, and containing the same ores. They both lie about one thousand fathoms deep. The fifth is that of *Stephano-schadt*, which may be considered as an assemblage of several contiguous parallel veins, reaching to the breadth of eight fathoms. At present it is the most famous of all the mines of Schemnitz, and is wrought upon a more magnificent scale than any of the others; the galleries being better constructed, and the machinery of greater magnitude. The last is the *Green-stohln* vein, where the matrix of the ore is *schistus*, indurated clay, and *pyrites*. It is the last which has been discovered at Schemnitz, and is hardly known. The average value of the Schemnitz ores is thus rated: a quintal (cwt.) of the ore contains from five to ten *lotos* of silver; and one mark of the silver, from three to six *deniers* of gold. This, however, is liable to very considerable variation, for one quintal of the ore of the *Oberbiber-stohln* vein has been known to yield 2200 lotos of pure silver, after its separation from the gold.

At Cremnitz, the direction of the vein in the principal mine is north and south, inclined from the west towards the east, according to an angle which varies from 25° to 30° and 40°. The ore consists of *auriferous quartz*, speckled with minute glittering particles of auriferous pyrites, and penetrated either by a buff-coloured clay, or by an *argentiferous* sulphuret of *lead*, and the oxide of *iron*.

"The manner of working the mines is fourfold. 1*st*, By a horizontal level, following the direction of the *vein*. 2*dly*, By an inclined plane, ascending according to its inclination; forming always stages of wood, as galleries for the workmen. 3*dly*, By an inclined plane, descending in the contrary direction. 4*thly*, By an excavation on either side of the vein, which is the most frequent at Schemnitz, owing to the great width of the veins." The apparent care, neatness, and advantage, with which the works are carried on; the spacious entrances into their mines; their dry, airy, and cleanly levels; and the great encouragement given to the study of mineralogy, and to all mining speculation, shew that the Germans surpass every other nation in skill and industry in the art of mining.

Dr Clarke, from whose excellent work we have extracted the preceding account of the Hungarian mines, has given us the following description of the process employed for the reduction of their ores:

"1*st*, The first operation with the produce of the mine is of course that common to all mines, of *stamping* the *ore*. But the richer ores are not submitted to the stamping machines.* They are carefully broken with hammers into small pieces about the size of beans, which, being mixed with lead, a single operation of the furnace is sufficient for their reduction. With regard to the common ores, after being *stamped* and *washed*, they are brought in the form of a fine powder or sand to Cremnitz. Here they are exposed to what is called the *crude fusion*, being simply smelted into a compound regulus, which is called *lech*, consisting of all the following metals, besides *sulphur: gold, silver, lead, copper, iron, arsenic, bismuth*, and *cobalt*. This is the first operation.

2*d*, The second operation relates to the treatment of the *lech*, or result of the first crude fusion. This is exposed to a furnace, the fire of which is regulated in the following manner: First, there is a layer of wood, then a layer of charcoal, and lastly a layer of the *lech*, broken into pieces. The fuel being ignited, the *lech* is here roasted for the evaporation of the sulphur.

3*d*, A third operation then follows: After the lech has been roasted, they add to it powder of the richer ores, and the whole is smelted in another furnace. This is called the *second fusion*, or the *fusion enriched*.

4*th*, The result or *regulus* obtained from the second fusion is then carried to another furnace. Here it is again smelted, with the addition of the richest ores. This *third fusion* is called the *fusion upon lead;* because, when the furnace is tapped, and the metal begins to flow into a receiver made with charcoal and clay, they cast lead upon it: this, after smelting, combines with the gold and silver, and falls to the bottom of the vessel. During this operation, the lighter metals, such as copper, iron, cobalt, bismuth, and arsenic, rise to the surface, and are raked off in the form of *scoriæ*, which they carry, as *lech*, to be fused again in the first operation. The lead, thus combined with gold and silver, is collected into large crucibles, and carried to the *fourth fusion*, or fifth operation, for the separation of the lead.

5*th*, The furnace used for the separation of the lead is called a *purification furnace*. The shape of it resembles a hollow sphere, whereof the upper part is so contrived, that it may be taken off like a lid, being raised by large chains. Here the richest ores that can be procured are added to the compound of lead, silver, and gold; and the whole is fused, not with charcoal, but by means of a flame drawn over the superficies, uninterruptedly, for twenty-four hours at least. During this process, the lead becomes calcined. A portion of it is absorbed by the bottom of the furnace, consisting of *wood-ashes* and *silica;* another portion escapes in a gaseous form; but the greater part is raked off as it rises to the surface, in the form of *galena*, by men employed with instruments for that purpose. During all this operation, the gold and silver concentrate more and more, until at the last they are found pure and combined together in a cake of metal, at the bottom of the pu-

* The rule is this: When a *quintal* of the *ore* does not contain two *lotos* of silver, it is sent to the stamping machines.

rification furnace. Then follows the *sixth* and the most beautiful of all the operations,—that of separating the gold from the silver.

6*th*, The *cake*, or combined regulus of gold and silver, obtained from the purification furnace, is separated into thin pieces in this manner: It is melted, and, in a state of fusion, cast into cold water. By this means it is obtained with a very extended superficies, and easily divided into a number of thin scales. These are put into immense glass retorts, of a spherical form, nearly filled with *nitric acid*. Here the silver dissolves, a gentle heat being communicated to the retorts, to accelerate the solution. It has been usual to exclude foreigners from the great *laboratory*, where this takes place; but as we had witnessed every operation, we were also permitted to view the interior of this chamber. The sight was beautiful. It was a spacious and lofty hall, filled with enormous globes of glass ranged in even rows, whence the *nitrous gas* was escaping in red fumes to the roof; the solution of silver being visible in all of them by the effervescence it caused; the gold falling at the same time, in the form of a black powder, to the bottom of every retort. After the solution of the silver is completely effected, the *acid* containing the silver, by augmenting the heat, is made to pass into another retort, and the gold is left behind in the former vessel. Afterwards increasing the heat to a great degree on the side of the silver, the whole of the acid is driven off, and the silver remains beautifully crystallized within the retort. All the glass globes containing the crystallized silver are then cast into a common furnace, where the glass, by its levity, remaining on the surface of the metal, is removed in the form of scoriæ. This is the last operation. The gold is smelted into ingots of 12,000 florins each."

"In the essaying laboratory, instead of the long process we have described for extracting the precious metals from their ores, two simple and easy experiments are sufficient. The first is a trial of the pulverized ore by *cupellation*. About a tea-spoonful of the pulverized ore, first weighed, is put into a small *cupel* made of calcined bones: this being exposed to the heat of a powerful furnace, the lead, semimetals, &c. are either absorbed by the cupel, or they are sublimed. Nothing remains afterwards in the cupel but a small bead of combined gold and silver; and by the proportion of its weight to the original weight of the ore, the value of the latter is determined. The gold is then separated from the silver by the solution of the latter in nitric acid; and the difference of the weight of the gold from the whole weight of the two metals, combined, determines the quantity of silver dissolved by the acid." "A hundred pounds weight of their richest ores contained from four to five *marks of silver*, and each mark of the silver about 15 *deniers* of gold."

The mines are wrought partly at the expence of the crown, and partly at the expence of individuals, who pay a duty called *urbur*, and are besides obliged to deliver the metal at a fixed price to the royal treasury.

The number of miners employed by the crown at these mines amounts to 9,500, of whom 8000 are at Schemnitz; and the expence to government of working is estimated at 50,000 florins a month, and the clear profits during the same period 12,000 florins, about 1333*l*. calculating the pound sterling equal to nine florins. The workmen are paid, when the ore is *rich*, according to the quantity and quality of the ore raised, but when it is *poor*, they receive wages. The Schemnitz ores, in the space of thirty-three years, (from 1740 to 1773) produced seventy millions of florins in gold and silver; and those of Cremnitz thirty millions during the same period. The greatest produce, however, was derived from them in 1780, when they yielded 2,429 marks of gold, and 92,267 marks of silver, making 3,043,000 florins. In common years, according to the calculations of Born and Ferber, these mines, including the copper mine of *Neusohl*, where one quintal of copper produces twelve ounces of silver, yield from 58,000 to 59,000 marks of silver, and from 1,200 to 1,300 marks of gold.

The silver mines in Upper Hungary at Nagy-Banya, Felsoe-Banya, and Lapos-Banya, in the county of Szatl.-mar; at Metzenseif, in the county of Bihar, with the copper mines of Retz-Banya and Schmoelnitz, according to Mr Ferber, give an annual produce of from 12,000 to 15,000 marks of silver, and from 300 to 400 marks of gold. The copper and lead mines in the Bannat at Oravitza, Saszka, Dognaszka, and Moldava, yield annually about 111,04 marks of silver, and 20½ marks of gold.

The copper mines of Hungary produce annually from 30,000 to 40,000 quintals. The richest are situated at Schmoelnitz in the county of Zips, and in the Bannat.

The lead mines in 1786 were wrought to the extent of from 14,000 to 15,000 quintals, but this produce is now considerably diminished.

The iron mines in this country are almost inexhaustible. The best is drawn from a mountian called Hradek, near Esetnek; but as this metal is not subject to any duty or tithe, the annual produce of these mines have not been ascertained. In the county of Goemor, including the district of Kleinhont, there are eight great furnaces, a floating furnace, eighty-seven small ones, and forty-nine forges, which furnish annually 94,200 quintals of iron, worth 1,304,240 florins. But, notwithstanding the great quantity of iron which this country produces and exports, they are obliged to be indebted to Austria for most of their tools and vessels made of this metal.

*Manganese* is found near Felsoe-Banya, and in some of the iron mines; *titanium*, in the county of Goemor near Roeze; and *tellurium*, which was discovered by Dr Kietaibel in a mineral of Deutsch-Pilsen in the county of Hont. Many valuable and beautiful minerals are found in the Hungarian mines. Among them may be mentioned, *amethysts* invested by efflorescent *manganese-spar*, in a minute crystallization upon the surface of the amethystine crystals; rich *sulphurets of silver*, called by the Germans *Weisgulden Erz*, or "white money ore," which is so malleable, that medals have been struck from the unwrought ore; *sulphurets of silver*, both massive and crystallized; *red antimonial*, or *ruby silver* crystallized: *dodecahedral* and *primary* crystallizations of *quartz*; phosphates and carbonates of *lead* crystallized; red sulphurets of *arsenic* crystallized; diaphanous crystals of the sulphuret of *zinc*, and of the sulphate of *barytes*; *pearl-spar* in spheroidal tubercles, upon silver ore; native gold crystallized, &c.

Of the precious stones of Hungary, the vallies of Konigsberg afford emeralds and rubies, and its mountain contains topazes, hyacinths, and chrysalites; granites are very common, and rock crystals of various forms; small crystals, remarkable for their brilliancy, are found in the county of Marmarosch, and receive the name of *Hungarian diamonds*. There are also amethysts of various colours, opals, jaspers, and agates.

The salt mines of Hungary are very productive, particularly those in the counties of Scharosch and Marmarosch. In the former county, near the village of Sevar, great quantities of rock salt were extracted during the 16th century; but towards the end of the 17th century, the quarries were inundated by salt springs, which contain a remarkable quantity of muriate of soda. Since that time other inundations have taken place; but, without neglecting the extracting of rock salt, establishments have been formed for obtaining common salt. These mines produce 27 per cent. All the salt pits and mines are under the direction of the crown, and produce annually about a million and a half of quintals. The price is fixed by the government, and cannot be augmented but by the king, with the consent of the diet. As the profits arising from the sale of this commodity form a part of the regal duties, it is not allowed to any individual to appropriate to his own use any saline earths or springs which he may have discovered, even on his own property.

Hungary abounds in quarries of limestone, and marbles of various colours. Alabaster and chalk are also common.

Manufactures and the arts are still in their infancy in Hungary, and do not nearly supply the consumption of its inhabitants. Linen and woollen cloths are made throughout the country; but there is only one cotton manufactory, which is established at Sassin, in the county of Neutra. In 1800 it employed 20,000 individuals in different parts of the country, and circulated every year nearly half a million of florins. There was formerly another cotton factory at Lisza, which consumed annually about 150 quintals of cotton, and yielded a gain of 18,000 florins; but the proprietor several years ago removed it to Baad in Austria. According to M. Schwartner, this manufacture in 1796 kept 1,700 looms in employment, which produced 25,000 pieces of cotton cloth. Those in the northern districts, though still very imperfect, are the most flourishing, and have made considerable progress within the last twenty years. The other branches of industry that are deserving of notice are, the manufacture of oils, paper, potashes, spirits, liqueurs, tobacco, woad, hats, soap, leather, alum, earthenware, glass, copper, and iron.

The Germans were the first who introduced the arts into this kingdom in the 12th century; and from that time the principal artisans have been of that nation. A true Hungarian would consider himself degraded by being employed in any other labours than those of agriculture or arms. This repugnance is very general; and though their national *costume* has always been a hussar dress, covered with lace and fringe, yet it is only within these fifty years that the capital possessed a single lace-maker.

Considering the extent of this kingdom, its commerce may be divided into two branches; the trade carried on between its different districts, and its trade with foreign countries, or its *internal* and *external* commerce. The inhabitants of the north, who, with their utmost industry, are unable to raise sufficient corn for their own consumption, exchange their iron, salt, cloths, and other manufactures, for a portion of the luxuriant harvests of the south; and this traffic is greatly facilitated by the establishment of fairs, of which there are 1640. The itinerant merchants, however, who frequent these fairs, and travel through the country, though they are serviceable in supplying the inhabitants with many articles which they could not otherwise easily obtain, are supposed to have done considerable injury to trade in general, and also to the revenue of the state. The merchants stationary in the towns presented a memorial to the diet on this subject in 1802, complaining that their itinerant brethren possessed neither knowledge nor character proper for merchants; that they defrauded the revenue, by smuggling articles of import; that they imposed upon the inhabitants with damaged goods, and exorbitant prices; and thus destroyed that confidence which the public ought to have in the merchant. Notwithstanding this remonstrance, however, the fairs are still continued.

The external commerce of Hungary was so very inconsiderable as late as 1779, that it yielded only 27,347 florins; but by the exertions and speculations of a few spirited individuals, who employed every possible mean for establishing foreign relations, it was brought, in the beginning of the present century, to 3,631,553 florins. Many difficulties, however, must be overcome, before Hungary can be formed into a commercial country. Its geographical situation is very unfavourable to commercial operations, being sixty-eight leagues from the maritime coasts of Austria; and consequently the expence of transportation precludes it from competing in foreign markets with those countries which are more favourably situated. Its productions, in spite of these obstacles, are carried into Austria, Italy, Switzerland, Germany, Prussia, Russia, and other northern states. These consist chiefly in grain, tobacco, wine, gall-nuts, cattle, wool, skins, tallow, honey, wax, buckthorn, antimony, and potashes. Grain is exported into the frontier states of Austria, and by the Adriatic. In 1803, Vienna alone received from this country 543,083 Presbourg measures of wheat and rye, 316,163 of barley, and 591,839 of oats. Hungary supplies Austria and the German states with tobacco, and exports wine into all the northern kingdoms and states of Europe. Vienna alone consumes annually from 30,000 to 35,000 *eimers*.

The imports of Hungary are derived chiefly from Austria, the government having prohibited the admission of goods through any other channel. Turkey, however, is excepted, as a prohibitory system with respect to this country could not be carried into effect without great difficulty and expence. The great magazine for Turkish produce, which passes into Hungary by land, is at Schuppanek. A considerable quantity enters also by the Danube at Panczova, Kubin, and Homolitz. The imports from Turkey by the city of Schuppanek, during the years 1803 and 1804, amounted to 2,652,473 livres: viz.

| | *Livres.* | | *Livres.* |
|---|---|---|---|
| Wool | 1,232,505 | Suet | 238,176 |
| Cotton | 194,877 | Bacon | 1,652 |
| Red thread | 61,743 | Hams | 550 |
| Rice | 32,064 | Candles | 116 |
| Honey | 156,378 | Sturgeon's spawn | 9,829 |
| Wax | 8.996 | Grease | 6,527 |
| Leather | 356,619 | Cabbage | 35.530 |
| Hare skins | 5.839 | Onions | 19,928 |
| Goat do. | 2,721 | Garlic | 365 |
| Sheep do. | 1,469 | Pot-herbs | 5,686 |
| Stag do. | 106 | Melons | 2,114 |
| Chamois do. | 11 | Plums | 659 |
| Badger do. | 8 | Lint | 490 |
| Buck do. | 38 | Tobacco | 155 |
| Wolf do. | 33 | Buck-thorn berries | 952 |
| Bear do. | 9 | Gall-nuts | 240 |
| Fox-tails | 371 | Olives | 288 |
| Horned cattle | 2,334 | Olive-oil | 54 |
| Calves | 129 | Frankincense | 48 |
| Horses | 609 | Raisins | 304 |
| Sheep | 3,150 | Buck-horns | 19 |
| Goats | 1,839 | Figs | 142 |
| Hogs | 6,589 | Lime | 23,349 |
| Fish | 214.584 | Soap | 1,268 |
| Tortoises | 2,239 | Reed-mats | 627 |
| Salt meat | 6,053 | Boots | 312 |
| Beef tallow | 4 419 | Cordage | 5,750 |

The imports which enter by the Danube are of the same description as those in the preceding Table; but their amount is comparatively inconsiderable. Of colonial produce, Hungary consumes annually about 8,000 quintals of coffee, and 10,000 quintals of sugar. Upon the wh

the

notwithstanding its commercial difficulties and obstructions, the exports of Hungary are to its imports in the proportion of more than four to three. According to the calculations of Schwartner, during ten years, (from 1777 to 1786,) its exports were valued at 148,229,177 florins, and its imports at 106,721,371 florins.

The money, weights, and measures of this country correspond nearly with those of Austria. In money, the common reckoning is in *florins* and *kreutzers*,—60 kreutzers being equivalent to one florin. The copper coins are, the *polturak*, equal to a kreutzer and a half; the *groszel*, value of half a polturak; and the *ungrisch*, of which five are equivalent to three kreutzers. The ideal or fictitious money of Hungary consists of

| | | | | |
|---|---|---|---|---|
| the *bauer-gulden* | = | 49½ | kreutzers | |
| the *kurze gulden* | = | 50 | do. | |
| the *vonas-gulden* | = | 51 | do. | and |
| the *ort* | = | 12 | do. | |

The measure prescribed for corn throughout the kingdom is the Presbourg bushel. In the county of Zips this measure is called a *kubel*, and is divided into two *koretzs*; but in other places the kubel is divided into four koretzs or *veka*. The *eimer* is the general measure for wine, but it varies in its contents in different parts of the country. At Oedenbourg it contains 84 *halben* or pints, and at Buda only 60. The great eimer of Debretzin is 100 pints, and the small one 50. In consequence of this discrepancy of measures, the merchants presented a remonstrance to the committee of commerce appointed by the diet. On this subject they remarked, that such a variety of measures were hurtful to commerce, and destroyed their credit among foreigners; that an *antal* of Tokay wine, which ought to hold an eimer and a half, in general contained scarcely an eimer; and that a *piece* of wine, which ought to contain 64 halben, has seldom more than 58.

The *foot* of Vienna is the standard square measure for surveying. According to a regulation called *urbarium*, the *joch* or acre is fixed at 1600 square toises; but in some of the counties, where this regulation has not been introduced, this measure varies greatly; as at Oedenbourg, for instance, the acre measures only 900 square toises.

The weights are in general the same as at Vienna, (except the *stein* used in Upper Hungary, which weighs 20 pounds,) viz.

| | | |
|---|---|---|
| 1 quintal (cwt.) | = | 100 pounds |
| 1 pound | = | 2 marks |
| 1 mark | = | 16 loths |
| 1 loth | = | 4 *quintales* or drams |
| 1 *quintale* | = | 4 deniers |

The greatest obstructions to the commerce of this country arise from the difficulty and expence of conveyance. Except in the districts on the north and west, there are few made roads in Hungary, and these are kept in very bad repair. The bridges in general are wretched, and almost all built of wood, which the rising of the rivers often carries away and destroys. Some of the flying bridges, however, used in this country, are very magnificent, and are adorned with considerable elegance. That over the Danube at Gran consists of a large platform constructed across two barges, and held by other boats at anchor. It is provided with several small houses, a large bell and cupola, images, &c. and is capable of conveying, at the same time, a great number of carriages, passengers, and cattle. From Pesth, the centre of Hungarian commerce, the road to Vienna passes through Komorn, Raab, and Wieselbourg; to Gallicia, by Erlau, Kaschau, and Eperies; to Transylvania, by Debretzin, and also by Ketschkemet, Szegedin, Temeschwar, and Lugosch; to Walachia, by Temeschwar, Karansebes, and Schuppenek; to Semlin and Belgrade, by Theresienstadt and Neusatz; to Croatia, by Stuhlweissenbourg, Veszprim, and Kanischæ; and to Stiria and Trieste, by Veszprim, Somogy, and Pettau.

The transportation of goods by water, though more expeditious, suffers many interruptions, from the shallows and rapids in the rivers. The Danube itself is far from being free of these inconveniences; but boats with from 6000 to 8000 quintals of grain can pass as high as Komorn. The formation of canals, however, which has of late become an object of improvement, promises to facilitate greatly the internal commerce of this country. Those that are finished are, the canal of Baatsch, the Bega canal, and the Tranzisci canal. The Bega canal commences near Facsed in the county of Krascho, and after forming a communication between the rivers Bega and Temesch, traverses all the Bannat, and falls into the Theisse. The Tranzisci canal was first opened only in 1802. It receives the waters of the Danube at Monoflor-Segh, and discharges itself into the Theisse at Foldwar; and in its whole extent requires only four sluices. In 1804, there passed through this canal 634 boats, many of which carried from 4000 to 5000 quintals; and their cargoes, which we here present to the reader, will enable him to form some idea of the internal commerce of this country.

| | | |
|---|---|---|
| Salt | 52,443 | quintals |
| Wine | 32,950¾ | eimers |
| Wheat | 607,874¾ | bushels |
| Barley | 7,540 | do. |
| Millet | 14,476 | do. |
| Maize | 4,407¼ | do. |
| Oats | 97,166½ | do. |
| Fruit | 1,250 | quintals |
| Copper and Silver | 2,400 | do. |
| Timber | 24,654 | do. |
| Fire-wood | 850 | do. |
| Oak-plank | 529 | do. |
| Pales | 3,639 | do. |
| Empty casks | 2,376 | do. |
| Furniture | 1,105 | do. |
| Hay | 150 | do. |
| Marble | 936 | do. |
| Free-stone | 300 | do. |
| Tobacco | 271 | do. |
| Planks | 1,444 | do. |
| Mill-stones | 402 | do. |
| Wheel-barrows | 199 | do. |
| Pitch | 115 | do. |
| Earthen-ware | 6,189 | do. |
| Hoops | 100 | do. |
| Lime | 1,450 | do. |

The population of Hungary is much less, in proportion to its extent, than that of the neighbouring countries of Austria, Moravia, or Bohemia; and this may easily be accounted for from the immense plains of sand, and the great numbers of morasses and heaths, which render a great portion of the lower plain entirely uninhabitable. According to M. Demian, the number of inhabitants amounts to 6,620,637, making 1654 to every square mile. These consist of a variety of nations, Hungarians, Slavons, Walachians, Germans, &c.

The Hungarians, or Huns, who settled here near the end of the ninth century, and gave their name to the country, have established themselves in the best and most fruitful part of the kingdom. They inhabit almost all the lower plain, beginning at Marmarosch, and the western part of Hungary, and form the population of 3,668 towns and villages. The true Hungarians are of a free and independent character, and affect to despise the Germans. They prefer the trade of arms, or the labours of agriculture, to every other employment. The dress, called *Hessian* in England, consisting of pantaloons and military half-boots, with spurs fastened to the heels, is so universal, that it is worn both by boys and men; and the Hussar uniform, which is peculiar to this nation, and consists of a tight vest, mantle, and furred cap, with the whiskers, give them a graceful and military appearance.

The Sclavons are more numerous, and are daily increasing. They are divided into several branches: Slowacs, Ruszniacs, Croats, Vandals, and Servians or Rasciens. The *Slowacs* inhabit chiefly the counties on the north and north-west, particularly those of Presbourg, Neutra, Trentchin, Thurotz, &c. and occupy 3,768 towns and villages. Of all the inhabitants of Hungary, this people are the most fruitful; for wherever they have established themselves among Hungarians or Germans, these have ceased to prosper, and their families have become extinct in a few generations. The *Ruszniacs* have settled in the counties of Marmarosch, Beregh, &c. bordering on eastern Gallicia. According to the *conscription tables* of 1787, they amounted to nearly half a million of souls, and peopled 702 towns and villages. The *Croats* dwell principally on the banks of the lake Neusiedl, and the counties of Wieselbourg and Oedenbourg; and the Vandals on the mountainous parts of Eisenbourg. The *Rasciens* or Servians came as colonists to Hungary during the reign of the emperor Sigismund. They occupy a great part of the military frontiers, and also many places in the interior, and have had considerable privileges granted to them by the kings of Hungary.

The *Walachians*, who are supposed to be the descendants of the ancient Roman colonies, dwell chiefly in the Bannat, on the confines of Walachia, and in the counties of Arad, Bihar, and Szathmar, in 1,024 towns and villages. Those of the Bannat bear a very bad character. They are noisy and quarrelsome, and fond of gambling. They commit many disorders and crimes, which have been attributed to the influence of their priests, who are called *Popes*; and it has been calculated, that in twenty executions for capital offences, there is always one pope.

The *German* population is scattered almost equally over all the kingdom, but it predominates in 921 villages and towns in the counties of Zips, Eodenbourg, and Wieselbourg, and in some of the royal free cities. They are almost all Suabians, and their reception as colonists into Hungary is of a late date, chiefly between the years 1765 and 1787. In the last of these years alone more than thirty villages were built for them. In general the establishment of new colonies in Hungary have cost the government more than six millions of florins. The population of the royal free cities varies from 30,000 to 1,100 inhabitants. Presbourg, Pesth, and Debretzin, are the most populous; but Rust, on the lake of Neusiedl, in 1794, contained only 1,105 inhabitants. Of the towns, the principal are, Ketschkemet, containing, in 1803, 24,000; Nagy-Koros, 12,000; Szarwasch, 9,000; Sazbereny, 12,000; and Bekesch, 11,000 inhabitants. The villages are very unequally peopled. In the lower plain, some are found with six, ten, and sometimes twelve thousand souls; but in the mountainous districts they seldom exceed 700.

Besides these principal nations, there are also *Macedonians*, or Modern Greeks, who have no settled habitations, but travel over the country, engaged entirely in commerce; *Jews*, who are chiefly itinerant merchants; *Armenians*, who are employed in agriculture; and *Bohemians*, or gypsies. This vagabond race are very numerous in Hungary; and, in spite of all the attempts of the Emperor Joseph II. to reform and civilize them, they still maintain their ancient customs and habits. Those of the Bannat get their livelihood as itinerant blacksmiths or musicians. During summer they go almost naked, and are then employed in washing gold from the sand of the rivers; and in winter they cut spoons, ladles, troughs, and other implements of wood. They form the orchestra at all weddings and merry meetings; and many of the richest nobles invite them to their castles, to amuse their guests with their music and national songs. Schwartner, in his Statistics of Hungary, attempts to account for this variety of population: "From the earliest history, Hungary has been the native abode of the Sarmatians or Sclavonic tribes. Since the fourth century, it has been the hospitable region where reposed the innumerable hordes which overturned the Roman Empire,—the asylum of many Tartar nations that were driven from their own homes,—the passage of those fanatic bands of crusaders, whom the knavery and avarice of monks sent to perish in Palestine, that they might take possession of their wealth in Europe,—as the frontier of Christendom, the theatre of European valour and Turkish ferocity,—and for a long time the cherished homes of the gypsies, the *El-Dorado* of the Germans, especially of the laborious Saxons, and numerous Suabians."

The inhabitants of Hungary may be classed under three heads, viz. the nobility, the citizens, and the peasants. The nobility are very numerous, and are calculated at 325,894 individuals, making nearly one for every twenty-one inhabitants and a half. These consist of the barons of the kingdom, or officers of state, and the order of *Magnats* (*liberi barones*). Of the latter there were, according to the Political Almanack of 1805, 95 families of counts, 79 of barons, and 297 of noble strangers, who had obtained letters of naturalization since the commencement of the Austrian sovereignty. There are only three families whose heads enjoy the title of *prince*: Esterhazy, Bathyany, and Grassalkovics. The first is supposed to be the richest subject in Europe. Among the nobility, also, are included all gentlemen who possess landed property, as the individual doing so is *ipso facto* ennobled. The title of citizen or burgher belongs only to the inhabitants of the royal free cities, who have particular privileges; and their number, including the inhabitants of the six free cities of Croatia and Sclavonia, amounts to nearly 366,000. The peasants are the inhabitants of the country, who belong neither to the noblesse, the clergy, nor the military, but who live entirely by husbandry, the cultivation of the vine, or the rearing of cattle. Of these they reckon 509,825. With them may also be classed 788,993 other individuals, whom thep call *haüsler*, who have no lands to cultivate, but who live by their own labour.

The government of Hungary is a limited monarchy, where the king enjoys great authority and influence; but where the nobility also have extensive rights and numerous privileges. The order of succession is established in the descendants of either sex of the House of Hapsburg, who at their coronation must take an oath in the presence of the diet, to preserve and maintain inviolate the liberties, privileges, rights, laws, and usages of the kingdom at present existing, or which may hereafter be decreed during their reign; never to carry the Hungarian diadem out of the kingdom, but to entrust it to two lay guardians elected by the diet for the purpose; to unite to the crown of Hungary all the countries which it formerly possessed, should they be reconquered; to restore to the estates of the realm the right of electing a king after the extinction of the line of the descendants of Charles VI., Joseph I., and Leopold I.; and that each of their successors shall be bound to sanction this conservative act at the diet of his coronation within six months after his accession.

The prerogatives of the monarch consist in his exercising the executive power in its full extent; but the legislative power he holds only in conjunction with the diet, whose decrees alone have the force of laws; the nomination to all bishoprics and abbeys, and ecclesiastical dignities, as also to all civil and military appointments, (the Palatine, and the two keepers of the crown excepted, who are chosen by the diet from a list of candidates presented by the king); the power of creating nobles, of making peace and war, and of calling out the personal levy; the right to the revenues of all vacant benefices, as also to the properties of all deceased nobles who have died without heirs, or who have been convicted of treason or rebellion; the immediate superintendance and direction of all establishments of public instruction, whether religious or temporal, whether Catholic or Protestant; and the right of convoking the diet, of pointing out the matters that are to be there discussed, and of proroguing or dismissing it.

The privileges of the nobility, by an act of the diet in 1741, were formed into a fundamental law of the kingdom, and consist in the right of assisting at the deliberations of the legal assemblies of the county, wherein they dwell or possess property, whatever be the subject under consideration; the inviolability of their persons from arrest, unless in the cases of felony, high-way robbery, and some other crimes; the sole right of possessing lands with the seignorial power over their vassals; and the exemption from all contributions and imposts.

The royal free cities enjoy the same rights as the nobles without exception, and are subject to the same laws and usages. They are considered as domains of the crown, which can neither be alienated nor mortgaged. They constitute the fourth order of the diet, and are represented by two members each; and the citizens elect their own burgomasters, judges, and magistrates. Besides the royal free cities, there are others which possess particular privileges; the most considerable of which are the sixteen cities of Zips, which were mortgaged to Poland by King Sigismund, but restored to Hungary in 1772. Their jurisdiction, civil and military, is independent of the county; and they enjoy the right of appeal from their own tribunals to the supreme courts of the kingdom. Their population is 45,000. The six cities of Heidukes, in the county of Saboltsch, which possess nearly the same privileges, and send two deputies to the diet. They contain about 27.500 inhabitants; and the districts of Jazyg, of Great and Little Cumania, which form a population of 112,723 souls. They are under the immediate jurisdiction of the palatine, and form, like the royal free cities, a domain of the crown. They pay neither duty nor tithe, and send two representatives to the diet. All these, however, are subject, like the other cities, to the general contributions.

The peasants, since 1791, by an act of the diet, are no longer attached to the soil, but are at liberty to leave their habitations at the proper term, and seek another lord. Formerly it was not permitted for plebeians to plead in law against a noble; but the free cities pleaded for their individual burghers, and one noble defended the rights of his vassals against another. By the diet of 1802, however, it was decreed, that, for the future, citizens and peasants should be permitted, in certain cases, to prosecute for themselves. Plebeians, also, as such, may fill the highest situations in the church; and it is not unfrequent, that, on account of their learning and good conduct, they obtain letters of nobility. When once ennobled, the career of honours is open to them, and they may then aspire to the first offices of the kingdom.

The principal officers of state are the *palatine*, who, besides other duties, presides at the assembly of the diet, is viceroy in the absence of the king, and generalissimo of the Hungarian troops; the grand judge of the kingdom; the *bann* of Croatia, Dalmatia, and Sclavonia; and the grand treasurer.

The *Diet* of the states is composed of four orders, viz. the prelates; the lay-barons and the magnats; the representatives of the counties, each county sending two members; and the representatives of free cities. They are invited to the diet, in the name of the king, by letters of convocation dispatched by the chancery; and these letters often contain a statement of the different points that are to be there discussed, that the counties and free cities may give proper instructions and powers to their deputies. According to the constitution, no one but a noble, that is, one who possesses landed property, can sit and deliberate in the diet. When assembled, all the members are considered as upon an equality, neither baron nor bishop having any privileges more than a simple gentleman. They meet in separate chambers: the chamber of *magnats*, where the palatine presides, and which is composed of the prelates, the barons of the kingdom, the governors of counties, and all the counts and barons who may be members of the diet; the other deputies, who are the most numerous body, constitute the chamber of *states*, where the grand judge presides. When a motion has passed both chambers, the king has the power of confirming or rejecting it, his approbation being necessary to give it the force of a law.

The internal police of the kingdom is administered by the supreme aulic chancery, the council of government, and other subordinate courts. The first sits at Vienna, and is composed of an aulic chancellor, vice-chancellor, and ten aulic counsellors, all chosen by the king. Of the counsellors, two are bishops, two magnats, and six nobles. It is the organ by which the king exercises his royal authority, and directs the political affairs of the interior. It expedites all letters-patent, granting favours and privileges, and also all diplomas, nominating to vacant bishoprics, ecclesiastical benefices, and other offices. The *council of government* sits at Buda, and consists of the palatine, who is president, and 24 counsellors. It has the superintendance of all inferior courts, and of all matters regarding general police and public safety, and the inspection of churches, universities, &c.; it encourages agriculture, industry, and commerce; and decides in all matters of litigation respecting the services of peasants towards their lords, &c.

The subordinate courts are those of the counties and free cities. Each county has its governor and two vice-governors, a procurator, and vice-procurator-fiscal, a receiver-general and assistant, a notary, &c. The governors are appointed by the king, except in the cases of the palatine, the primate, the princes Esterhazy and Bathyany, the counts Kobari, Illeshazy, Palfy, Nadasdy, Schonhorn, Csaky, Erdody, and baron Revay, who are hereditary governors of counties; the other magistrates are appointed by the county, and are renewed every three years. The governor convokes the county whenever he thinks it necessary, and all the nobility within its bounds have a right to deliberate and vote. The subjects which are there discussed, regard the police and agriculture of the county; the election of their deputies and magistrates; the levying of contributions and imposts; and the publication of the decrees of the diet, and of the council of government.

The magistracy of a free city consists of a judge, a burgomaster, a counsel, a notary, &c. to whom are entrusted the administration of justice and police within the royalty.

The tribunals of justice, which possess general jurisdiction throughout the kingdom, are the septemviral table, and the royal table. The *septemviral table* consisted formerly only of seven members, but it is now augmented to twenty-two, of whom the palatine is president. It is only a court of cassation, and receives processes by appeal from the royal table and inferior tribunals. The *royal table*, where the grand judge presides, is composed of seventeen members, nine of whom must be present, in order to constitute its decisions valid. It pronounces on all disputes respecting property, the maiming or murdering of nobles, and crimes of high treason. It is also a court of appeal, and holds four sessions during the year.

The inferior and special judicatories are the four tribunals of the circles, which decide only in civil cases, having no criminal jurisdiction; the county tribunals, which have also four sessions, and take cognizance of all matters civil and criminal, except in cases of high treason; the district tribunals; the city tribunals; and the tribunals of individual nobles. Croatia has also a court of appeal, called *tabula banalis*, which sits at Agram, and of which the ban of Croatia and Sclavonia is president. It has the same jurisdiction within these provinces as the royal table at Pesth, with this difference, that an appeal may be carried from the *tabula banalis* to the royal table.

The bases of Hungarian jurisprudence are the *corpus juris Hungarici; decretum tripartitum Verboeczianum*, and *decisiones curiales*. The *corpus juris Hung.* is a collection of all the decrees passed by the diet from the commencement of the monarchy, and was first formed in 1584. Since that time it has received so many additions, that it is increased one half; but, latterly, these laws have been so ill digested, and so intermixed with other matters, that the confusion which is thus occasioned renders the study of them both difficult and laborious. The *decretum tripartitum Verboeczianum*, is a collection of customs introduced into the administration of justice, which, by long usage, have received the force of laws. This collection was made by Verboecz, the grand judge in the reign of Ladislaus II.; and though it has been rejected as a national code by several diets, yet, through the course of time, it has acquired such reputation, that it is actually acknowledged throughout the kingdom, as forming a legitimate part of Hungarian law. The *decisiones curiales* are the decisions of the judges of the royal table on certain questions to which no existing law could be directly applied. They were collected by order of Maria Theresa in 1769; and, after having been revised by the septemviral and royal tables, were published under the title of *planum curiale*.

The revenue of Hungary arises from three sources; the royal domains, the legal duties, and the contributions or imposts. The *royal domains* consist of the *kron-güter*, or such property as is attached to the crown, and is unalienable; and the *kammer-güter*, that which belongs to the king personally, and which he can dispose of at his pleasure. The annual value of both amounts to 6,000,000 of florins. The *regal duties* comprehend the management of the salt, which is supposed to yield nearly 6,800,000 florins; the mines, which, after deducting all expences, produce 1,097,000 florins; the duties upon exports and imports, valued at 1,300,000 florins; the quit-rents of the royal free cities, and of the sixteen cities of the Zips, amounting to 34,000 florins; the royal exchequer, which brings 94,000 florins; the toleration tax paid by the Jews, producing 100,000 florins; the tax of 5 per cent. upon all employments, to which is attached a retiring pension, yielding 37,000 florins; the ecclesiastical subsidy, which, in 1781, was 71,000 florins. To these may be added the post-office, the tolls upon the bridges, the tax of 10 per cent. which all must pay who carry their fortune out of the country; the lottery; and the banks, of which there are two, one at Presbourg, and the other at Buda. The contributions or imposts are levied upon the counties and cities. The total amount is fixed by the diet, and is divided into *porten* or portions, each of which is valued at 688 florins, 50 kreutzers. Every county and city is then burdened with so many *porten*, according to its population and resources, which they collect from the citizens and peasants. The sources of this branch of the revenue arises from the poll-tax, tax upon cattle, &c.; the land-tax paid by the farmer; and a tax upon trades, &c. The total amount of the contributions in 1802 was $6210\frac{2}{8}$ *porten*, making 4,277,827 florins, $12\frac{4}{8}$ kreutzers; to which may be added 113,615 florins, $58\frac{2}{8}$ kreutzers for Croatia. The total revenue of Hungary cannot be well ascertained, as the different items given above are not for the same year, and authors are also much divided in opinion respecting it. Schloezer makes it 13,500,000 florins; Busching, 18,000,000; De Lucca, 15,000,000; Schwartner, 11,750,000; and Demian, who is the latest author, fixes it at between 15 and 16 millions of florins. After deducting the public expenditure, the surplus, according to Schwartner, amounts to 1,002,296 florins.

The management of the finances is entrusted to the royal chamber of Buda, which is independent of all other authority within the kingdom, and corresponds with the royal treasury at Vienna. It administers all the royal revenues, except the contributions which are lodged in the government chest, and the mines and mint, which are entrusted to a particular council.

Since 1802, the Hungarian army, exclusive of the frontier regiments, is formed of twelve regiments of infantry and ten regiments of cavalry, making an armed force of 64,000 men. The military cordon, which extends along the frontiers from the Adriatic to the county of Marmarosch, is formed of seventeen regiments of armed peasants, each regiment having its particular district; viz. eight in Croatia, three in Sclavonia, two in the Bannat, and four in Transylvania. Each regiment has two battalions, and in time of war a battalion of reserve; the whole, exclusive of the reserve, amounting to 49,402 men. There is also a regiment of hussars, whose complement, in time of peace, is 1364 men and 1212 horses. The Hungarian army is maintained by an annual contribution, fixed by the diet in 1715, which is levied upon the citizens and peasants, and amounts to nearly three millions of florins. The country is also obliged to furnish bread and forage necessary for the troops at a fixed price, whatever be the price of these necessaries in the public markets; and the loss which is thus sustained by the counties, is computed at about a million of florins. The extraordinary contributions, however, which were required during the late wars with France, were paid almost entirely by the nobility.

In addition to the permanent army establishment, the diet, in urgent cases, grants a levy at the request of the king. During the middle ages, every Hungarian noble, by a law of the kingdom, was obliged to arm himself and his vassals in defence of the country when threatened by an enemy; and in cases of imminent danger, the whole nation took up arms. The levy now, however, is confined to a certain additional force, furnished and paid by the counties and cities. The first levy of this description was raised in 1741, for the war of the succession; and in the first coalitions against France, regular levies were decreed by the diet; but they were always too late of being brought into the field, to be of any service to the common cause. The levy of 1797, 40,000 strong, was scarcely assembled before the peace of Campo Formio was concluded; that of 1800 was stopped in their march by the peace of Luneville; and that of 1805 was withdrawn on account of the peace of Presbourg.

All religious sects enjoy full toleration and security in this kingdom, as well as in other parts of the Austrian dominions. The Roman Catholic is the established religion, and is under the jurisdiction of three arch-bishops, Gran, Kolotcha, and Erlau; 14 diocesan bishops, and 16 titular bishops; 16 metropolitan chapters, and two others of collegiate churches; 178 beneficed canons, and 79 honorary canons; 1 archabbot, and 146 abbots; 19 grand provosts, and 89 provosts. The revenues of the bishops and chapters are very considerable; and, according to Schwartner, that of the former, in his time, amounted to 864,776 florins, and of the latter to 530,668; but, according to Demian, they may now be valued, when taken together, at above two millions of florins. The inferior clergy are composed of pastors and monks. Of the former, there are 4189, including 2298 rectors, 402 chaplains, and 1489 curates; and of the latter are 3059, including 2236 priests, 214 novices, and 609 lay brethren. The Emperor Joseph II. increased the number of the pastors, so that every *commune*, containing a certain number of parishioners, should have one; and fixed their allowance at 300 florins for each rector, and 240 for each chaplain or curate. According to Grellmann, the Roman Catholic pastors, comprehending those of Croatia and Sclavonia, receive 1,379,500 florins. But, while the Emperor Joseph augmented the number of pastors, he at the same time suppressed 134 monasteries, containing 1209 priests and 275 lay brethren. There are still 136 remaining, of different orders: the *Piaristes*, who have two residences and 23 colleges; the *Benedictines*, four abbeys and three residences; the *Premontres*, five abbeys; the *Citeaux*, two abbeys and three monasteries; the fathers of *Charity*, ten monasteries; the *Cordeliers*, 61; the *Minimes*, eleven; the *Capuchins*, seven; the *Dominicans*, four; the *Carmes*, one; the *Servites*, three; and the *Augustines*, one. The support of these religious beggars, since they were precluded from seeking alms, costs the chest of religion 75,000 florins a year. There are also ten convents, containing 274 nuns and 116 lay-sisters; six of the order of *Sta. Ursula*, two of *Sta. Elizabeth*, one of *Notre Dame*, and one for English ladies at Buda. Six convents had been suppressed by the Emperor Joseph, containing 152 nuns and 39 lay-sisters. In 1802 there were 500 monks and nuns of the suppressed convents still living, who received pensions from the chest of religion; the priests and nuns from 300 to 200 florins, and the lay-brethren and sisters 150 florins. The number of Roman Catholics in the kingdom is calculated at about 4,000,000.

The Greek Catholic church, whose members amount to nearly 500,000, is under the direction of two bishops, who are suffragans to the Roman Catholic archbishop of Gran; two chapters composed of two grand provosts; eleven beneficed canons and six titular canons, and 820 pastors. The revenue of the two bishops is 28,000 florins, that of the chapters 9150, and that of the pastors 78,000 florins. Belonging to this church are eight monasteries of the order of *St Basil*, containing 68 monks, 21 novices, and 17 lay brethren.

The Greek Schismatic Church has five bishops, all suffragans of the metropolitan archbishop of Carlowitz in Sclavonia, whose dioceses contain 1120 parishes. There are ten monasteries of this religion, having a revenue of about 17,000 florins, and are inhabited by 82 monks. This sect amounts to 1,877,587 souls.

The Protestant Evangelical, or Lutheran Church, consisting of 700,000 souls, has 445 places of worship, and 478 ministers, who are chosen and supported entirely by their congregations.

The Reformed Evangelical Church is under a similar constitution, and includes 1324 churches, 1361 ministers, and 1,300,000 members.

There are 75,128 Jews, who have 42 synagogues, and 56 rabbies. This sect is excluded from all the cities which are near the mines; and some other cities consider the prohibiting of Jews to settle within their walls among the number of their privileges. The Anabaptists are inconsiderable in number, and are to be found only in a few cities.

The establishments for public instruction in Hungary, may be distinguished into General and Particular. Of the former, there is an elementary school, with two masters, established in every Catholic commune, where are taught, reading, writing, arithmetic, and religion. In addition to these, there are also 73 principal schools, to which are attached 234 teachers; 9 normal schools, with 51 masters; 43 gymnasia, with 88 professors; and 5 arch-gymnasia, with 26 professors. In all these establishments, education is gratuitous, and costs the state about 90,000 florins. For the higher sciences, there are four academies, at Presbourg, Kaschau, Grosswardein, and Raab; a lyceum at Erlau; two schools of philosophy at Stein-am-Anger and Szegedin; and a university at Pesth. Besides a school in each of their parishes, the Lutherans have several other establishments for the education of their youth. In all of them, however, the sciences are very imperfectly taught, and the masters very poorly paid. The Reformed, in addition to their parish-schools, have two colleges at Debretzin and Saros-Patak, which are intended chiefly for the education of their ministers. The Greek Schismatics have very few schools, except in the military frontiers of the Bannat, where there are 130, with 3615 scholars; and those of this persuasion who wish to study the higher branches of science attend the Catholic or Protestant academies.

The Special Schools consist of the practical schools for rural economy in all its branches, of which there are four, at Szarwasch, Kessthely, St Miklosch, and Hradek; a school for the deaf and dumb at Waitzen, and the royal school of mines at Schemnitz. To the school of mines at Schemnitz are attached two professors, one for metallurgy and chemistry, and the other for mathematics and other subjects connected with the mines. It is of great repute on the continent, and is generally attended by 90 students of different nations.

Notwithstanding the number of public establishments for education in this country, the state of the sciences and literature is still very low. The Latin language is in general use among the inhabitants, and indeed there are few parts of the country where it is not understood even by the lower orders. At Schemnitz, "the most prevailing tongue is the Sclavonian; next to this the Hungarian; then the German; and lastly the Latin." "Some conjecture," says Dr Clarke, "respecting the state of literature in any nation, may perhaps be formed by examining the booksellers' shops belonging to its capital; and with this view we eagerly inspected those of Presbourg, but no prospect could be more barren: there was not a single volume worth a moment's notice either upon sale in the town, or mentioned in any of their catalogues." The public library at Pesth, however, contains all the best editions of the classics, and some manuscripts, but these are of little value. The Hungarian language cannot boast of one work of merit; and even its Latin writers are very little known. The most voluminous and celebrated authors of this nation are Pray and Windisch. The researches of the former, who wrote in Latin, were confined chiefly to the history of his country; and those of Windisch, in German, to its geography.

See Gibbon's *Roman Empire*, 4to. vol. ii. p. 577, vol. iii. p. 362, and vol. v. p. 143, 548. *Anc. Un. Hist.* vol. xix. p. 204. *Mod. Un. Hist.* vol. xxxii. p. 99. Demian *Tableau Geographique et Politique des Royaumes de Hongrie*, &c. translated from the German. Clarke's *Travels*, vol. iv. p. 627—700. Pray's *Historia regum Hungariæ*, &c. Windisch's *Political, Geographical, and Historical Description of the Kingdom of Hungary*, in German; also his *Geography of Hungary*. Schwartner's *Statistics of the Kingdom of Hungary*. Sacy's *History of Hungary*. Townson's *Travels in Hungary*. Born's *Travels in Hungary*, &c. (*p*)

HUNGER. See ABSTINENCE and FASTING.

HUNS. See HUNGARY.

HUNTER, WILLIAM, M. D. celebrated as a physician and author, and as the collector of the Hunterian museum now in Glasgow, was born on the 23d of May, 1718, at Long Calderwood, his father's estate, in the parish of Kilbride. At the age of 15 he was sent to the university of Glasgow, where he passed five winters, being destined by his father for the church. This pursuit, however, did not accord with some modes of thinking which he had adopted; and an acquaintance which he formed with Dr Cullen, then a practitioner at Hamilton, inspired him with a taste for the medical profession, to which accordingly he attached himself. He resided three years with Dr Cullen as his pupil; after which it was agreed that he should study in Edinburgh and London, and afterwards return to Hamilton, to settle in partnership with Dr Cullen. In pursuance of this plan, he studied in Edinburgh in the winter of 1740 and 1741; and in the summer of 1741 he went to London, where he lived in the house of Dr Smellie; and prospects gradually opened on him, which induced him to remain in the metropolis. He brought with him a letter of recommendation to Dr Douglas from Mr Foulis of Glasgow, (the well-known printer of excellent editions of several of the classics,) who had formed a connection with that physician, by procuring for him various editions of Horace, of which the enthusiastic admiration of Dr Douglas made him anxious to possess himself of every existing edition. Dr Douglas, entertaining a favourable opinion of Mr Hunter's talents, proposed to engage him as his assistant in performing dissections for a splendid work on the bones, which he was then preparing for publication. Mr Hunter, obtaining his father's consent, accepted of this offer. His father died soon after, and in a few months he also lost his patron, Dr Douglas, who died, leaving a widow and two children. Mr Hunter continued to reside in the family, superintending the education of the children, and prosecuting his own studies. In 1743, he communicated to the Royal Society his observations on the structure of the cartilages of the joints, in which he shewed that, contrary to the ideas previously entertained, they were formed of short perpendicular fibres, like the enamel of the teeth. Meeting with applause in his anatomical pursuits, he wished to lecture on anatomy; and an opportunity was soon afforded him by Mr Sharpe, who had for some years lectured to a society of naval surgeons, and declined this task in favour of Mr Hunter. In commencing his first course, he felt great solicitude; but he soon met with applause which encouraged him. He had little difficulty to encounter, compared to one who commences such an undertaking without previous introduction to public notice. His eminent talents were in the first instance exercised in a field in which they were sure to be recognised. He therefore proceeded, not merely with confidence, but with enthusiastic zeal, in the pursuits in which he so much delighted. The profits of the first winter put him in possession of a larger sum than he had ever before possessed, 70 guineas; but as his generosity led him to supply the wants of different friends, his fund was completely exhausted before next winter, and he was even obliged to delay his lectures for a fortnight, for want of money to pay for advertising. This incident, together with the ultimate inutility of some of his generous acts to those who were the objects of them, impressed on him a lesson of prudence, which preserved him ever after from similar inconveniences, and laid in part the foundation of that fortune, which he expended in a public-spirited manner.

In 1747, he became a member of the college of surgeons; and in the spring of the following year he made a tour with the son of Dr Douglas through Holland to Paris. The beautiful anatomical preparations of Albinus, which he saw in Holland, inspired him with admiration, and an ambition to emulate their excellence. He returned to resume his lectures; and in the mean time he practised both surgery and midwifery. But he soon gave up the former of these branches, and attached himself to midwifery, in which his late preceptor Dr Douglas had been eminent. He was elected, in 1748, surgeon accoucheur to the Middlesex hospital, and the following year to the British lying-in hospital. These appointments, together with his agreeable person and address, in which he furnished a favourable contrast to Dr Smellie, who at that time enjoyed a high reputation, promoted greatly the extension of his practice, which was rendered still greater by the death of Sir Richard Manningham, and the retirement of Dr Sandys.

In 1750, he obtained the degree of M. D. from the university of Glasgow. At this time, he quitted the family of Mrs Douglas, and took a house for himself in Jermyn Street. In the summer of 1751, he paid a visit to his mother and other relations in Scotland, where he had an opportunity of exchanging congratulations with Dr Cullen, who was now, like himself, rising into eminence, and was established as a physician and professor in Glasgow.

In 1755, he was made physician to the British lying-in hospital on the resignation of Dr Layard, was admitted licentiate of the college of physicians, and soon after became a member of the medical society of London. He published, in the *Observations and Inquiries* of this body, a history of an aneurism of the aorta.

Dr Hunter turned his extensive practice to very eminent account, by adding to the pathological and medical knowledge of the age. He had the merit of first explaining the nature of the disease called *retroversio uteri*, and distinguishing it from other diseases with which it had been confounded; he explained the texture of the cellular membrane, and the pathology of anasarca and emphysema; he also threw much light on the subjects of ovarian dropsy, diseases of the heart and stomach, and hernia. For his papers on these and many other subjects, we refer to his *Medical Commentaries*.

In 1762, he was consulted during the pregnancy of the queen, and in two years after was appointed physician-extraordinary to her Majesty. In 1767, he became a fellow of the Royal Society, and enriched their Transactions with his learned observations on the bones of animals found on the banks of the river Ohio, and on the rock of Gibraltar.

He, after this, became engaged in some personal disputes with the present Dr Monro, senior, of Edinburgh, on their contending claims to priority in anatomical discoveries. This contest became keen, and was enlivened with wit and pleasantry; but probably more was lost by the irritation which it created, than was in any respect gained by either party. A man, in defending his own claims, is tempted to expose every defect which tends to shake the general credit due to his adversary, and the feelings which are most profitable and becoming for men of liberal pursuits are extinguished. Those are happiest who feel no temptation to enter on such controversies, or who, if accidentally betrayed into them, soon perceive their pernicious tendency, and in good time relinquish them. The subjects of dispute were indebted to both of these celebrated anatomists, but they both had been anticipated in some of their boasted discoveries by Haller, in others by Nouguez. The principal of them were the origin and uses of the lymphatics; the possibility of injecting the epididymis, and the excretory ducts of the lacrymal gland.

In 1768, Dr Hunter was elected a member of the Society of Arts, and was appointed anatomical professor to the Royal Academy of Arts. By now applying his anatomical knowledge to the elucidation of painting and statuary, he displayed in a new field the versatility and extent of his genius. In 1781, he was unanimously elected to succeed Dr John Fothergill as president of the London Medical Society. In the same year, the Royal Medical Society of Paris elected him one of their foreign associates; and, in 1782, he received a similar mark of honour from the Royal Academy of Sciences of Paris.

Dr Hunter's most distinguished publication was his *Anatomy of the Gravid Uterus*, which he began in 1751; but, from his great ambition to give it in the most complete state, he delayed to publish it till 1775.

In consequence of a memoir read by Mr John Hunter in 1780 to the Royal Society on the functions of the placenta, Dr Hunter was led into another keen dispute with this eminent man and near relation, in which he claimed, with considerable warmth, the share of merit which belonged to himself in the discovery. He seems to have perceived that he carried these disputes too far. They promoted an irritability of temper, which must have created to him much uneasiness; and it was remarked by those who occasionally conversed with him on professional subjects, that sometimes, when an organ or function was barely mentioned which had been the subject of a dispute, he broke out into a torrent of abuse of the knavery of his adversary. In the supplement to the first part of his *Commentaries*, he excuses his polemical appearances by representing *enthusiasm* as necessary to promote the sciences, and observing, that no man had ever been a great anatomist who had not been engaged in some violent dispute.

Dr Hunter was long employed in collecting and arranging materials for a history of morbid concretions formed in the human body. This design, however, was left imperfect, along with others contained in different manuscripts.

The magnificent museum, which we have already mentioned, is a monument which will perpetuate the name of Dr Hunter. The systematic manner in which he planned and conducted that undertaking, was characteristic of a strict philosophic prudence. He did not follow the occupation of a collector under the influence of a passion, the effects of which might afterwards interfere with his private happiness. He first laid aside a sum which he reckoned an adequate provision for himself whenever he should be obliged to retire from practice, and resolved to dedicate the remainder of his fortune to some plan of public utility. In 1765, he projected an anatomical school on a grand scale, proposing to expend 7000*l.* on the building, and to endow a professorship of anatomy. He did not, however, receive the encouragement from government which he expected; and, though afterwards the Earl of Sherburne entered so much into the scheme as to offer 1000 guineas to encourage the execution of it by means of subscription, the doctor's delicacy would not allow him to accede to this plan, and he chose to execute it at his own expense: for which purpose he purchased a house in Great Windmill Street, to which he removed in 1770, in which he had an amphitheatre and apartments for dissection, besides a magnificent room for a museum. Previously to this time he had confined his collection to human, comparative and morbid anatomy; but he now extended his views to the formation of a general museum, including fossils, antique medals, and rare books in the Greek and Latin languages. In an account of a part of this collection published by his friend Mr Combe, the expence of it was estimated at 20,000*l.* In 1761, he added to it the collection of Dr Fothergill, consisting of shells, corals, and other curious objects in natural history, which were purchased for 1200*l.*

About the year 1773 he had experienced so much injury to his health from gout, that he thought of giving up practice, and returning to Scotland; but prudential considerations, and his attachment to his favourite pursuits, determined him to remain in London. The returns of his disease became more frequent; and at last, on Saturday, the 15th of March, 1783, after having experienced a return of wandering gout, he complained of great head ach and nausea, and was confined for a few days to bed. He then thought himself so well, that he gave his introductory lecture to an intended course of surgery; but, towards the conclusion of the lecture, he fainted away, and was carried to bed. This happened on a Thursday. On the Saturday morning he told his friends, that he had a paralytic stroke in the night, though no symptom of it then appeared about him. He suffered little or no pain; and at one time, turning to his friend Mr Combe, he said, "If I had strength enough to hold a pen, I would write how easy and pleasant a thing it is to die." His death happened in ten days after his last lecture, viz. on the 30th of March, 1783. His figure was small and slender, but symmetrical and becoming. He was an agreeable, lively companion. The chief blemish in his character was an irritability on some subjects, which gave his manner an air of imperiousness. He will long be held in high estimation as a man, who, when the limited extent of his means is considered, contributed in a singular degree to the promotion of science. His nephew, the present celebrated Dr Baillie, was left the use of his museum for life, to be succeeded by Mr Cruickshanks, Dr Hunter's assistant, who was to enjoy it for thirty years, and then it was to become the perpetual property of the university of Glasgow. The right of reversion of Mr Cruickshanks was extinguished by the death of this gentleman; after which Dr Baillie generously gave up his claim, and the museum was removed to Glasgow, where magnificent apartments have been built for it, and the annual interest of 8000*l.* left by Dr Hunter, is appropriated to the preservation and augmentation of it. It has already been enriched with many additional articles; and, on the whole, adds a new lustre to that seminary, and tends to promote the resort to it which it has so long and so deservedly attracted. (*H. D.*)

HUNTER, John, an eminent surgeon and author, and brother to the subject of the preceding article, was born at Long Calderwood on the 14th of July, 1728. He was about ten years old when he lost his father; and, being the youngest child, was so much indulged by his mother, that, though sent to the grammar school in Glasgow, he made no proficiency in his studies, and, at last leaving them, lived for some time idle in the country. Tiring of this mode of life, he wrote to his brother Dr Hunter in London, proposing to become his assistant in his dissections; or, if that would not suit him, to go into the army. The doctor gave him a kind invitation to London, and he went up to him in September, 1748. The doctor found, on a very short trial, that he promised to become an expert dissector; and, entertaining great hopes of him, gave him every encouragement to persevere in professional pursuits. The following summer he attended Chelsea hospital, where he learned the first rudiments of practical surgery. By the succeeding winter he had made such proficiency, that his brother left in a great measure to him the superintendence of his public dissecting room. In the following summer he renewed his attendance at Chelsea hospital, and the summer after that he attended at St Bartholomew's. In 1753, he entered as a gentleman commoner at St Mary's Hall, Oxford. In 1756, he was appointed house surgeon to St George's hospital, where he had attended as a pupil the two preceding summers. In 1755, he was admitted to a partnership in his brother's lectures. His uncommon dexterity in making anatomical preparations, and some distinguished discoveries which he made in anatomical science, gradually raised him to great celebrity. He traced the ramifications of the olfactory nerves on the Schneiderian membrane; he demonstrated the mode of termination of the arteries of the uterus in the placenta; and he was the first who discovered the lymphatic vessels of birds. By directing his labours extensively to comparative anatomy, he laid the foundation of his splendid anatomical museum. These labours were not conducted with the design of exhibiting preparations of the entire bodies of different animals, but for the more useful purpose of illustrating, in a regular series, the varieties of organization subservient to each function in the different classes of animals. He applied to the keeper of the Tower, and other persons who kept wild beasts, to procure the bodies of those that died; and he had generally in his possession living animals of different species, for the purpose of observing their manners and instincts. Two anecdotes are related by his brother-in-law Sir Everard Home, that are very characteristic of his enthusiasm in this amusement. Two leopards which he kept broke loose on one occasion from their den, and the howling of his dogs in the same yard, alarmed the whole neighbourhood. Mr Hunter ran into the yard, and found one leopard scrambling over the wall, while the other was surrounded by the dogs. He without reflection seized both the leopards, and led them back into their den; but immediately after, when he thought of the risk which he had run, as an unlucky irritation on their part might have terminated in his immediate destruction, he was so much agitated that he almost fainted away. On another occasion, while he was struggling with a young bull, a species of amusement in which he had delighted, the animal got him down on the ground, and would have proceeded to the utmost extremities, if a person luckily coming to the spot had not rescued him.

In 1767, he was made fellow of the Royal Society, and formed a party of friends, who met at a coffee-house to discuss points of science after the meetings of the Society, which he soon found to increase, and to consist of some of the most eminent men of the age. It contained Sir Joseph Banks, Dr Solander, Sir Charles Blagden, Sir Harry Englefield, Mr Watt of Birmingham, and several others. An accident which he suffered, the rupture of the tendo achillis of one leg, in dancing, led him to study particularly the surgical pathology of that part, which he illustrated by experiments on animals. In 1768, Mr Hunter went to the house which had been occupied by his brother in Jermyn-street, as the latter moved to his house in Windmill-street, which he had just completed, and adapted on an extensive scale to his learned pursuits. Mr Hunter was thus placed in a favourable situation for private practice, and he now became a member of the College of Surgeons. In May, 1771, he published his celebrated work on the natural history of the teeth. In the following July he married Miss Home, of whom the present Sir Everard Home was a younger brother. The latter was then at Westminster school, and was brought up by Mr Hunter to the profession of surgery. It is to this gentleman that we are indebted for the interesting life of Mr Hunter, prefixed to a posthumous edition of his book on Inflammation. Mr Hunter's progress in acquiring practice was at first slow, as he was not possessed of those winning manners, and did not study those superficial arts, by which many rise in this respect to distinction. But the weight of his character for genius and professional industry at last brought him into the highest repute. His income was greatly augmented; but it was chiefly expended on his museum, to which he also regularly devoted his mornings, from sun-rise to the hour of breakfast. He continually laboured to turn his physiological discoveries and observations to account, in improving the art of surgery. To enumerate his improvements would far exceed our limits, and they are only to be learned by perusing his valuable works. He always delighted in making acute discoveries, and striking out new views. It is in explaining the phenomena of inflammation in its various forms, and the principles on which the healing process under various circumstances is conducted, that Mr Hunter's genius is most usefully displayed. Some of his opinions cannot be easily admitted as well-founded; such as his doctrine of the life of the blood, and of the identity of syphilis and gonorrhœa. In the winter of 1773, he began to give lectures on surgery, in which he delivered a full account of his practical improvements, as well as his pathological views. His first two courses were given gratis. He continued to improve comparative anatomy by the dissection of various animals, some of which were rare and curious, such as the torpedo and the gymnotus electricus, the electrical organs of which he described. He repeatedly dissected the elephant; he discovered those receptacles in the bodies of birds, to which the air passes through the lungs, which threw a new light on the function of respiration, as performed by that class of animals. He engaged an artist to live with him, for the purpose of making drawings of such parts as did not admit of being preserved. In 1776, he was appointed surgeon extraordinary to his Majesty. In the autumn of that year, however, he was taken dangerously ill, and began to reflect seriously on his situation and that of his family. As he had expended his fortune in his museum, he was desirous of making it appear to advantage, that it might bring its value after his death. Accordingly, as soon as his health permitted, he arranged it, and made out a systematic catalogue of its contents. He afterwards regained sufficient health to prosecute his physiological and surgical investigations; and numerous ingenious papers, written by him after this period, appeared in the Transactions of the Royal Society. In 1783, he had the honour of being admitted into the Royal Society of Medicine, and the Royal Academy of Surgery, of Paris. The lease of his house in Jermyn-street having at this time expired, he purchased one of a large house in Leicester Square, on which he was tempted to expend above 3000*l.* which sum was in a great measure lost to his family by the shortness of the lease. Here he had ample accommodation for his museum. The eclat which this great object gave to him, however, was very great; and the services of his friends and the public were always readily furnished, when they could contribute to adorn it with new articles in comparative anatomy. In 1786, he published his work *On the Venereal*, and his *Observations on certain parts of the Animal Economy*, consisting of a collection of papers which had appeared in the Philosophical Transactions. About this time his health began to decline, and he was obliged to resign much of his laborious duty to his brother-in-law Mr Home; but we find him still active in adding to the stock of professional information. He wrote some physiological papers, for which he obtained the Coplcian medal. In 1792, he gave up his course of lectures entirely to Mr Home. But he continued to receive splendid marks of public respect; he was appointed inspector-general of hospitals, and surgeon-general to the army; he was made a member of the College of Surgeons of Dublin, and one of the vice-presidents of the Veterinary College, then first established in London. He continued to write various papers, which appeared in the Transactions of the Society for promoting medical and chirurgical knowledge.

His health during the last twenty years of his life was greatly impaired. The symptoms of his disease, which was *angina pectoris*, are minutely described by Sir Everard Home in the account of his life. The first attack was brought on by mental irritation, and, though he was liable afterwards to slight affections from causes of different kinds, every severe attack arose from some mental cause. Unfortunately his mind was easily provoked by trifles, while matters of real importance produced no effect. He died suddenly under an accidental irritation at St George's hospital, while he laudably attempted to controul it till he obtained information of the circumstances by which it was occasioned. This event took place on the 16th of October, 1793, in the 65th year of his age.

He was a man of uncommon originality of thought, which he displayed under considerable deficiencies of general erudition. In this respect he was a contrast to his brother, who united genius with erudition in an eminent degree. This circumstance seems, however, to have had the effect of concentrating his attention more completely in his favourite objects of pursuit, and to have given a character of more obvious originality to all his writings. Though ambitious of a high name in his own line of investigation, he was not envious of the well merited honours of others. But he was liable to strong indignation at the presumption of ignorant mediocrity or indolence. He was prone to undervalue too much those professional men, who were his inferiors in merit, and who, while they paid no homage to his doctrines, made feeble attempts to shine by their own light. He was frank in his manners and conversation, a decided enemy to all deceit and intrigue, but on the whole too apt to speak harshly of his cotemporaries.

The museum which he left was purchased by the British government, was by them committed to the charge of the college of surgeons, and is now contained in a splendid hall fitted up for the purpose, where a professorship of comparative anatomy is attached to it; and it is open to the inspection of the public on certain days of the week for the greater part of the year. This museum affords a brilliant proof of the comprehensive views and persevering assiduity of the collector. It presents a very extensive collection of anatomical facts, arranged in such a manner as to illustrate, in a beautiful series, the various functions, as performed in the gradations of organized nature, from vegetables to animals, and from the lowest tribes of animals to the beautiful complication exhibited in the fabric of the human body. It is divided into four parts, corresponding to a fourfold division of the functions. 1. The parts adapted to motion; 2. The parts essential to the internal economy of the different tribes; 3. The parts which connect living beings with surrounding objects; and 4. The parts subservient to the propagation of the species. We understand that the arrangement has undergone some modifications since the appointment of Mr Lawrence, the present professor of comparative anatomy. In this museum, the eye surveys, as in one vast landscape, all that is interesting in the sublime science of physiology. It furnishes even to the most ignorant a pleasing and rapid view of the subject, which could not be obtained from books without much study. To those who are already well informed, a visit to this museum affords an opportunity of giving form and body to their knowledge, and adds a permanence to their impressions which they could not have otherwise obtained. It is indeed now imitated on a smaller scale, by the laudable industry of many other professional men; but it is still an object of the highest interest, both for its own merits, and when considered as one of the earliest of those vast efforts which have been made, to give an intellectual celebrity to the whole seminaries of our native country. (*H. D.*)

HUNTING, or the pursuit of wild animals, in its most comprehensive signification, includes those of every denomination, and all the different means by which their capture is accomplished; but, in its more restricted sense, it chiefly denotes the pursuit of terrestrial and amphibious quadrupeds.

Mankind, in establishing themselves in uncultivated regions, find it alike essential to destroy those creatures, whose ferocity may endanger their life, or to seek subsistence from the flesh, and clothing from the skin of others, from which no danger is to be dreaded. Originally a measure of necessity, hunting becomes an enterprise, wherein all the strength and activity of the human frame is called forth; or it is converted into an amusement, in which equal skill and ingenuity must be exercised, to combat the power and instinct of animals. Savage nations, during their repose from war, are principally occupied in the chace; and there are some, to whose country nature has been so sparing of vegetation, that, without the resources obtained by hunting, a famine would infallibly ensue. Hunting has enabled us to bring the most useful animals into a state of domestication. While employed to subdue the horse, the ox, and the elephant, in their native climates, it is elsewhere followed to procure those precious furs, which pay the tribute of entire countries, and are so highly valued, as to be the emblem of royalty itself. Hence have resulted various expedients and stratagems to ensure the capture of wild animals. But it is to his faithful ally, the dog, that man is chiefly indebted for their possession. This invaluable creature is trained, not only to rouse the game in the forests, to pursue it on the plain, and after a successful chace, instead of devouring its prey, to watch until the approach of its master, or to lay it uninjured at his feet. What substitute could the huntsman find for his dog? Deprived of its aid, those excursions, which enable him to return laden with spoils, would terminate in fatigue and disappointment.

Hunting is prosecuted after a great variety of fashions, according to the nature of the country and the description of the game. 1. Wild animals are hunted by means of others specially trained for that purpose. 2. They are caught by various stratagems; as by nets and pitfalls, or in traps formed either for the purpose of destroying them, or of taking them alive. 3. They are shot by fire-arms or arrows, or destroyed by the same weapons set in their paths. 4. They are taken by intoxicating substances, which they are induced to swallow, or killed by poisons. These are the principal methods employed throughout the world in destroying wild animals.

Man is engaged in incessant warfare against the rest of the animated creation: the numbers sacrificed by him exceed all credibility; for scarcely has he come into the world, and gained the use of his members, when he begins to think of destruction. But animals have opponents equalyl formidable among each other, and frigthful havoc is committed among the weaker by the stronger and more carnivorous tribes. Endowed with natural antipathies, they hunt each other down for the purpose of extirpation, not for the sake of prey. The ancients have told us of an invincible antipathy entertained by the ichneumon against the crocodile; and although this singular property has not been witnessed by the moderns, it indubitably exists in respect to snakes. The rhinoceros, a herbivorous animal, is said constantly to seek the elephant, when the most furious combats ensue between them; and it is affirmed to delight in the destruction of all other animals. Dogs incessantly endeavour to destroy cats, on which they are not known to feed; and horned cattle will frequently make an attack, and gore the object to death, from rage and antipathy combined. But it is less for the indulgence of such antipathies, than to satisfy the cravings of nature, that animals hunt each other in their wild state, and have thus taught men to avail themselves of their properties. Yet, as they carefully shun our presence on those ocassions, we are acquainted only with some of the methods which they pursue. Animals of the canine species seem to hunt in troops; those of the feline race are in general solitary. The nature of the wild-dog, which we can so materially improve by education, is little known; but it appears to hunt in packs of eight, ten, or twelve, in India and Persia; and in this way it does not dread to attack the most ferocious of beasts of prey, the tiger. In Africa, it has been observed, that wild-dogs hunt with much sagacity, always acting in concert, while each in particular does its best to overtake or meet the game, until at length it becomes their joint victim. Not content, however, with merely satisfying their hunger, they are said to wound and destroy every thing that comes in their way, and prove the greatest enemies of the herds which are kept among the colonists or natives of Southern Africa. The wolf, the fox, and jackal, all hunt in troops, though each may be seen alone in quest of prey. But many animals are by nature solitary in their pursuits, and seem jealous of the presence of each other. The lion never hunts in company, and is said to chace its prey at full speed by the eye, from its sense of smelling being obtuse. It makes a spring when within reach of the object; but, if foiled by distance, skulks away, as if ashamed of the disappointment. The tiger, a cruel and terrible destroyer, is generally single in its immediate attack; and instead of trusting to speed, like the lion, it lies in wait in some thicket, whence, with an astonishing leap, it pounces on its victim in an instant. Immediate death follows a blow from its tremendous paw, and the prey is then dragged off to be devoured at leisure. Nothing can restrain the ferocity of the tiger; not even fire, the dread of all wild animals. It is the terror of the forest; it attacks man as readily as beasts, and even pursues boats while navigating rivers. As the fatal blow is always inflicted by the paw of this animal, in like manner others evince the same uniformity in the mode of hunting and killing their prey. The wolf bites it in the throat; the jackal invariably seizes a cow by the udder; and the crocodile, fixing its teeth in the nostrils, draws its prey into the water to be drowned.

Man, in every country, has availed himself of the instincts evinced by certain animals in hunting their prey, to aid him in the chace. Dogs of many different kinds are trained to it, and in every possible fashion; either running down the game by speed, conquering it by absolute strength, or dislodging it from its haunts, or merely pointing out its position. In the East, a species of panther, there named *cheeta*, but more commonly the hunting tiger, is taught to pursue the antelope; but if caught young, and brought up among mankind, so much of its activity and fierceness are lost, that it proves unserviceable. Therefore the cheeta is always taken old in pits, and soon becomes familiar with its keeper. The cheeta is carried hoodwinked on a cart to the vicinity of the game; and being then unhooded, steals from bush to bush, until approaching within 70 yards of it. Rushing forwards with surprising swiftness, by a dexterous use of its paw it throws the animal down, and seizes it firmly by the throat, until it feels that respiration has ceased. Sometimes the cheeta cannot be induced to run; but, if it is forward to the chace, it seldom continues longer than for 300 or 400 yards, within which space the antelope is either caught, or escapes. If disappointed in its original spring, should it get near enough, or be foiled in the course, it lies down, testifying much disappointment; and in its resentment will sometimes, though rarely, turn on its keeper. On the day of hunting, the cheeta is kept without food, at other times it is allowed 4lb. of flesh daily. The lion is said to be taught by the Africans to hunt for them, as is also reported to have been practised by the ancient Romans. In this country, we teach the ferret to hunt after rabbits; and, considering that many animals are susceptible of this education, it is not unlikely that more would be trained to hunt, were not their use superceded by the universal employment of the dog. There is hardly a situation in which the dog is not serviceable. There is scarcely an animal which it will not venture to attack, when encouraged by the voice and presence of its master; and it equally promotes the capture of the terrestrial and the feathered tribes.

The most general mode of pursuing game is by a small and select company of huntsmen, and then, perhaps, the greatest success attends their exertions; but in some countries vast multitudes assemble, surrounding a great extent of territory, and driving numbers of wild animals into a narrow space, where their destruction is accomplished at will. Some of the sovereigns of China have carried an army of people into Tartary, and occupied themselves several months uninterruptedly in the chace, while the monarch himself, unable to use fire arms, dexterously shot the animals with arrows. The modern princes of Hindostan were wont to advance with 400 or 500 elephants, besides horses, and all the necessary equipment of several hundred dogs, nets, and weapons, to the country where the game was sought. Even in Scotland, we read of hunting matches conducted on a great scale, where 12,000 men were present, and when "thirty score of wild beasts" were killed. But the real hunting for profit and utility, in which many thousands engage for subsistence, is conducted by small parties, or by individuals only. It appears that in Britain it was very common for ladies anciently to participate in the pleasures of the chace.

The lion is a large and powerful animal, less ferocious, and not equally dreaded as the tiger, perhaps from an imaginary attribute of generosity, and from the belief that it never wantonly kills its prey. Nevertheless, the lion is also a terrible enemy, and its roar inspires all other animals with fear. Shaw, the eastern traveller, affirms, that the wild boar is principally its prey; but sometimes after so courageous a defence, that victory has inclined to neither, or both have been found lying dead together, and torn in pieces. We have said that the lion never hunts in company, and on this head M. Golberry relates, that a lion and a lioness having discovered a wild boar on the skirts of a forest, the latter sprung forward to the attack. Having furiously seized the boar by the throat, she lashed its sides with her tail, while the lion sat a silent spectator of the combat, which lasted five minutes, seemingly indifferent to the struggles of both. At length the boar, yielding to the force of its opponent, fell with horrible cries; and only when dead, the lion leisurely advanced to participate in the repast of his mate. It is supposed that the lion will not attack women, but the number of victims evince the fallacy of this hypothesis. However, it is confidently affirmed, that no person is in danger who has courage to look the lion stedfastly in the face. An African colonist of the Cape of Good Hope having unexpectedly met a lion, levelled his gun, but the ball fell short, as the piece hung fire; and, apprehensive of the consequences, he immediately fled. The lion closely pursued him, when the colonist, leaping on a small heap of stones, resolved to defend his life with the butt end of his gun, being precluded from loading it again, as he had unfortunately dropped his powder flask in his flight. At this moment the lion made a sudden stand also; and then lay down, at the distance of a few paces, quite unconcerned. Meantime the colonist durst not move; but the lion, after remaining before him completely half an hour, slowly retired. The fleetness of this animal enables him to keep up with a horse galloping, and its strength is such that it can drag away a heifer with perfect facility. In general, it is said to lie in ambush, whence it springs upon its prey; but should the object be missed, no second attempt is made; the lion returns silently to the spot, to practise more address on the next occasion. Probably animals are more usually preferred, but there are instances of a single lion attacking a whole caravan. The lion is hunted by horsemen on the plains, and large dogs, but not of any particular species, are used to dislodge him from his haunts. At the first sight of the huntsmen, he always endeavours to escape by speed; but if they and the dogs get near, he either shakes his head with a terrible roar and slackens his pace, or quietly sits down to wait their attack. The dogs immediately rush on; and he has time only to destroy two or three, each with a blow of his paw, until they tear him in pieces. Twelve or sixteen are, in this manner, a sufficient match. Huntsmen going on the enterprize keep together in pairs. If they they have not the requisite number of dogs, one, when within reach of the lion, leaps off his horse, and aims at the animal's heart; but he must instantly remount, in order to fly from its rage if wounded. Should he miss, the same is done by his companion, who must also give full reins to his horse; and then the third of the party follows. This mode of hunting is represented as quite free from danger, there being no example of its being attended with fatal consequences. In the northern parts of Africa, where lions are not so numerous, the whole surrounding district is raised when one is discovered to infest it. A circle of three, four, or five miles in compass is formed, according as circumstances require, and dogs of large size are employed to rouse the game. Horses are here trained for the purpose, and the party proceeds, always narrowing the circle until the lion appears. But this is a moment of danger, as he will readily spring on the person nearest to him. The expert huntsman, however, is generally prepared to terminate his career by a musket-ball. The lion is likewise killed by spring guns set in the path by which it returns to commit its ravages; or the Moors and Arabs dig a pit, which, being slightly covered with reeds and branches, the animal falls in, and is taken.

One of the noblest sports of the East is the hunting of the tiger; and indeed, considering the size, the strength, and the ferocity of the game, no inconsiderable gratification must arise from the conquest. The tiger is sometimes so large as to measure 13 feet from the nose to the tip of the tail. It is active, bold, and cunning; it is one of the most destructive beasts of prey: flocks and herds are its usual pursuit, but it is the mortal enemy of man; and, having once tasted his blood, it is said to reject ever after the blood of other animals. The immense and extensive thickets of Asiatic countries are so many retreats where it can lurk in concealment, and spring forth upon its victim, which it does with a horrible growl; or if the prey is in motion, where this cannot be accomplished, the tiger creeps along parallel to it and unperceived, until it gains the favourable position for its spring. A deadly blow from the paw precedes the seizure of its victim, and the prey is then dragged away. An instance occurred of a Sepoy on a march acquainting his comrades that he observed a tiger, "which had set him," as it is called, stealing along through a jungle. Divesting himself of all incumbrances, he drew a broad sword, and intrepidly watching the moment of the spring, with dexterity, as singular as his courage, immediately disabled his assailant. Sometimes a tiger takes possession of a pass, whence it has, for a length of time, carried off a man daily. This animal is hunted in various fashions, but chiefly by a numerous party of sportsmen, and elephants trained for the chace: those males having long tusks are preferred, but few females are fit to be employed in it. Indeed the elephant and the dog are the only auxiliaries of man on this occasion. Horses become fractious and ungovernable; camels offer an insecure position to their riders, independent of their natural dread of the game; and even the elephant can with difficulty be urged onward with due preparation. When the retreat of a tiger is discovered, which is generally in a jungle near the carcase of a mangled animal, a line of elephants is formed, and every exertion made for its dislodgment. The jungle, however, may contain more than one; and as the tiger becomes lethargic when satiated, and does not remove far from the spot of its depredations, the jungle is entered with much precaution. Here the search is made with the largest and best trained elephants; and it is they that first disclose the presence of the tiger by a peculiar kind of snorting and trumpeting, and likewise an uncommon agitation. The tiger is prone to spring on an approaching object; but if skulking off, the whole covert becomes impregnated with its smell, and the elephants, uncertain of its distance, and always dreading an attack, frequently become perfectly ungovernable, nor can some be restrained from flight. A certain emanation from the body of the lion and the tiger, even when unseen, has a powerful effect on other animals: and men themselves have experienced a kind of shuddering sensation solely from that cause. The huntsmen who, mounted on their elephants, are not above ten yards asunder, immediately on discovering the tiger, fire from a piece of large calibre; but should the shot not prove instantly fatal, the tiger springs up with a furious roar, and endeavours to attack its enemy. Particular danger may thence ensue, and both skill and dexterity are required in the hunter expeditiously repeating his discharge for his own preservation. The elephant may then be brought forward to crush the fallen animal, and gore it with its tusks; which, although quite dead, it often testifies a repugnance to do. Horses shew the most decided antipathy, and dogs take a tour around the carcase. Sometimes the tiger will spring upon the elephant, and put the hunter in the most perilous situation. Notwithstanding its intimate resemblance to the cat in every thing, the tiger takes the water without hesitation, and it has been known to force its way into a boat in spite of all opposition. It does not appear that hunting this ferocious creature solely with dogs is ever attempted: indeed it could not be accomplished without great loss to the huntsman. It is taken in nets, however; but the sport is dangerous, for the game is apt to recoil on its pursuers; and besides, the nets are not always of sufficient strength, nor is the tiger so perfectly enveloped and secured, as to be deprived of the power of doing mischief. Tigers are caught, but very rarely, in traps and pits, the former constructed like a large cage, and baited with a live dog or goat, which is confined in an interior division. They are likewise shot by a single sportsman, who, having discovered a carcase half devoured, promptly constructs a platform of bamboos, 15 or 20 feet high, and there awaits the depredator's return. The natives of the hills of Bengal set poisoned arrows in their path to be discharged from a bow of extraordinary strength, sometimes so great, that the weapon penetrates to the heart. It is difficult, however, to give it the proper direction from the step of the tiger, which effects the discharge. Even though the arrow does not touch a vital part, the poison speedily begins to operate, and never fails to destroy the animal within an hour. The same apparatus is used with an arrow free of poison. By means of the vigorous warfare carried on against tigers, many places of India, formerly almost uninhabitable, are completely cleared of them. In other parts they are still common, and the appearance of one inspires the whole neighbourhood with alarm.

The panther, leopard, ounce, and lynx, all of the feline tribes, are closely allied in habits and disposition to the lion and tiger. But none readily attack man. Their depredations, nevertheless, are not confined to smaller animals, as some of them are endowed with considerable strength. The leopard is particularly expert in climbing trees, whence it drops or springs on its prey. It greedily devours dogs ; but seldom prowling about by day, it chiefly commits nocturnal ravages. All animals of prey, of every tribe, are for the most part occupied in seeking their sustenance at dawn and twilight. Leopards are roused by by dogs, and shot with fire-arms or arrows. The natives of the East also capture them in deep pits, which are baited with the carcases of beasts.

Animals of the canine species are endowed by nature with the most remarkable sagacity. Almost all, with suitable treatment, may be rendered tractable, while those of the feline tribes seem absolutely indocile and void of attachment. The hyæna is one of the fiercest of the canine kind ; its strength enables it to resist the lion, and encourages it to attack the panther. It overpowers the bear, and readily assails mankind. Acting as a decoy, it is said to imitate the cries of other animals, or, by a frightful howl, to scare a whole herd, that it may then seize some one of the stragglers. It is a solitary animal, inhabiting the clefts of rocks and caverns in mountains, whence it issues forth on its prey at night. Hyænas are hunted by dogs, and traps are set for them, but few are taken. One of the most remarkable methods of capturing these animals is practised by the gypsies of Aleppo ; who, according to M. Olivier, enter with torches in the day-time into the grottos known as the haunt of hyænas, and, on perceiving one, make a great outcry, or boldly approach, speaking aloud, in order to intimidate the animal. The hyæna, which is terrible by night, does no injury by day ; and the effect of the light and clamour are such, that it retires farther and farther to the extremity of the cavern, where no sooner do the gypsies reach it, than it is bound, muzzled, and led out. When taken after other methods by the Arabs, they carefully bury the head, lest the brain should be employed against them in sorcery and enchantment.

Hunting the wolf, an animal the type of destruction, and the enemy of the shepherd, has been every where and in every age an ardent pursuit. But its sagacity is so great, that while others run headlong into danger, it carefully avoids the snare. When roused by hunger, the ferocity of the wolf is great. It attacks man, and runs down creatures far larger than itself. It boldly leaps inclosures, and steals into cottages to carry away children, which are always seized by the throat. A wolf suddenly appeared in a district of France, which it ravaged a whole year about 1765, proving so crafty, that an association of 63 parishes provided a band of 40,000 men for its destruction. At length 40 huntsmen and their dogs accomplished its destruction. Hunting the wolf was anxiously enjoined by the laws of this country, particularly in Scotland, formerly a wild and mountainous country, whence it could not be easily extirpated. King Edgar is said to have effected the utter destruction of wolves in England, by commuting the tribute of money into an annual tribute of the heads or skins of these animals. They still subsisted in Ireland in the reign of Elizabeth, and were not extirpated from Scotland until the year 1670. The means which have been devised of destroying this redoubtable enemy are not few ; but owing to the habits and sagacity of the animal, they are of very uncertain success. Its haunts are exceedingly diversified : It sometimes seeks the recesses of the woods, sometimes the bottom of the cavern ; it hunts by day and also by night, first assuming one path for its exit, and then another for its return. In certain seasons of the year it has no fixed abode. In Tartary, and other parts of the East, the wolf is hunted by eagles trained specially for the purpose. In Europe, the strongest greyhounds and other dogs are employed, and the chace is prosecuted either on foot or on horseback. Much difficulty, however, is experienced in running down the wolf; nay, it frequently proves impracticable, for the full grown animal is infinitely stronger than any dog. An old wolf is able to run 20 miles easily, which, added to the nature of the ground to which it resorts, often renders the pursuit abortive. The wolf, besides, has recourse to many stratagems for deceiving both the dogs and the huntsman. When one is known to infest a district, the first attempt is to dislodge it from the covert, and to bring it to an open chace. But hunting the whelps is more interesting sport, because they have fewer means of defence, nor are they so capable of foiling the hunter as the old and experienced animals. Independent of the constant use of fire arms, it becomes necessary to recur to various stratagems, as nets, traps, and pitfalls. If an animal of large size, as a horse or an ox, is discovered to have become the prey of a wolf, to which it will return for the purpose of satisfying its appetite, the huntsman drags the carcase above a mile from the spot, always proceeding against the wind. Then leaving it in a place exposed to view, as the wolf will follow, he takes his station in concealment by moonlight, in a spot whence he may pierce the animal with a ball. It is said that the wolf never passes through by a door where it can leap a wall ; whence the position of traps is regulated, so as to deceive its watchfulness. Sometimes the traps are constructed with springs and iron teeth ; sometimes with a wicket, which yields to gentle pressure, but refuses an exit to the captive. Some years ago, during a terrible famine in India, where the miserable sufferers were devoured half alive by wolves, these creatures, emboldened by the want of resistance, continued their ravages after its cessation. They openly attached men and women, and children at the breast seemed to be their favourite prey. An ingenious and simple apparatus was devised for their destruction. Two bamboos eight or nine feet high, were erected at the opposite sides of an old well, and their tops being brought together, a basket, containing a kid, was suspended from the junction. A pot of water with a hole in the bottom, loosely stopped by a rag, was hung over the animal, which was kept bleating and in constant agitation by the dripping upon it. Brushwood and thorns disguised the edge of the well, and the wolves in stretching over or leaping up to reach the bait, readily tumbled in. On another occasion, they were successfully smoked out of burrows in the earth, which they had chose for a retreat, or were killed in attempting to escape suffocation. In digging up the burrows, an incredible quantity of trinkets, not less than ten pounds weight, was found belonging to children they had carried away and devoured. The affliction of the unfortunate parents at recognising the different ornaments that had decorated their offspring, presented a most impressive scene. At present packs of wolves are said to infest a district of France, where the inability of the inhabitants to resist them has led to extraordinary instances of their attacks in open day, and on every opportunity.

Similar address, though demonstrated in a less conspicuous manner, is displayed by the jackal and the fox, both of the canine species. The former is hunted by greyhounds, which it will so harass by its extreme cunning in incessantly crossing the haunts of its fellows, that it can seldom be taken in this manner. Likewise the dogs, while in full pursuit, are sometimes attacked with great fury by another troop of jackals attempting to rescue the fugitive, and beaten off with severe injuries. The jackal itself hunts in packs of 30 or 40 together.

As fox-hunting is so common a sport in Great Britain, and of so much consequence to other nations which traffic in the fur of animals, we shall lay before our readers a pretty full account of it. Though the total number of foxes in this island may not exceed a few hundreds, yet in the north of Europe and America, and in the north-eastern parts of Asia, they are more numerous. There they are frequently to be found in vast multitudes, and of various species, called the black, blue, grey, and arctic fox, some of them changing their colour according to the season of the year. Two islands, St George and St Paul, were discovered in 1786 in the Northern Pacific Ocean; the first does not exceed 30 miles in length, nor the second 19; yet, in the course of only two years, 8000 blue foxes were taken upon them. But to enable the huntsman to conduct the chace successfully, he must always render himself intimately acquainted with the nature of the game: it is by this means that he can ascertain its haunts, defeat its stratagems, and avail himself of those particular circumstances which will lead to its capture. The instincts and propensities of the fox are exhibited in the most decided manner; though they receive strong modifications from the circumstances under which the animal is placed. In populous and civilized countries, it is shy and watchful: in those seldom trodden by the foot of man, it exhibits no apprehensions at his presence, and may easily be led to destruction. In one country it will devour nothing except what has been killed by itself; in another, where scarcity usually prevails, every kind of animal food is acceptable. It is highly carnivorous in many places; yet in some it fattens on grapes, and is noxious to vineyards. The craftiness of the fox is proverbial. Without the strength of the wolf, it possesses equal sagacity, which is similarly exercised in destroying creatures weaker and more timid than itself. In addition to the smaller quadrupeds, its ravages are considerable among birds which nestle on the ground, and also among poultry of the domesticated kinds. The day is the period of repose; while the dawn and twilight are industriously employed in quest of prey. The fox is a bold and a cunning animal, adventurously approaching the object it has singled out, and waiting a favourable opportunity of accomplishing its ends; but, not content with satisfying the cravings of hunger, it often destroys many more victims than it can devour; which are either left behind, or carried away and stuffed into a hole, or buried in the ground, to provide for future necessity. It is said to feign sleep, in order to betray its prey into security; and a tame fox has been known to spurt its food around it, for the purpose of attracting poultry within the length of its chain. Foxes burrow in the earth, or inhabit the clefts and cavities of rocks, and also dwell in thick coverts, or among furze. As swallows testify their antipathy to the hawk, the common enemy of their tribe, so does the clamour of crows and magpies disclose the retreat of the fox, when unseen by his enemies; and during pursuit the latter will scream from tree to tree, according to the course which the animal takes. By the northern nations, where the preservation of the fur is an object, the fox is captured in traps, by bows set in its path, discharging arrows against it, and it is also destroyed by poisons. Sometimes a net is used. The natives observe, as a remarkable circumstance, that the more valuable foxes are the most cunning: and Krascheninikow mentions, that the Cossacks of Kamtschatka tried unsuccessfully during two years to catch a black fox frequenting the Great River. But it is likely that this arises from such animals becoming more sagacious in endeavouring to avoid danger, than those which have none to apprehend. In Britain and some other countries, foxes are hunted almost exclusively by packs of hounds trained to the sport; and the chief source of entertainment arises from the nature of the animal itself. A rank odour, peculiar to its species, of which it can never be divested, constantly escapes from its body, and is distinguishable by the hounds from that which emanates from other animals, whereby they are enabled to follow the same course without once obtaining a view of the game. The manner in which this effluvia is conveyed, is a point of exceedingly difficult explanation; but, like all odorous emanations, it is of very unequal intensity at different times. Our ancestors were certainly acquainted with the properties of hounds, as "sharp-scented dogs fit for hunting wild beasts," are mentioned at a very early period of English history; and the aborigines of every nation are addicted to the chace. But we are unacquainted with the particular species which were employed. Much attention is requisite both for the breeding and training of hounds; and no where has the art been more studied than in Great Britain. When the dogs are bred and trained, then the selection is to be made. Hounds are prized for colour, figure, voice, and especially for staunchness, without which the rest of their qualities are of little avail. In respect to the first, there can be no absolute rule; and the huntsman who has had a few excellent hounds of a certain colour, will be prejudiced in its favour; but we must admit, that the properties depending on colour are very uncertain, particularly when we reflect that a total change takes place in several animals according to the alternation of the seasons, and that it is again restored without having occasioned any extraordinary effects. Naturalists have not yet determined the inseparable concomitants of colour. Hounds of a uniform colour seem to rank highest in the estimation of sportsmen; next, those spotted with red, and white hounds with black ears and a black spot at the root of the tail. Those spotted with dun are conceived to be defective in courage, and therefore bear an inferior value. Properties which would require the most undoubted confirmation by repeated trials, are ascribed to some external characters. Thus it is said, that the black tanned, the uniform white, the true Talbots, are the best for string or line; that the grizzled, if the hair is shaggy, are the best runners, and that a couple of these should always belong to a pack. Those uniformly dun are thought fit for all kinds of the chace; their sagacity is great; they are more sensible of their master's voice or his horn, and less liable to be influenced by the unsteadiness of other hounds. The figure of the hound is probably more essential than his colour, being more decisive of pure descent. A small head, very pendulous ears, a thin neck, broad back, deep chest, straight legs, and round feet, not too large, are esteemed prominent characteristics. Defective proportions indicate that little can be expected from exertion. Hounds of middle size are the strongest, and most capable of protracted fatigue: and here it is necessary to regulate the equality of the pack. There should be complete uniformity in speed; for, though the fleetest hound is commonly esteemed the best, yet he may do much injury among his companions in the chace. Speed and vigour are indispensible qualities, and these are likely to be promoted by having hounds of the same family. Both are conspicuous in those of English breed. A hound has been known to run seven miles in four minutes; and a fox chace is said, on one occasion, to have been continued for about 120 miles, calculating, as nearly as possible, from the places where the hounds were seen. The ardour of the hounds is so great, that they sometimes actually die in the course of pursuit. A prejudice formerly prevailed in France against British hounds, which probably arose from their having degenerated on being transported from their native climate. Most animals degenerate under great transitions, whereas, were they carried to moderate distances, they might easily be habituated to the change of climate and of circumstances. The breed of all the useful animals ought to be anxiously studied, because real quality can be obtained in no other way than by selection from the offspring of parents who are themselves of the genuine stock. On both sides those alone should be chosen which demonstrate the properties of the fox hound in a superior manner: age must be avoided; and, as both sexes reach maturity nearly about the same period, there ought not to be a great disparity between them. General rules nevertheless admit of many exceptions, as the origin and properties of animals are but little known. The breeder will often be disappointed of his expectations, and he will sometimes have to admire the offspring of parents from whose union nothing was expected. In both cases, good qualities and defects may lurk in concealment during one generation, and be unfolded in the next. Some persons who have paid strict attention to this subject, maintain, that, in the course of numerous experiments, they succeeded in obtaining excellent hounds. The whelps must be kept very clean, both before and after leaving the mother. When they cease to obtain subsistence from her, it is recommended that they should be fed with wheat bread, to improve their strength; but in France, it is said that bread made of barley-meal is universally admitted to be better feeding, and is given at the rate of two pounds and a half or three quarters daily, in two portions. The whelps should be well aired, and have sufficient exercise, until they attain their full strength, or arrive at an age a little beyond it, when their active powers are to be called forth. It is supposed that dogs continue to grow during eleven months. Something probably depends on climate; for a much longer time frequently elapses before some of them have acquired all their vigour. Numerous specific rules are given regarding the entrance or initiation of hounds to the chace, on which head there are hunters who advance extraordinary, and apparently inconsistent, opinions; such as, that the first object of pursuit ought to be different from that for which the dog is ultimately destined. But it has been judiciously remarked, that "*nature* will instruct hounds how to hunt; *art* only is necessary to prevent them from hunting what they ought not to hunt." Instinct is incessantly operating; and if it is to be modified, we must always keep in remembrance, that early habits have a great preponderance; and that animals will probably be most eager in the pursuit of that game which they have been taught to hunt originally. One of the primary qualities of a dog is, to addict itself exclusively to the specific object of pursuit, and to abstain from every other; whence it would appear as inconsistent to enter pointers with larks, as fox hounds with rabbits. If hounds are accustomed, at an early age, to woods, or hills and vallies, it is likely that they may not be equally successful when there is a complete transposition of circumstances, whence a considerable variety of surface seems beneficial in exercising those which are young. These necessary preliminaries having been attended to, hounds are to be assorted in packs, the extent of which is quite arbitrary. Experienced hunters affirm, that 25 couple are sufficient at any time to be taken into the field; and this is the ordinary number. Forty couple will admit of hunting three times a-week; but if packs are very numerous, each hound will have too little occupation in the chace: hence it is essential that the qualities of hounds should be frequently brought into action, in order that they may be preserved by practice. Although instinctive habits may be permanent, yet artificial acquirements are soon forgotten. A pack of good hounds is a valuable property, and has been sold in England for a thousand guineas. With respect to the actual practice of fox-hunting, it is a subject susceptible of so much detail, that we must chiefly refer those who are desirous of becoming masters of it, either to certain districts of England and Ireland, where gentlemen of fortune follow it as a kind of profession, in preference to more useful pursuits of agriculture, and more delicate and refined amusements, or to the modern authors Beckford and Daniel, who treat copiously of the subject. They have not only exhausted the observations of their predecessors, but have embellished their writings with new and entertaining illustrations. As the fox leaves his burrow in quest of prey before the day breaks, all the earths are to be stopped at a very early hour in the morning; and the huntsmen having met at the appointed covert, it is to be carefully drawn for the game. A bad or windy day is always to be avoided, as the scent is so much affected and so precarious, that the hounds may be disappointed, which is injurious to their nature. It is not necessary that the fox should ever be seen by the dogs; when once roused, they pursue him by the scent alone, continuing the chace through many miles. But this animal neither possesses much speed, nor apparently entertains great dread of the hounds. His principal object is gaining the earth; and he trusts by wiles and stratagems to deceive his pursuers. If he is foiled, many turnings, doublings, and crossings, are resorted to: when fatigued, he will either lie down in a field, should one be in his way, or run amidst a flock of sheep, or a herd of cattle. In the course of the chace, sometimes, the scent becomes quite imperceptible, especially when confounded with the emanations of other animals, as in the latter case, when the hounds are said to be *checked* or *at fault*; and the recovery of it becomes most interesting to hunters. Silence is then to be observed, as the dogs will be industrious enough themselves in endeavouring to regain the scent. If they are successful, which does not invariably happen, they rapidly renew the pursuit, and gaining distance as the strength of the fox declines, they at length come up, and tear him to pieces. "Then," say sportsmen, "they should be allowed to eat him ravenously." It frequently occurs, that amidst a number of earths all are not stopped, and the fox, having taken shelter, is dug out or dislodged by terriers; sometimes the hounds pursue him thither, and are themselves suffocated within. It is difficult to kill the female while breeding, from her never wandering far from the burrow, and retreating into it on the slightest alarm. A modern author remarks, that "the whole art of fox-hunting is to keep hounds well in blood; therefore every advantage of the fox is taken. Sport is but a secondary consideration with the true fox hunter; his first motive is the killing of the fox, by which he makes his hounds. Present success is almost a sure forerunner of future sport; and he is better pleased with an indifferent chace, with death at the close of it, than with the best chace possible, if it terminates with the loss of the fox." This kind of amusement has been practised a considerable time in Great Britain. That King James I. had its commendation in view, when treating of the education of a prince, we shall not affirm; but he says, "I cannot omit here the hunting with running hounds, which is the most honourable and noblest sort thereof; for it is a thievish form of hunting to shoot with guns and bows; and greyhound hunting is not so martial a game." Fox-hunting is certainly no inconsiderable enterprise, when we hear of horses running themselves blind, or dying of fatigue under the lash of their riders; of dogs perishing during the chace, and of men breaking their limbs, or dislocating their necks. But whether it is an amusement either humane, or attended with any utility, might admit of some discussion.

Wild cattle are numerous on the southern continent of America, and herd together in great flocks; and the same may be said of horses. Both are hunted by the Indians in two different ways. A lash or belt is made of skin or leather, about fifty feet in length and two inches broad, with a running noose at one end. The huntsman holds the noose in his right hand, and being well mounted, on approaching within a few yards of the wild animal, throws the noose over its head, though running at full speed, whereby it is easily taken. By the second method, an iron ball, of about two pounds weight, is fastened to each end of a leather strap about twelve feet long, and the huntsman, when within the necessary distance, having swung one of the balls several times around his head to give it an impetus, throws it at the animal's legs, also parting with the other whereby they are entangled. Hunting the buffalo, which is a powerful, fierce, and intractable animal, is attended with great danger; for it readily attacks its pursuers, who must trust to the swiftness of their horses for escape. It entertains the utmost antipathy to every thing coloured red; and it is said that if a piece of red cloth is thrown in its way, it will be so much occupied in venting its rage upon it, that the huntsman has sufficient opportunity to advance or to retire.

A valuable animal, the deer, has been liberally dispersed by nature throughout the world, especially in the colder regions. In Siberia, vast herds of reindeer shift their abode at certain seasons, leaving the woods to seek for better pasture, and swim across wide rivers, always having a leader at their head. Then they become an easy prey; but if the leader suspects danger and returns, he is invariably followed by the rest, and the sportsman is disappointed of his game. The elk or moose deer north of Hudson's Bay, is hunted in a singular manner; for there the Indians themselves absolutely run it down. This is attempted only when the earth is covered by snow, and especially when the surface is encrusted over; then it sinks with the weight of the animal, while the snow shoes of the huntsman bear him up. A good runner will generally tire a moose in less than a day, and very often in six or eight hours; though it sometimes happens, that the hunters continue the pursuit two days before they can come up with and kill the game. They are very lightly clothed on such occasions, and carry only a bow with two or three arrows, and a small bag with implements for striking fire. Dogs are trained for this sport by the southern Indians, which renders it easier and more expeditious; and they are likewise used in Europe and other countries inhabited by the deer. In Britain, stag hunting is followed with hounds, and the strength and swiftness of the animal renders this description of the chase particularly interesting. Its agility surmounts every obstacle; the plains vanish under its feet; rivers are no barrier; and it seeks for shelter alike in the woods and mountains. Thence the pursuit is generally long and difficult, and the stag can be wearied down only by the strongest and most sturdy hounds. When the stag despairs of escaping, it sometimes stands at bay; and, presenting its antlers to the pursuers, seems resolved to sell its life as dearly as possible. The huntsman, however, is always the victor, and his precautions most commonly secure him from injury. But a more treacherous method is generally followed in stalking or approaching in disguise to shoot this fine animal, at least in those parts of the north and western parts of Scotland where it still runs wild. In the northern climates deer are shot with arrows, by means of a spring bow set in their path.

The antelope is a gregarious animal, very shy, and of great speed. Besides the use of the cheeta, it is hunted by numbers of men forming a circle, which, gradually closing, brings it within reach of the sportsman; or it is pursued by dogs, while hawks, trained for the purpose, being let fly, retard its swiftness by striking it on the head, and fluttering before its eyes.

There are various species of bears, which are hunted after different fashions both in the warmer and colder climates. The white bear, an enormous animal of the polar regions, is never seen but on ice and snow. Winterers on Nova Zembla remark, that it retreats from their abode as the sun sinks below the horizon in November, and returns with his appearance in January; meanwhile, they are visited by the arctic fox, which retires as the bear approaches. White bears attack man, and swim around ships as if to get on board. They are hunted by the northern savages, on the ice and snow, with pikes, swords, bows and arrows; but the bear makes a vigorous defence, turning on its assailants, whose victory is sometimes dearly purchased. However, a single man has been known to engage intrepidly in combat with a very fierce bear, without any other weapon than a knife, and to destroy his antagonist. The black bear never attacks man unless when provoked; it then rises upright, and, clasping him in its fore paws, endeavours to crush him to death. Before any encounter, it is said to make its young ascend trees. This animal can be dislodged with difficulty from its retreats by dogs; but when once roused, it is pursued, and shot. It is likewise taken by a great number of stratagems, of which we have already given an account under the article Bear, Vol. III. page 365. Hunting the badger, which pertains to the same genus, is followed in another shape. It burrows in the earth, and is also difficult to dislodge. When driven out by terriers, it fights boldly, inflicting severe lacerations on its pursuers. However, it is generally overpowered. Though covered with a strong hide and long hair, which render it tenacious of life, a slight blow on the nose occasions inevitable death. The badger is caught alive in sacks covering the mouth of its burrow, into which it is driven by the terriers.

After speaking of all these powerful, ferocious, and crafty animals, it is painful to treat of the hunting of the timid hare—a weak, harmless, and defenceless creature, which the very sight of man renders breathless with alarm. Yet, in Britain, whole troops of men, horses, and dogs, col-ject, to enjoy the gratification of running it down; a feat which is accomplished either by grey-hounds surpassing its utmost speed, or by slow hounds wearing it out with fatigue. But these are not the only means devised for its destruction, as numberless traps and snares besides fire-arms are always ready to bereave it of life. The hare is the ordinary prey of other animals; yet it feeds on none: its subsistence is derived exclusively from vegetable productions, and in few instances does it appear in sufficient numbers to occasion injury. Many fables are interwoven with the history of this animal, and the prejudices of mankind have determined its presence to be ominous on certain times and occasions. In general the hare shuns the haunts of men: it is abroad chiefly at dawn and twilight, and during the night troops of this animal meet to sport in the fields. Its vigilance is incessant: the eyes, which are not closed while it sleeps, are so constructed, that it can see farther around in the same position than other animals: its ears are adapted for the reception of the faintest sounds, and its foot is particularly fashioned for protection against different substances that cover the ground. As if aware that safety is to be found in concealment, it remains closely squatted in its form, even though its enemies be near; but when once roused, no bounds are set to its flight. Unlike the fox, which is regardless of distance, the hare feels confidence only when beyond the voice of its pursuers; but it is nevertheless full of stratagems. In the first outset a circular figure is described: all the subsequent course will approximate to the original line: but doubles are repeated after doubles, and the point of departure will frequently be approached during the chace. Hares are hunted either by harriers, a species of slow hound, or by greyhounds, the latter sport being technically designed *coursing*. Under a few modifications, nearly the same rules and principles are applicable here as before, regarding the choice, breeding, treatment, and entrance of hounds; but it is invariably to be observed, that the best harriers are those that never pursue any other game than hares. There is a very diminutive species called beagles, which are in much request for this kind of sport, and some of them are so small, that ten or eleven couple are said to have been carried to the field in a pair of panniers slung across a horse. Twenty couple of harriers are estimated a sufficient number in any pack. The hare, though swift, and endowed with considerable strength, is weaker than the fox, and the chace is rarely of equal duration; yet there is an instance of a hare, after having been chased sixteen miles, taking to the sea, and swimming nearly a quarter of a mile before it was caught, and also of one running above twenty miles in about two hours. The chace is followed by the scent, which is lost and recovered as in fox-hunting; and this peculiar emanation is thought to depend on the motion of the animal, because it is seldom perceptible while the hare remains quiet in its form. When it is first started, strict silence should be preserved by the hunters, as the hare is so timid, it is very readily headed back; whereby the hounds pushing forward lose the scent. Coursing is more generally practised in different countries, from requiring less of the apparatus of hunting, and because every master is in this case his own huntsman. Whether the shaggy or the smooth greyhound should be preferred, is not decided; but a greater portion of strength is usually ascribed to the former. Contrary to the nature of the harriers, greyhounds hunt entirely by the view, and while the others remain intent on recovering the scent, they very soon become bewildered on losing sight of the game. They should attain their full vigour before they are initiated into the chace, and in the meantime they should have abundance of air and exercise; but sportsmen are commonly too impatient to wait for the proper period. The qualities of the greyhound are often to be discovered almost entirely from their figure; and some have instinctively the property of carrying the game to the hunter's feet. Coursing can be traced to a very early period: it is said, however, that the Britons anciently abstained from eating the flesh of hares. Grants of land were obtained from several of the earlier sovereigns, for an annual tribute in horses, hawks, or hounds; and as greyhounds are used in stag-hunting, it is not to be supposed that they would be omitted. In the reign of King John, two charters were granted in 1203 and 1210, in consideration of which a certain number of greyhounds should be delivered, in addition to other obligations. Coursing is a favourite amusement in many countries besides Britain; and a good greyhound is so highly prized by some tribes in the eastern parts of Persia, that, according to a recent traveller, Lieut. Pottinger, the natives sometimes pay fifty pounds for one of acknowledged quality; a very high sum, considering their narrow finances. But sportsmen go farther still among ourselves, as, under the article Dog, it will be seen that 152*l*. has been paid for a greyhound. The greyhounds of Cyprus interrupt the chace by the huntsman merely throwing a pole before them, which indicates singular docility. It is said that a huntsman should acquire so much knowledge of the stratagems of the hare, as to be able to defeat the whole in two or three seasons; and he will also find his greyhounds improve by experience. The speed of the hare is great, and so are the speed and strength of the greyhound. Two are reported to have coursed a hare seven miles, though they were then so completely exhausted, that medical aid could scarcely preserve them; and there are examples of their dying in the very act of seizing the game. Whether the hare can see distinctly during the rapidity of its flight, or how its vision is then directed, is doubtful. It runs against obstacles with great violence; and we are told of a terrier eagerly coming up to join the chase having been met by the hare, when the latter was killed on the spot by the concussion, and its skull broken to pieces. When hard pressed, the hare will run to earth like a fox or rabbit: it often takes the water; seeks shelter in a house; or even leaps on the breast of a spectator. Thus do we behold the effect of terror and the love of self-preservation conquer its almost invincible timidity. But the devoted victim seldom essapes its merciless pursuers. Compared with that description of the chace, where the power, the ferocity, and the craftiness of animals, are to be combated by the strength and ingenuity of man, it may be questioned whether hare-hunting should be ranked among the more elevated kinds of sport.

We shall now say a few words of hunting animals which are sought only for the value of their furs, without any regard to the species to which they belong. These are more particularly of the weasel tribe, the *Mustela* of naturalists. The fur of some of these, as the ermine sable and sea otter, are of the finest quality, and always bear a very high price. A large portion of the revenue derived by Russia from her Siberian possession consists in the skin of the sable only. But hunting it is a more tedious occupation than the capture of any of the animals hitherto named, as it occupies the hunters a whole year at a time. Companies of from 6 to 40 men agree to hunt together, and they ascend the river Witim and two subsidiary streams, dragging boats capable of containing 3 or 4 people, and their provisions along with them, as far as the Lake Oronne. There they erect huts, and constitute a leader, to whom the whole promise implicit obedience. The party subdivides to hunt in different districts, and in this second excursion small huts banked up with snow are built, while all are occupied in constructing traps. As the sable is a carnivorous animal, they are suitably baited and set; and being so devised that the slightest touch ensures its capture, they are seldom long empty: but should the huntsman be unsuccessful in this manner, he is conducted by the tract of the sable in the snow to its burrow, from which being dislodged by a piece of smoking wood, it falls into a net spread for it, and there the huntsman kills it with his dog. Smoke is never used where there is only one hole to the burrow, as the sable would rather perish than come forth. Sometimes it runs up a tree, which is then cut down, the huntsman again spreading his toils in the direction in which it is to fall; or he employs blunt arrows to shoot the sable, whereby its skin is preserved from injury. Hunting being closed as the ice begins to melt, the whole produce is collected, the skins properly prepared, and when the rivers are open, carried down in the boats. Many superstitious ceremonies are practised by the hunters: they never articulate while skinning the sable; nor must any thing hang on the stakes around them. The carcase is laid on dry sticks, which are set on fire, and afterwards carried round it, previous to its being buried in the earth or snow. A portion of the spoils called God's sables, is always devoted as an offering to some church, in honour of which each leader also builds his hut.

However arduous and tedious a task it may be to hunt the sable, the pursuit of the sea otter, combined with that of several other animals, exceeds it infinitely in duration. Parties of huntsmen, consisting of from only a few to many hundreds together, engage in it, and ten years sometimes elapse before their return home. Far from being a pursuit of sport or pleasure, it is an occupation of dire necessity: the hunters are sparingly subsisted, they are scantily clothed, and, exposed to all the inclemency of a rigorous climate, they lead the most miserable lives. Such is particularly the case with the Russians in Siberia, and the natives of the continent, or the islanders under their controul. The sea otter is of an amphibious nature. It inhabits the shores of the Northern Pacific Ocean, and is found, though not in plenty, as far as Japan, or even the Yellow Sea. It is exceedingly pacific, and seeks safety only in flight; but it is unceasingly persecuted, and destroyed for the sake of the beautiful jet black fur that covers it. The hunters having obtained a vessel, to which the Russian government appoints a steersman, they sail from Okhotsk, or the harbours of Kamtschatka, with a small cargo of what will prove most acceptable to the savages of the distant islands which they mean to visit. Taking possession of some of these, they either compel the natives to depart alone in quest of game, (and in this way a fleet of canoes, carrying 300 Aleutans, went out some years ago, which was never after heard of,) or they are themselves of the party. Hunting the sea otter is in other respects attended both with danger and difficulty. Two very small canoes, each containing two expert hunters, are prepared with bows and arrows, and a small harpoon, to which last is attached a line a few fathoms in length. Though the animal is hunted also on ice, it is more commonly captured by pursuit in the water, continued during several hours. From the necessity of respiration, it can dive but for a few minutes; the principal skill to be displayed is in the canoes taking the same direction which it does in its course. They separate, therefore, as the sea otter goes down, in order to inflict a mortal wound either with the arrows or harpoon at the moment it rises. If hunted on a larger scale, the mode adopted renders the animal so sure a prey, that scarcely one in a hundred can escape. A number of hunters being engaged, when one observes a sea otter he endeavours to pierce it, and at all events rows to the spot where it plunges. Here he stations his canoe, and raises his oar as a signal, on which the rest of the hunters form a surrounding circle. The moment of reappearance, he discharges his arrows, or throws another harpoon, and hastening to the place where the otter dives, makes a signal by again raising his oar. A second circle is then formed, and the chace protracted, until the animal is exhausted. The first plunge exceeds a quarter of an hour, the next is of shorter duration, and thus the intervals diminish until the animal can plunge no more. When the female sea otter is overtaken with its young, parental affection is manifested in the most interesting manner; it supersedes all sense of danger. Taking the cub in her paws, she dives to save it; but obliged to rise for breath, she is exposed to the hunter's weapons. Should it be taken first, she becomes regardless of her own safety, and, approaching the boat, falls an easy sacrifice. But both parents sometimes defend their young furiously, tearing out with their teeth the arrows that have pierced them, and even attacking the canoes. Incessant pursuit of this animal has almost totally extirpated it from places where it was common formerly.

It would require a long enumeration to specify all the different modes of hunting, and the various stratagems employed for the capture of wild animals. Some are exceedingly ingenious, and others require continual alteration, according as the game becomes more wary of the designs of its pursuers. The skill of the huntsman, which an ordinary spectator is ready to undervalue, is the result of long continued experience only: the footstep, the track, the pasture of the animal, and other indications, are all studied, to discover its age, its sex, and its haunts; and it cannot be denied, that much of the naturalist's knowledge is deduced from the information of huntsmen alone. The whole geographical discoveries of the Russians in the north-east of Siberia originated exclusively with their hunters, to whom also they were indebted for the discovery of the Kurile and Aleutan islands, the promontory of Alaksa, and the island Kadiak. Hunting, when directed to the more important game, is an interesting, manly, and athletic exercise. Yet, if prosecuted for no other object than to deprive an innocent animal of life, or merely for the pleasure of witnessing its speed, and beholding the vigour of its defence for self-preservation, it is a cruel and hateful pastime. Men familiarised with the torture of animals, whose flesh is needlessly torn from their bones, will soon behold with indifference the pain of their fellow creatures. See *Chasse au fusil*. Williamson's *Field Sports of the East*. Daniel's *Rural Sports*. Beckford *On Fox and Hare Hunting*. *Sportsman's Dictionary*. *La Chasse Encyclop. Method*. Krascheninikow's *History of Kamtschatka*. Meare's *Voyage*. Lisianky's *Voyage*. Krusenstern's *Voyage*. Hearne's *Journey*. Cartwright's *Journal*. See Beaver, Bear, and Elephant, for an account of the method of hunting these animals. (*c*)

HUNTINGDON, is a town of England, and the principal town in Huntingdonshire. It is situated on a gently rising ground on the northern side of the river Ouse. It consists principally of one street, stretching in a north-west direction from the Ouse to nearly a mile from it, with several lanes branching off at right angles. The houses, which are built of brick, are genteel and commodious, and the streets are well paved and lighted. The town is nearly connected, by a causeway and three bridges, with the village of Godmanchester.

The principal public buildings and establishments are St Mary's church, All Saints church, and the town-hall. St Mary's, which is the corporation church, was rebuilt between the years 1600 and 1620. It has an elegant embattled tower at the west end, with nave, chancel, and aisles. All Saints church stands on the north of the market-place, and appears to have been built in the time of Henry VII. It is an embattled edifice, with nave, chancel, and aisles, and a small tower at the north-west angle. The town-hall, which stands on the south side of the market-place, is a good modern brick building, with a piazza at the front and sides, and butchers' shambles behind. In the lower part of the building are the civil and criminal courts, where the assizes are held. Above is a spacious assembly-room, adorned with the portraits of George II. and III. and their respective Queens, and of Lord Sandwich, who died in April 1792. The Free Grammar School is well endowed, and well conducted. There is also a greencoat school, called Walden's Charity, where 24 poor boys are clothed and educated. The county gaol, which stands at one end of the town, has recently been repaired and rendered more commodious. There are two places of worship here belonging to the dissenters, one for the Quakers, and the other for the sect patronised by the Countess of Huntingdon.

As Huntingdon is situated on the great north road, it has several good inns. The brewing trade is carried on here, though less extensively than formerly. It has also a small vinegar manufactory. Coals, wood, &c. are brought to the town by barges, which come up the river from Lynn in Norfolk, and return with the corn of the surrounding country.

This borough returns two members to Parliament, the right of election being vested in about 200 of the freemen and inhabitants. It is governed by a mayor, 12 aldermen, and a number of burgesses. The following is the population of the borough of Huntingdon in 1811:

| | |
|---|---|
| Number of houses | 450 |
| Number of families | 522 |
| Families employed in trade and manufactures | 291 |
| Males | 1085 |
| Females | 1312 |
| Total population | 2397 |

See the *Beauties of England and Wales*, vol. vii. p. 345.

HUNTINGDON. See PENNSYLVANIA.

HUNTINGDONSHIRE, an inland county of England, is almost inclosed by Cambridgeshire and Northamptonshire; by the former it is bounded on the north-east, and part of the south; by the latter, on the north and west. Bedfordshire bounds it also partly on the south-west. Its limits are nearly artificial. The river Nen, and the canals which join it to the Ouse, form its limits on the north and north-east, on the Northamptonshire and Cambridgeshire borders. The Ouse, at its entrance, separates for a short space from Bedfordshire, and at its exit from Cambridgeshire. The figure of this county is so irregular as scarcely to afford a proper measurement; but reckoning from its furthest projection, it does not exceed 24 miles each way, and in general is of much less extent. In fact, it is the smallest county in England except Rutland, and is very nearly the size of Middlesex; Huntingdon containing, according to the best accounts, about 210,000 acres; Rutland, 110,000; and Middlesex about 200,000 acres. The whole upland part in ancient times was a forest, and particularly adapted to the chace, whence the name of the county took its rise. It was disafforested by Henry II., III., and Edward I., the last of whom left no more of it a forest than what covers his own ground.

It is divided into four hundreds, namely, Normancross towards the north; Toseland towards the south; Hurstingstone towards the east; and Leightonstone towards the west. It contains one county-town, Huntingdon; six market towns, of which the principal are Kimbolton, St Neots, St Ives, and Godmanchester. The number of parishes is 104. It is in the province of Canterbury, and diocese of Lincoln. The ecclesiastical government is managed by the archdeacon of Huntingdon, and it is divided into five deaneries. It is in the Norfolk circuit, and returns four members to Parliament, viz. two for the county, and two for Huntingdon. This county and Cambridgeshire are joined together under one civil administration, there being but one high-sheriff for both, who is alternately chosen one year out of Cambridgeshire, the second year out of the isle of Ely, and the third year out of this county. It is one of the seven counties, Bedford, Huntingdon, Bucks, Berks, Hertford, Essex, and Suffolk, that are contiguous without a city.

The fenny part of it lies in the Bedford level on the north-east, and joining the fens of Ely. There are besides three distinct varieties of surface in this county. The borders of the Ouse, flowing across the south-east part, consist of a tract of most beautiful and fertile meadows, of which Portsholme Mead, near Huntingdon, is particularly celebrated. The middle and western parts are finely varied in their surface, fruitful in corn, and sprinkled with woods. The upland parts still bear the appearance of ancient forest lands.

The soils are various. In the upland parts, they are chiefly a strong deep clay, more or less intermingled with loam, or a deep gravelly soil, with loam. Of what are called the deep stapled lands, by far the greatest part are still in an open-field state. Indeed, there is a larger proportion of this most unproductive land in Huntingdonshire than perhaps in any other county of England; upwards of one-third of the high lands being still uninclosed. The more anciently inclosed parts are, generally speaking, in the possession of a few proprietors; but in the new inclosures, and in the open fields, property is divided among a much greater number of persons. The woodlands are but of inconsiderable extent, and the county is thin of timber. This is attributed to the very great demand for it in the fens, underwood being sold at a higher price than in most other counties. The meadow lands consist of about 1200 or 1400 acres, bordering on the rivers Nen and Ouse, but chiefly on the latter. They are extremely productive, but the produce is frequently damaged or carried away by the floods.

The fens consist of about 44,000 acres, besides nearly 5000 acres of what are provincially called skirty lands. The fens of Huntingdonshire constitute nearly a seventh part of what is called Bedford Level. About 8000 or 10,000 acres of them are productive; but the expence of preserving them from inundation amounts to almost one-third of the rents, in consequence of the drainage having been undertaken on an erroneous and imperfect plan. It is effected by engines, which throw the water out of the lands into the rivers, without having a proper out-fall near the sea. In consequence of this, the embankments are frequently broken through by the immense pressure of the weight which they contain. The mode of management of the fen lands has been much improved of late years, and the fen-men are very expert at the plough; no such thing as a driver being known, though they frequently plough with three horses abreast. The *skirty* lands, in general, afford luxuriant grazing.

The climate is rather mild, and by no means so unhealthy as might be anticipated from the fenny nature of a large portion of the county. The most unhealthy parts are the low moorish tracts near Huntingdon, Godmanchester, Ramsey, and Yaxley; for in the other parts about Kimbolton, and indeed through the whole of the hundred of Leightonstone, the air is remarkably good.

The principal rivers connected with Huntingdonshire are the Ouse and the Nen. The Ouse, which is generally called the Lesser Ouse, to distinguish it from a river of the same name in Yorkshire, enters this county from Bedfordshire between St Neots and Little Paxton, and, in its course southwards to Huntingdon, is increased by a number of small streams from the north-west. After passing that town, it flows eastward, and passing the west end of St Ives, becomes, near Holywell, the boundary between this county and Cambridgeshire, till it enters the great level of the fens near Erith. It is navigable along its whole line across this county. The Nen rises in Northamptonshire, and reaches Huntingdonshire near Elton, where it becomes the boundary between the two counties. It afterwards flows to Peterborough, below which it sinks into the fens. Some smaller streams water the north-east side of the county, together with several large meres or pools of water. Of these, Whittlesea Mere is by far the largest. In the time of Camden, it was six miles long and three broad; but its limits are now much contracted, so that the water is said at present to cover only an area of 1570 acres. It affords excellent sailing and fishing; and is, in the summer season, much frequented by parties of pleasure. Anciently, there was a navigation from Peterborough by the river to this Mere, and from thence to Ramsey.

Though this county has long been celebrated for its wealthy farmers, particularly in the vicinity of Godmanchester, yet its agriculture presents very little that is interesting or important. In Camden's time, Godmanchester was reckoned the largest village in England; and at that period, no place employed so many ploughs; and, according to that author, no people had so much advanced in agriculture, either by their purse or their genius. When James I. came through it on his journey from Scotland to take possession of the throne of England, the inhabitants met him with 70 new ploughs, drawn by as many teams of horses; for they hold their lands by this tenure, that, whenever the sovereign took this place in their progress, the farmers should make the most pompous appearance with ploughs and horses, adorned like triumphal cars with rustic trophies. King James was so pleased with the sight, that he granted them a charter constituting Godmanchester a borough, at the same time condescending to partake of a collation prepared under a bush, still known by the name of the King's Bush, and the Beggar's Bush. But Huntingdonshire is no longer remarkable for the excellence of its agriculture; nor, indeed, could improvement in this most useful art be excited in a county where so large a proportion of the land is still in the barbarous state of open field. Besides the common produce of wheat, barley, oats, hemp, and rape in the fens, turnips on the drier soils, and a few hops, this county grows a considerable quantity of mustard: it is cultivated on various soils, chiefly rich loam, good old pasture land, rich clay, and the best fen soils. The ground is ploughed only once for it: it is sown any time between Candlemas and Lady Day. There are two kinds, the black and white; the former is most esteemed. The weeding is performed by sheep, which will not eat the mustard. The produce is from 28 to 44 bushels per acre.

The breed of sheep upon the enclosed lands is of a mixed description, nearly approaching to the Leicestershire and Lincolnshire kinds, with which the native breeds have been much crossed. Those bred on the open fields and commons are much inferior. The cattle are for the most part the refuse of the Lancashire, Leicestershire, and Derbyshire breeds: oxen are purchased for grazing generally without any attention to the breed, and are never used in husbandry. From the open state of the county, dairy farming is not much followed; and the cows are used for suckling calves in the southern parts, to supply the London market. The rich and celebrated cheese, called Stilton cheese, takes its name from a village in Huntingdonshire; but it is made in the vicinity of Melton Mowbray in Leicestershire; and it is generally supposed never to have been made at Stilton, but always to have been sent there for sale: of this, however, there seems some doubt. Mr Nicholls, in his History and Antiquities of the County of Leicester, says, that it began to be made in the parish of Little Dalby, in that county, about the year 1730; but, on the other hand, there is the evidence of a very old inhabitant of Stilton, who died there about the year 1777, aged 80 years, that, when he was a boy, the cream used to be collected in the neighbouring villages for the purpose of making Stilton cheese: this of course fixes the making of this famous cheese at Stilton long before, according to Mr Nicholls' evidence, it was made in Leicestershire. In the fens of Huntingdonshire, mares are used for all the purposes of agriculture; and every farmer breeds from them as many foals as he can, selling the colts off at two years old, and as many of the fillies as can be spared, with proper attention to the team. The high roads in this county, in general, are tolerably good; the cross roads are but indifferent, and in the winter season many of them are nearly impassable.

No manufactures of note are carried on in Huntingdonshire, except wool, stapling, and spinning yarn: the latter is the chief business of the women and children in the winter season; in the summer they find more profitable employment in the fields. There is a small manufacture of lace at Kimbolton; and at St Neots, there is a very large paper mill worked by patent machinery. At Standground, there are two manufactures for sacking. The markets and fairs of St Ives for live cattle are some of the greatest in England.

In the year 1803, the poor's rates amounted to 30,952*l.*: in the year ending the 25th of March, 1815, it amounted to 40,625*l.*

There are few remarkable antiquities in this county. Dornford, in the north-west part of it, formerly called Deorm-ceaster and Caer Dorm, is probably the *Durobrivæ*, a passage of the Nen mentioned in the Itinerary of Antoninus. A little above Stilton, a Roman pathway, leading from Dornford to Huntingdon, appears with a very high bank, which, in an old Saxon charter, is called Ermingstreet. From Ramsey, which stands on an isle of the same name, formed by the fens, there runs a causeway, called Kings-delf, for ten miles, to Peterborough. It appears upon record in King Edgar's time. At Ramsey, was formerly a very rich abbey, built in the midst of a bog. There is little left of it, beside a part of the old gate-house, and a statue of its founder Alwyn, who was called alderman of all England, and cousin to King Edgar. The keys and ragged staff in his hand denote his offices. This is reckoned one of the most ancient pieces of English sculpture extant.

This county, under the Saxon heptarchy, formed part of the kingdom of Mercia, or the middle Angles. Mr Speed mentions an observation of Sir Robert Cotton, that the families of this county were so worn out even in his time, (about the beginning of the 17th century,) that, though it was formerly very rich in gentry, yet few surnames of any note were then remaining that could be traced higher than

Henry VIII. Mr Camden remarks, that, in the civil wars, there were more actions in this than in much larger counties, because it was the native county of Oliver Cromwell.

According to the returns made in the year 1800, the population of this county was 37,568. In the year 1811, the returns afford the following results.

| | |
|---|---|
| Houses inhabited | 7,566 |
| Families occupying them | 8,808 |
| Houses building | 23 |
| ——— uninhabited | 153 |
| Families employed in agriculture | 5,361 |
| ——— in trade and manufactures | 2,205 |
| ——— not comprised in these classes | 1,242 |
| Males | 20,402 |
| Females | 21,806 |
| Total | 42,208 |
| Square statute miles | 370 |
| Rental of land | *l* 202,076 |
| Amount of tithe | *l* 10,166 |
| Annual value of square mile | *l* 574 |
| Persons in a square mile | 114 |
| Agricultural population | 61 |
| Net product per family | *l* 40 |

(W. S.)

HUNTLY is a small town of Scotland, in the county of Aberdeen. It is pleasantly situated on a point of land at the confluence of the rivers Bogie and Deveron. It consists of two principal streets, crossing each other at right angles, and forming a spacious market-place at their junction. The town contains some good houses, and has of late years increased considerably. In 1792, it contained 52 flax-dressers, the annual value of whose manufactures was 16,224*l.*; and 209 weavers, who produced yearly 73,150 yards of cloth. Huntly Lodge, the seat of the Marquis of Huntly, stands near the town, on the banks of the Deveron; and near the bridge over the same river are the remains of Huntly Castle.

The town and parish contained, in 1811,

| | |
|---|---|
| Inhabited houses | 608 |
| Number of families | 720 |
| Ditto employed in agriculture | 190 |
| Ditto employed in trade and manufactures | 510 |
| Males | 1186 |
| Females | 1578 |
| Total population | 2764 |

HURON, Lake. See Canada.

HURRICANES. See Meteorology.

HUSBANDRY. See Agriculture.

HUSS, John, the celebrated reformer and founder of the sect called Hussites, was born at Hussinez, a village in Bohemia, about the year 1376, and received his education at the university of Prague, where he took his degrees of M. A. and B. D. and at length became minister of a church in that city. In the year 1400 he was chosen confessor to the queen Sophia; and at this early period, he already began to distinguish himself by his freedom and zeal in reprehending the corrupt morals of the laity, as well as the vices of the clergy. The monks, under the protection of some of the nobles, complained of him to the king Winceslaus; but this prince, who was no friend to the clergy, declined to interfere.

About this period, in consequence of the marriage of Ann of Bohemia with Richard II. of England, a communication and intercourse were opened between these two countries; and several young Bohemians repaired to England, where they became acquainted with the writings of Wickliffe. Among these was Jerome of Prague, who had formerly been a pupil of Huss, and after spending some time at the university of Oxford, returned to his native country, bringing along with him several of the works of the English reformer. Huss perused these writings, and having found that many of the opinions which they contained coincided with those which he himself had been led to entertain, he continued to preach openly and zealously against the errors and corruptions of the reigning church. His eloquence was powerfully directed against the sale of indulgences; he inveighed against this system of Papal extortion with uncommon warmth; and his arguments received countenance both from the monarch and the people. By this conduct, however, he rendered himself greatly obnoxious to Subinco, the archbishop of Prague, a violent, bigotted, and illiterate prelate, who from thenceforth became his irreconcileable enemy. Being aware that Huss was secretly attached to the doctrines of Wickliffe, he obtained a decree of the university, in which the opinions of the English reformer were condemned as heretical, and those who should in future attempt to disseminate these opinions were threatened with the punishment of burning. Huss perceived at once that this decree was levelled at his person, rather than the opinions of Wickliffe; but he relied upon the protection of the queen, and the acknowledged purity of his life and conversation.

Meanwhile, two young Englishmen, and zealous disciples of Wickliffe, having arrived at Prague, contributed to strengthen his attachment to the doctrines of that reformer; and Wickliffe's treatise *De realibus Universalibus* having fallen into his hands, he relished it so much, that he adopted the opinions of the author, and became a decided *realist*. The whole university was at this time divided into two parties, the German and the Bohemian, or the *nominalists* and *realists*, whose contests were carried on with great animosity, and not without bloodshed. The German, or foreign party, possessed most influence in the university, as the original constitution allowed them three votes in all elections and deliberations; while the native Bohemians had only one. This constitution conferred upon the former a superiority, which the latter could not contemplate without jealousy, especially as the Germans conducted themselves with great arrogance towards the natives. Huss took upon himself to contest the right of the Germans to this superiority, and demonstrated, that although, by the original constitution of the university, the German masters had been allowed three votes, while the Bohemians had only one, as the latter were then inconsiderable in point of number; yet that, by a later act of Charles IV. it was expressly declared, that in all matters they should be governed by the constitution of the university of Paris, according to which foreigners had but one vote, and the natives three. Through his great influence at court, Huss actually succeeded in carrying this measure, the consequence of which was, that almost all the Germans withdrew from Prague, and repaired to Leipsic, where a new university was soon after founded.

No sooner did the Bohemians find themselves in full possession of the university, than they proceeded to elect Huss for their rector. He now exerted his eloquence more powerfully than ever in declaiming against the scandalous corruption of morals among the clergy; and, among other doctrines, he strongly recommended a diminution of the superfluous revenues of the church, as the best means of producing a moral reformation. He even ventured to attack the supreme power of the pope, in whom he would acknowledge no superiority over other bishops.

As soon as the conduct of Huss was represented to Pope Alexander V. he gave the Archbishop Subinco a commission to take measures for repressing these dangerous doctrines. The archbishop accordingly not only prohibited all preaching in chapels, but ordered all the writings of Wickliffe, which he could collect, to be publicly burnt. Huss, however, entirely disregarded the prohibition, and continued to preach, as zealously as ever, in favour of the condemned doctrines. At length, in the year 1410, he was summoned to appear before the papal tribunal by John XXIII.; but Huss, under the protection of the king and queen, several powerful nobles, and the university, declined appearing in person, but sent three deputies to excuse his absence, and to answer all that should be alledged against him. In the mean time an event occurred, which made the breach between Huss and the court of Rome utterly irreparable. In the autumn of 1411, Pope John caused a general indulgence to be proclaimed for all those who should assist him in his crusade against the excommunicated king, Ladislaus of Naples; and for this purpose he sent his commissaries to Prague. Huss, who had formerly opposed the sale of indulgences, now raised his voice boldly against this papal traffic; while his friend Jerome of Prague, even went so far as to burn the papal bull in the market-place under the gallows. This was sufficient to call forth the vengeance of the Roman pontiff. Huss was now excommunicated for his contumacy in declining to appear personally at the papal tribunal; and the town of Prague was laid under an interdict. The number of his friends and adherents would probably have enabled Huss to set at nought this sentence; but, in order to remove every pretext for tumult and disorder, he resolved to withdraw from Prague, and accordingly retired to his birth-place, Hussinez. Here, and at Cracowitz, to which place he soon after repaired, Huss continued to disseminate his doctrines by preaching, and composed several treatises, with a view to expose the most objectionable tenets of the Romish church.

Matters were in this situation, when the emperor Sigismund agreed with Pope John to assemble a general council at Constance. To this general council Huss was summoned, in order to defend himself publicly against the accusation of heresy. His friends having procured for him a safe-conduct from the emperor, and being likewise provided with attestations of his orthodoxy and innocence from the university and the papal inquisitor at Prague, he set out upon his journey to Constance, where he arrived shortly before the opening of the council. The pope treated him with kindness, assured him of his protection, and even removed the sentence of excommunication. But shortly afterwards, some of his most violent persecutors having arrived at Constance, they used their utmost influence to procure his condemnation; and Huss himself having had the imprudence to promulgate the doctrines of Wickliffe at Constance, he was summoned before the pope and the cardinals, and, notwithstanding the emperor's safe-conduct, thrown into prison.

Upon receiving intelligence of these proceedings, the emperor, who had not yet arrived, sent an order to his ambassador to insist with the pope and the cardinals upon the liberation of John Huss, and to threaten, if they refused to comply, that the prison would be opened by force. The pope and the cardinals, however, disregarded the command of the king, and caused the prisoner to be more strictly confined. When Sigismund arrived at Constance, he allowed himself to be persuaded by the theologians and canonists, that he was not bound to keep faith with a notorious heretic; and he issued a declaration that the council should have free power in all matters of faith, and should be allowed to proceed as judges against all those who were accused of heresy. Some of the most considerable among the Bohemian nobles, indignant at the perfidious conduct of the emperor, repeatedly requested, in pretty bold language, that John Huss, who had received a safe-conduct from the monarch himself, and otherwise would certainly not have repaired to Constance, should be set at liberty, and publicly heard in his defence before the whole council. But Sigismund excused himself in evasive terms, and thereby drew upon himself the mortal hatred of the Bohemians, which, in the sequel, proved highly dangerous to his power.

After Huss had remained more than six months in prison, he was, for the first time, allowed a public hearing, in a general congregation, in which, however, the proceedings were so irregular and tumultuous, that he found it impossible to speak. In the following audience, three points of accusation were read; to which Huss answered in a manner so satisfactory, that no charge of heresy could be fixed upon him, and every impartial judge must have acquitted him. In the third diet, thirty-nine articles were read to him, which had been drawn up by his enemies, and were alleged to have been extracted from his writings. Huss acknowledged such of these as contained opinions which he had really held; but with regard to the greater number, he utterly denied them, declaring that they were either garbled and distorted, or altogether forged by his enemies. Some of the prelates, and even the emperor himself, now urged him to retract and abjure the whole of these articles; but Huss required that he should first be convicted of error; for so long as this was not done, it was impossible for him to retract any of his opinions. And to this determination he adhered, with immoveable firmness, as often as the council endeavoured to induce him to retract, and even threatened to bring him to the stake.

At length, in the 15th session, which Sigismund attended in person, the final sentence was pronounced, that the writings of Huss should be publicly burnt; and that he himself, as a manifest heretic, who openly taught, and refused to retract doctrines which had long been condemned as dangerous to the Catholic faith, should be deprived of his ecclesiastical dignity, and delivered over for punishment, to the temporal arm. Huss, who was obliged to listen on his knees while this sentence was publicly read, repeatedly attempted to complain, and to vindicate himself in regard to several offences which were falsely laid to his charge; but he was always interrupted, and compelled to keep silence. The unfortunate victim was now forced to submit to the punishment of degradation, which was performed with several absurd ceremonies, by seven bishops commissioned for that purpose. He was then delivered over, by the emperor, to the elector palatine, who was commanded to execute upon him the usual punishment of heretics.

Immediately after the termination of the session, Huss was conducted under a strong escort, to the square in front of the episcopal palace, where he was compelled to witness the public burning of his writings; and from thence to the place of execution before the city gate. While he was preparing for the stake, several fruitless attempts were made to extort from him a recantation; but his fortitude remained unshaken to the last. When he was fastened to the stake, and fire was laid to the faggots around him, he continued his devotional exercises until the vital spark became extinct within him. His ashes were gathered up and thrown into the Rhine.

Such was the fate of John Huss, who fell a victim to the most abominable persecution. His talents and acquirements, although not of the first order, were highly respectable; and his moral character was universally acknowledged to be irreproachable. In his manners he was gentle and condescending. Strict in his principles, and virtuous in his conduct, he looked more to the practice than to the opinions of others. His piety was calm, rational, and manly; and his zeal in the cause of Christianity was untainted with fanaticism. The events of his life sufficiently prove, that his fortitude was not to be shaken by any human power.

It is difficult to conceive how such a character as that of Huss should have been exposed to such unrelenting animosity and furious persecution. His creed, it is true, did not exactly square with the tenets of the established orthodox faith; yet several of his persecutors had publicly maintained almost all the offensive doctrines which he was charged with disseminating. It seems most probable, according to the opinion of some authors, that the violent animosity excited against him, is to be ascribed chiefly to the zeal with which he declaimed against the dissolute morals of the ecclesiastics, the usurpations of the Roman court, and the temporalities of the clergy. These principles were naturally considered as dangerous to the power and influence of the priesthood; and his brethren, who dreaded the effects of his eloquence and example, were glad to have recourse to an accusation of heresy, as the best and least unpopular means of destroying the enemy of their corruptions, and of crushing those principles which appeared subversive of their privileges and pretensions.

Jerome of Prague, the friend and pupil of Huss, underwent the same fate with his companion. He, indeed, was at first terrified into a temporary submission; but he afterwards resumed his fortitude; and, at length, on the 30th of May, 1416, sealed by martyrdom, his belief in the principles he professed.

The memory of John Huss was long cherished by his countrymen, the Bohemians; the sixth of July was for many years held sacred, as the anniversary of his martyrdom, and medals were struck in honour of the martyr. The Bohemian and Moravian nobles addressed a spirited protest to the council of Constance, in answer to the intimation of his sentence and execution; and the zeal of his indignant disciples afterwards broke out into an open war against the emperor, which was conducted, on both sides, with a savage spirit of barbarity, and gave rise to acts of atrocity at which humanity shudders. These troubles were at length fortunately terminated by the interference of the council of Basil, in the year 1433. See Zitte *Lebens beschreibung des Mag. Johan. Huss*, Prague, 1799; Æn. Sylvii *Hist. Bohem.* in Freheri *Script. rer. Bohem.*; Wil. Seyfried *De Johannis Hussi martyris vita, fatis et scriptis*, Jena, 1743; Pelzel's *Geschichte der Böhmen*, Prague, 1782; Mosheim's *Ecclesiast. Hist.* vol. iii.; Gilpin's Lives, *Life of John Huss*; and the *Gen. Biog. Dict.* (*z*)

HUSUM is a sea-port town of Denmark, situated on the west coast of the duchy of Sleswick, about two miles from the small river Ow, and about four from Sleswick. It was formerly celebrated for the great quantities of malt which it exported. At one time 40 large vessels belonged to this town, and the oyster trade was almost confined to its inhabitants.

HUTCHESON, Francis, an ingenious philosopher and elegant writer, was the son of a dissenting minister in the north of Ireland, and was born on the 8th of August, 1694. From his childhood he discovered a superior capacity, and an ardent thirst after knowledge; and having received the usual elementary instruction at a grammar-school, he was sent to an academy to begin his course of philosophy. In the year 1710, he was entered a student in the university of Glasgow; where he renewed his application to the study of the Latin and Greek languages, and explored every province of literature; but devoted himself chiefly to divinity, which he proposed to make the peculiar study and profession of his life.

After spending six years at Glasgow, he returned to his native country; and having entered into the ministry, he was just about to be settled in a small congregation of Dissenters in the north of Ireland, when some gentlemen about Dublin, who were acquainted with his great talents and virtues, invited him to undertake the charge of a private academy in that city. With this invitation he complied; and he had resided but a short time in Dublin, when his talents and accomplishments attracted general notice, and procured him the acquaintance of persons of all ranks, who had any taste for literature. Lord Molesworth is said to have taken great delight in his conversation, and to have assisted him with his criticisms and observations upon his *Enquiry into the Ideas of Beauty and Virtue*, before it was committed to the press. He experienced the same favour from Dr Synge, Bishop of Elphin, with whom he cultivated an intimate friendship. The first edition of the work to which we have just alluded, was published anonymously; but its great merit did not allow the author to remain long concealed. Lord Granville, who was then lord-lieutenant of Ireland, sent his private secretary to enquire at the booksellers for the author; and when he could not learn his name, he left a letter to be conveyed to him, in consequence of which he soon became acquainted with his excellency, and was ever after treated by him with distinguished marks of familiarity and esteem.

From this period, his acquaintance began to be still more courted by men of distinction, either for station or literature, in Ireland. The celebrated Archbishop King held him in great esteem; and the friendship of that prelate was highly useful in screening him from two attempts which were made to prosecute him, for venturing to take upon himself the education of youth, without having subscribed the ecclesiastical canons, and obtained a regular license from the bishop. He also enjoyed a large share of the esteem of the Primate Boulter; who, through his influence, made a donation to the university of Glasgow of a yearly fund for an exhibitioner to be bred to any of the learned professions.

In the year 1728, Mr Hutchinson published his *Treatise on the Passions*; and about the same time he wrote some philosophical papers, inserted in the collection called *Hibernicus's Letters*, in which he accounted for laughter in a manner different from the theory of Hobbes, and more honourable to human nature. Some letters having appeared in the "*London Journal*, 1728," subscribed Philaretus, containing objections to some parts of the doctrine contained in the *Enquiry*, he was induced to give answers to them in those public papers. Both the letters and answers were afterwards published in a separate pamphlet.

After he had conducted his private academy at Dublin for several years with great reputation and success, he was invited to Scotland in 1729, to fill the chair of moral philosophy in the University of Glasgow. In this situation he spent the remainder of his life, in a manner highly honourable to himself, and useful to the university of which he was a member. About this time, the degree of Doctor of Laws was conferred upon him. A firm constitution, and a pretty uniform state of good health, with the exception of some slight attacks of the gout, seemed to promise his friends a long enjoyment of his valuable life; which, however, was terminated by a sudden attack, in the year 1747, when he had only attained the age of 53.

He was married, soon after his settlement in Dublin, to Mrs Mary Wilson, the daughter of a gentleman in the county of Longford; by whom he left one son, Francis, Hutcheson, M. D. who published from the original MS. of his father, *A System of Moral Philosophy*, Glasgow, 1755, 2 vols. 4to.

Dr Hutcheson was a man of considerable learning, and various acquirements. He was not only acquainted with those subjects most intimately connected with his profession, but was also well versed in mathematics and natural philosophy. His works have been frequently reprinted, and have been universally admired, both for the sentiments and language, even by those who have not assented to the author's principles. He belonged to that class of philosophers, who deduce all our notions of right or wrong from a moral sense or faculty implanted in our constitution, which leads us to perform good actions ourselves, and to approve of them when performed by others, independently of any reasoning with regard to their utility or fitness. He was a decided antagonist of the doctrines of Hobbes; entertaining high notions of the dignity of human nature, and being persuaded that, even in this corrupt state, it is capable of great improvement, by proper instruction and assiduous culture. See Dr Leichman's *Account of the Life, Writings, and Character of Dr Hutcheson*, prefixed to the *System of Moral Philosophy*; and the *Gen. Biog. Dict.* (z)

HUTTON, James, M D. well known as the author of an ingenious Theory of the Earth, was the son of a respectable merchant in Edinburgh, and was born on the 3d of June 1726. He received at the high school and the university the rudiments of a liberal education, during which his curiosity was powerfully excited by various facts in chemistry which came under his knowledge, and he acquired a taste for chemical pursuits, which distinguished him through life. His friends, however, placed him as an apprentice with Mr Chalmers, Writer to the Signet. But this gentleman soon perceiving that he disliked his employment, and occupied much of his time with chemical experiments, liberally released him from his engagements, and advised him to turn his attention to more congenial pursuits. He now entered on a course of medical studies, which he prosecuted first in Edinburgh, from the year 1744 to 1747. He next studied at Paris; and in 1749, he took the degree of M. D. at Leyden. Having thus completed his education, however, he perceived serious difficulties opposed to his views of success in obtaining practice. He also apprehended that the labours of a professional life might interfere with the gratification of his taste for chemistry; and in 1750 he resolved to apply himself to agriculture. For the purpose of learning that art, he went to Norfolk, where he resided two years in the house of an intelligent farmer. During this residence, he made pedestrian excursions to different parts of England for his improvement in agricultural knowledge; in the course of which he contracted an attachment to mineralogy and the kindred speculations of geology.

In 1754, he extended his agricultural knowledge, by making a tour in Holland and Flanders. During all these peregrinations, he made a collection of facts, which were afterwards made to contribute to his theory of the earth. He returned to Scotland, and reduced his agricultural knowledge to practice, by improving his patrimonial property in Berwickshire. In this occupation he was engaged for 14 years. He had the honour of being among the first who introduced good husbandry into our country, where it has since been so successfully cultivated. In 1768 he let his farm, which he had now brought to a high state of improvement. He had been for several years concerned in a manufactory of sal ammoniac, conducted in Edinburgh under the name of Mr James Davie, who was one of his early and constant friends; and in 1765, a regular partnership had been formed, after which the work was conducted in the name of both. When he gave up his farm, he took up his residence in Edinburgh, and devoted his attention to the pursuits of science, in which he was assisted and animated by his learned friends, whose company he enjoyed in this metropolis. In the course of his chemical pursuits, he discovered that soda was contained in zeolite; the first time an alkali had been found in a stony mineral. He continued to make tours to various parts of the island, in prosecution of his geological enquiries, which assumed greater and greater consistency. In 1777, Dr Hutton published a pamphlet, entitled *Considerations on the Nature, Qualities, and Distinctions of Coal and Culm*, with a view to throw light on a disputed point, whether the small coal of Scotland was liable to the duty on English coal, or to that on English culm. On this subject he displayed great accuracy of observation, and his discussion led to a satisfactory decision of the question. From the time of fixing his residence in Edinburgh, Dr Hutton had been a member of the Philosophical Society, known by the three volumes of literary and physical essays which it published. In that Society he read several papers, none of which have been published, with the exception of one which appeared in the second volume of the Transactions of the Royal Society of Edinburgh, "On certain natural appearances of the ground on the hill of Arthur's Seat." The institution of the Royal Society, which happened in 1783, called forth from Dr Hutton the first sketch of his Theory of the Earth, which he had matured in his own mind, but communicated only to his friends Dr Black and Mr Clerk of Eldin, both of whom approved of it. For an account of this theory, see the article Mineralogy. The distinguishing feature of it was, the universal agency of heat in consolidating the rocky strata, after the materials of which they were formed had been collected by the subsiding of loose earthy materials at the bottom of the sea. This heat he conceived to be seated in the central parts of the earth. To the expansive power of this agent, acting on water or other bodies, he ascribed the elevation of the strata from the bottom of the sea to the higher situations which they have since occupied. He thus accounted for the present appearances. He supposes the earth to have undergone many revolutions at very distant intervals of time, and to be subjected to a law, which produces a general and sudden convulsion as a stage in certain cycles of changes, which at all other times are slowly yet incessantly advancing. This theory has been defended by the author and his followers with much learning and ingenuity; and in a particular manner by his zealous and enlightened admirer Professor Playfair. It has, however, met with a formidable competitor in that of Werner; the leading feature of which is, to account for consolidation by crystallization from a state of aqueous solution, rejecting the hypothesis of a central heat, whether as concerned in the fusion of the rocks, or in the elevation of the strata. It supposes the materials of the strata to have subsided at their present elevation; and its chief embarrassment consists in the difficulty of accounting for the retiring of the waters. The illustration of these opposite general views includes a vast variety of discussion on the constitution of the rocky strata. The controversy has eminently promoted the investigation of the mineral kingdom. A great part of the world content themselves with a smile bordering on contempt, when they casually listen to these speculations; and a superficial observer is generally struck with the character of extravagance, which appears so prominent in the hypotheses assumed. No hypothesis, however, within the limits of possibility, is too extravagant for the subject. The disposition of the strata is itself an extravagant fact, if we may be allowed to apply this epithet to any thing in nature. It points to causes so different in their general character from any that we see in actual operation, that no hypothesis is to be rejected for its strangeness; and hypotheses of this kind are unavoidable to those who attempt to explain the phenomena before them. A wish of this sort cannot be reasonably condemned. There can scarcely be a more sublime speculation in physics, than to attempt the resolution of problems which nature suggests on so magnificent a scale. We may indeed sometimes wonder to see a particular theory so tenaciously adhered to; and it may be regarded as a curious fact, that in the present age the one or the other of the theories now mentioned should be adopted by all geologists. It might be supposed, that the subject would afford several others equally plausible; but it is probably not so much a satisfaction with their own theory as a simple preference of it to its opponent, that is indulged in by the greater part of geologists. The unexplained phenomena of magnetism, particularly the fluctuating variations of the needle, and the supposition of interchanges of materials among the different planets, (countenanced in some measure by the well authenticated instances of stones which have fallen from the atmosphere,) will perhaps at some future period lead to a modification of our geological theories, or to the formation of others.

A paper of Dr Hutton "On the Theory of Rain," was published in the first volume of the Edinburgh Transactions. It forms the only scientific explanation of the phenomena that we have. The discovery of it evinced profound genius and accurate information, and it will probably always be retained by meteorologists. Two portions of air of different temperatures, both saturated with humidity when mixed, and thus reduced to a medium temperature, have not the power of retaining the same quantity in a state of vapour. The reason of this is, that the quantities of humidity retained in this state proceed in a geometrical ratio, while those of temperature increase arithmetically. A larger quantity of water is retained by that heat which had kept the one portion of air above the resulting medium, than when the same heat is employed in raising to that medium the temperature of the coldest portion. The consequence of this is, that a part of the water is precipitated. This theory was opposed by Monsieur de Luc, who maintained, that the heat was communicated from one part of the atmosphere to another without the actual intermixture of different portions of air. Dr Hutton made several other acute improvements in meteorology, which were afterwards published in his "Physical Dissertations," in which his theory of rain was again given. It was by the theory of the earth, however, that the greatest portion of his interest was absorbed. The journeys which he made to Glen Tilt, to Galloway, the isle of Arran and St Abb's Head, supplied him with facts which afforded him exquisite delight, especially those which elucidated his peculiar views of the nature of granite, and the circumstances under which it assumed its present situation in relation to the other rocks. He supposed it to have been forced up in a state of igneous fusion by the expansive power of the central heat, and injected in that state into the rents produced in the superincumbent strata, which had previously formed the exterior crust of the globe. It was the continuation of the granite upward into these rents or veins that so much delighted Dr Hutton. This is a fact which still furnishes one of the strong points of the Huttonian theory.

This philosopher also turned his attention to another subject suggested by his chemical pursuits, viz. the general nature of matter. His doctrines on this subject are given in his "Dissertations on different subjects in Natural Philosophy." They bore some resemblance to those of Boscovich, though somewhat different, and seem to have been with Dr Hutton altogether original. After this he published a more voluminous work, entitled "An Investigation of the Principles of Knowledge and the Progress of Reason from Sense to Science and Philosophy," in three 4to volumes. His leading idea was, that matter is an assemblage of powers; that our ideas of external substances have no resemblance to the causes which produce them; and consequently that the world, as conceived by us, is entirely the creation of the mind itself, acted on by unknown external causes.

In 1793, Dr Hutton was seized with a severe and dangerous illness from a retention of urine. When he recovered from its severest symptoms, he continued his literary occupations. It was then that he prepared the work last mentioned for publication. He was also now called on to defend his doctrine on the theory of the earth, from the arguments of Mr Kirwan, published in the Transactions of the Irish Academy, especially as these were accompanied by some misrepresentations which it was incumbent on him to expose, and some charges of an odious tendency which it was necessary to repel. It was only now that he began to publish his theory of the earth in a separate state, as it had hitherto been but partially unfolded in a variety of papers. He published two octavo volumes in 1795, and a third was left behind in manuscript.

After this he published his "Elements of Agriculture," and eminently contributed by this publication, as he had done by his former example, to give an impulse to the progress of that important art.

After this he suffered under a renewed and very severe attack of his complaint; and in 1796 and 1797, his strength was greatly reduced, and his constitution broken. Still, however, he employed himself in reading and writing. Saussure's Travels among the Alps, which at this time were newly published, furnished him with high entertainment, congenial with the favourite scientific amusements of his life. On Saturday the 26th of March 1797 he suffered much pain, but continued to make some efforts in study. In the evening of that day, his complaint increased in a most rapid manner, and carried him off before time was allowed for his medical attendant to arrive.

He was undoubtedly a man powerfully qualified to advance science. It is reckoned by some persons a reflection on the memory of any philosopher, to have been the author of a theory of the earth. But we have already observed, that such persons are not aware of the engaging nature of such speculations to a philosophical and attentive mind, to which it is a natural object of ambition, to throw a consistent light on the stupendous and mysterious appearances exhibited in the mineral kingdom. Some who have studied this subject profoundly, and have embraced conclusions very different from those of Hutton, have betrayed too great proneness to throw reflections on the degree of soundness attached to this author's general philosophical discernment. They show themselves little sensible of the uncertain nature of all such speculations, and thus furnish greater evidence of their own deficiencies than of those of their opponents. The theory of the earth should be acknowledged to be as yet an enigmatic department of science; and the various attempts which have been made to solve its difficulties, both those of old and those of recent date should be allowed their respective share of plausibility, while the defects of each should be equally kept in view. It is a mistaken idea to suppose, that enthusiasm in favour of one system is in any degree necessary to keep up the spirit of science. Such an enthusiasm partakes of intemperance; the activity to which it gives birth is of a spurious complection, and is not of that kind which promises greatest durability. Dr. Hutton's private character was highly amiable. His manners were simple, but his conversation was animated. A combination of sincerity and ardour gave a charm to his company in the eyes of all his learned friends, though he was not formed on such a model as to fit him for gay or general society, which he did not relish or in any degree cultivate. His expressions in explaining his views of points of science were remakably clear and forcible, and would not have led his friends to expect so much obscurity as is found in some of his writings. For an interesting view of his character and pursuits, we refer to the account of him published in the 5th volume of the *Transactions of the Royal Society of Edinburgh*, from the pen of his friend Professor Playfair. From that source the present short abstract has been chiefly taken. (*H. D.*)

HUYGENS, Christian, a celebrated mathematician and natural philosopher, was born at the Hague on the 14th April 1629. He was the son of Constantine Huygens, Lord of Zelem and Zuylichem, who had acted as secretary and counsellor to three successive princes of the house of Orange. Constantine Huygens was not only a poet, but a good mathematician, and took particular pleasure in the instruction of his son, who, at the early age of thirteen, exhibited an ardent passion for mathematical learning, and was constantly occupied in examining all the machines and pieces of mechanism that accident threw in his way. In the sixteenth year of his age he went to the university of Leyden, to study law, under Professor Vinnius; but he still pursued his mathematical studies, in which he was assisted by the learned Professor Schooten, the commentator of Descartes. After remaining a year at Leyden, he prosecuted his studies at the university of Breda, which had been newly established, and placed under the direction of his father. In the year 1649, he travelled into Holstein and Denmark, in the suit of Henry, Count of Nassau; but on account of the short stay which that prince was to make in Denmark, he was prevented from visiting Descartes in Sweden, an object which he was very anxious to accomplish.

In the year 1651, he began his career as an author, by publishing a refutation of the famous work of Gregory St Vincent, entitled *Opus Geometricum quadraturæ circuli et sectionum Coni.* Huygens' reply, which is considered as a model of distinctness and precision, was entitled *Exetasis quadraturæ circuli P. Greg. à sancto Vincentio*, 4to. He published, in the same year, his *Theoremata de circuli et hyperbolæ Quadratura;* and in 1654 appeared his ingenious work, entitled *De circuli magnitudine inventa nova, accedunt problematum quorundam illustrium constructiones.* In 1656, he travelled into France, and took out his degree of Doctor of Laws at the university of Angers. The new subject of the calculation of probabilities, which had been successfully begun by Pascal and Fermat, and which has recently been so much advanced by La Place, now occupied the attention of Huygens, who developed the principles of the science in his treatise *De Ratiociniis in Ludo Aleæ*, which appeared in 1657. In the same year he printed his *Brevis institutio de Usu Horologiorum ad inveniendas Longitudines*, in which he described the model of a newly invented pendulum. In 1659, Huygens published his *Systema Saturninum, sive de causis mirandorum Saturni phenomenon, et comite ejus Planeta novo*, which contains the various important discoveries relative to the planet Saturn, of which we have already given a full account. See Astronomy.

In the year 1660, Huygens travelled into France; and in the following year he came to England, where he made known his method of grinding the lenses of telescopes. In the year 1663, he paid a second visit to this country, and was one of the hundred individuals who were declared members of the Royal Society at a meeting of the council held on the 20th May 1663. At this time the Royal Society had requested its members to apply themselves to the consideration of the laws of motion, and Huygens resolved several of the cases which were proposed to him. On the 15th November 1668, Dr Wallis communicated to the Society his principle of the collision of bodies. Doctor, afterwards Sir Christopher, Wren made a similar communication on the 17th of December; and on the 5th January 1669, Huygens wrote a letter to Mr Oldenburgh, containing his first four rules, with their demonstration, concerning the motion of bodies after impact. The method of Wallis was the most direct, but related only to bodies absolutely hard. Wren's method was founded on the same principle, but related only to elastic bodies; and the method of Huygens was the very same as that of Wren.

Huygens had now acquired such a reputation, that, in the year 1663, he was invited by Colbert to settle in France. He accepted of the honourable and advantageous conditions which were offered to him, and took up his residence in Paris in 1666, when he was admitted into the Academy of Sciences. In 1668, he published, in the *Journal des Sçavans*, and also in the Memoirs of the Academy, a paper entitled *Examen du livre intitulé Vera Circuli et Hyperboles quadratura a Jacobo Gregorio*, which led to the dispute of which we have already given some account in our life of Gregory. In the year 1673, he published his great work, entitled *Horologium oscillatorium; sive de motu pendulorum ad horologia aptato demonstrationes geometricæ*, in which he published his great discovery of applying pendulums to clocks, and rendering all their vibrations isochronous, by causing them to vibrate between cycloidal cheeks. This discovery was made about the year 1656; and about the middle of 1657, he presented to the States of Holland a clock constructed on this new prienciple. In our article Horology,* we have given a description and a drawing of this machine. The contrivance of cycloidal cheeks, however, though exceedingly beautiful in theory, was found in practice to be of no advantage.

About this time our author invented the spiral spring for regulating the balances of watches, without knowing what had been done by Dr Hooke; and he applied to the French government for the exclusive privilege of employing it. The Abbé Hautefeuille had, however, conceived the first idea of this invention, and communicated to the Academy of Sciences, in 1674, the secret of regulating the balances of watches " by a small straight spring made of steel." He therefore disputed Huygens' right to the exclusive privilege, and the affair was accommodated in consequence of Huygens renouncing his claim. The observations of Montucla on this subject are certainly unjust towards the Abbé Hautefeuille, when he characterises his invention as rude and clumsey, and claims all the merit for Huygens. The idea of regulating the balance by a spring was certainly the principal part of the invention, which is unquestionably due to the Abbé Hautefeuille; while Huygens is entitled to the credit of having perfected the invention, by giving a spiral form to the spring.

Huygens would probably have continued in France during the remainder of his life, had it not been for the revocation of the edict of Nantz. He resolved to remain no longer in a country where his religion was proscribed, and

* See Horology, and Plate CCC. Fig. 4.

its professors persecuted; and, anticipating the fatal edict, he returned to his native country in 1681.

After his return to Holland, he continued to prosecute his favourite studies with his usual zeal. In 1684, he published his *Astroscopia Compendiaria tubi Optici molimine liberata*, in which he gives an account of a method of using telescopes of great focal length, without the incumbrance of a tube. He published also in 1690, at Leyden, his *Traité de la Lumiere*, and his *Tractatus de Gravitate*. The first of these works contains his Theory of Light, which he supposes to be propagated like sound, by the undulation of an elastic medium,* and the beautiful law by which he represented all the phenomena of double refraction, as exhibited in Iceland spar. The remainder of our author's life was occupied in composing a work on the plurality of worlds, entitled Κοσμοθεωρος. *sive de terris celestibus, eorumque ornatu conjecturæ*. While this work was in the printer's hands, Huygens was seized with an illness, which proved fatal on the 5th of June 1695.

All his papers were bequeathed by his will to the Library of Leyden, with a request that Burcher de Volder and Fullenius, two excellent mathematicians, should print such of them as seemed of most importance. In the year 1700, this posthumous volume was published. The *Cosmotheorios* had appeared in 1698, and was speedily translated into French, English, German, and Dutch. In 1703, there appeared another posthumous volume, entitled Christiani Hugenii *Dioptrica, Descriptio Automati planetarii; de parheliis, Opuscula Posthuma*. This work contains Huygens' interesting dissertation on coronæ, and mock suns, of which we have given a short account in our article Halo. And which was reprinted by Dr Smith in his *Complete System of Optics*. A complete edition of the works of Huygens was published, in four volumes, by M. S'Gravesende. The two first appeared at Leyden in 1724, in 4to. entitled *Opera Varia*, and the two last at Amsterdam in 1728, entitled *Opera Reliqua*. He published also several papers in the early volumes of the *Philosophical Transactions*, and in the *Memoirs of the Academy of Sciences*. In the *Machines Approuvées par l'Academie*, tom. i. p. 71 and 72, he has published two papers, one of which is entitled *Machine pour Mesurer la force mouvante de l'air*; and the other, *Maniere d'empecher les vaisseaux de se briser lorsqu'il echouent*. He also published a letter on a new microscope, in the *Collections Academiques*, tom. i p. 281; and another on the Toricellian experiment, in the second volume of the same work.

Christian Huygens was unquestionably one of the most eminent mathematicians and natural philosophers of the age in which he lived. His application of the pendulum to regulate the motion of clocks; his beautiful investigation of the isochronism produced by making pendulums swing between cycloidal cheeks; his discovery of the ring and satellites of Saturn; his application of the spiral spring to regulate the balances of watches, (in which, however, he was anticipated by Dr Hooke;) his discovery of the law of collision, which he shares with Dr Wallis and Sir Christopher Wren; his theory of the centre of oscillation; his investigations respecting central forces; and the beautiful law, by which he has represented the phenomena of double refraction, exhibit the depth and variety of his attainments, and entitle him to a very high rank among those illustrious men who have done honour to their species. In our articles Astronomy, Halo, Horology, Mechanics, and Optics, the reader will find an ample account of his various labours.

HUYGEN's Temperament of the musical scale. In 1682, M. Christian Huygens published his *Cyclus Harmonicus*, or commensurate system, of thirty-one equal divisions in the octave; of which his mean tone is five, and major limma 3, of these divisions. The temperaments calculated by Mr Farey's 12th scholium, in the *Philosophical Magazine*, vol. xxxvi. p. 52, are as follows, viz. V—2.651765Σ, III+0.400802Σ, and VI—3 05256Σ. In p. 224. of the second edition of Dr Smith's *Harmonics*, he gives the monochord lengths of strings for each of the notes of this system; and at p. 207. he mentions a method by which the beats of its concords may nearly be obtained: but this being neither sufficiently easy of application, or exact enough, we have calculated them anew, as follows, viz.

| 1. | 2. | | | 3. | 4. | 5. | 6 | 7. | 8. | 9. |
|---|---|---|---|---|---|---|---|---|---|---|
| C | 612.000000 | 12 | 53 | 480.0000 | | | | | | |
| B | 552.741175 | 11 | 49 | 448.8583 | 9.2608 | 51.7853 | 5.3810 | 4.0233 | 1.6234 | 7 7449 |
| ♭B | 513.303530 | 10 | 44 | 429.2280 | 65 6060 | .9712 | 5.1456 | 3 8480 | 77.4450 | 7.4058 |
| A | 454.044705 | 9 | 40 | 401.3804 | 8.2824 | .9076 | 4.8118 | 3 5984 | 1.4532 | 6.9254 |
| ♯G | 394.785880 | 8 | 36 | 375.3394 | 7.7449 | 43.3030 | 4 4996 | ♯22.0202 | 1 3582 | 49 0570 |
| G | 355.348235 | 7 | 31 | 358 9243 | 7.4058 | .8117 | 4.3028 | 3.2173 | 1.2984 | 6 1927 |
| ♯F | 296.089410 | 6 | 27 | 335.6379 | 6.9254 | 38.7225 | 5.3810 | 3 0089 | 1 2142 | 43.8681 |
| F | 256.651765 | 5 | 22 | 320.9590 | 49.0570 | .7266 | 4.0233 | 2 8770 | 57 9100 | 5.5384 |
| E | 197.392940 | 4 | 18 | 300.1357 | 6.1927 | .6791 | 4 3028 | 2.6905 | 1.0856 | 5 1787 |
| ♭E | 157.955295 | 3 | 13 | 287.0096 | 43.8681 | .6492 | ♭22.0202 | 2.5728 | 51 7853 | 4.9520 |
| D | 98.696470 | 2 | 9 | 268.3889 | 5.5384 | .6071 | 3 2173 | 2.4059 | .9712 | 4 6304 |
| ♯C | 39.437645 | 1 | 5 | 250.9762 | 5.1787 | 28.9550 | 3 0089 | 2.2498 | .9076 | 32 8030 |
| C | 0. | 0 | 0 | 240.0000 | 4.9520 | .5428 | 2.8770 | 2.1514 | 43.3030 | 4.1412 |
| Notes. | Σ Value of the Notes. | +f | +m | Vibrations in 1″ of time. | *Sharp* of 3ds on | *Sharp* of IIIds on | *Sharp* of 4ths on | *Flat* of Vths on | *Flat* of 6ths on | *Flat* of VIths on |
| | | | | | Beats in 1 Second of Time. | | | | | |

* This doctrine has found an able supporter in Dr Thomas Young; but recent discoveries respecting the polarisation of light seem to give a new degree of probability to the doctrine of the emanation of material particles.

In column 2. the values of the notes are given as they arise in calculating by the series of tempered fifths, as above, its wolf fifth ♯G ♭E being V+17.161553Σ. Col. 3. is as usual, adapted to the octave above the tenor cliff C. All the beatings in columes 5. to 9. are *sharp* or *flat*, as marked at the bottom of each column, except the 4th and Vth wolves, which are contrary to all the others of these concords.

Mr Ambrose Warren, in a thin quarto work, called *The Tonometer*, published in 1725, gave the lengths of strings for this system, without any intimation of its having been before published by M. Huygens. (ϱ)

HYÆNA. See Hunting, and our article Mammalia.

# HYBERNATION OF ANIMALS.

The changes which take place in the condition of Plants at the approach of winter are familiar to all of us. In the course of a few weeks in autumn, the fields exchange their dress of summer green for the harvest yellow, while the forests acquiring an orange hue, speedily become leafless. While these alterations are taking place, the vital principle retires to the roots, or is in part condensed in the buds. In this state of preparation, the various tribes of perennial plants await the approach of winter,—a state which is termed their *hybernation*. As this department of vegetable physiology has been already illustrated in the article Botany, and may be found fully explained in the elementary works on that science, we refrain from farther discussion on the subject.

In the *Animal Kingdom*, changes equally remarkable precede the rigours of winter. The swallow forsakes the windows of the altar, the landrail retires from the fields, and the cuckoo deserts the hedges. The nightingale ceases to pour fourth her evening song, and in the grove all the warblers are silent. The lost or broken feathers of birds are renewed, to complete their covering, and to enable them, if necessary, to retire to warmer regions. Quadrupeds, and other animals, obtain an additional supply of clothing, collect a stock of provisions, or peacefully fall into a temporary lethargy. In these various conditions, animals prepare to pass the winter, or are said to *hybernate*.

This subject is still involved in much obscurity. It does not immediately interest us, as being but remotely connected with the ordinary concerns of life. Hence we possess few well established facts, and even those which have been ascertained, are still widely scattered in various publications; as naturalists in general are more anxious to establish the nomenclature of animals, than to investigate their habits and instincts.

Naturalists are in the practice of restricting the term *hybernation*, to that condition of animals during the winter season more familiarly expressed by the term *torpidity*. We are not aware of any reason to induce us thus to limit the original meaning of the word; and therefore, in this article, we use it as expressing the various conditions in which animals are found during the winter season, and the circumstances by which these conditions are distinguished.

The subject naturally divides itself into four branches, corresponding with the different states of hybernation which animals exhibit. The first includes those animals which obtain a change of dress;—the second, those which provide for themselves a store of food;—the third, those which migrate; and the fourth, those that become torpid.

## CHAP. I.

### Hybernating Animals which obtain a Supply of Clothing.

"Ante omnia (says Pliny when comparing the condition of man with that of the inferior animals) unum animantium cunctorum alienis velat opibus: cæteris varia tegumenta tribuit, testas, cortices, coria, spinas, villos, setas, pilos, plumam, pennas, squamas, vellera. Truncos etiam arboresque cortice, interdum gemino, a frigoribus et calore tuata est. Hominem tantum nudum, et in nuda humo, natali die abjicit ad vagitus statim et ploratum, nullumque tot animalium aliud ad lacrymas, et has protinus vitæ principio." But this condition of man is most agreeable to his nature, as he can provide for himself a suitable covering, and accommodate his dress to all climates, seasons, and occupations.

As the inferior animals do not possess such powers of contrivance, we find that nature has furnished them with clothing suited to their situations and habits. Hence those animals, whose appointed residence is in the warm regions of the earth, are in possession of the thinnest coverings; while those which are destined to dwell in the arctic regions, are enveloped in fur. Thus in the climate of Spain and Syria, the dog and the sheep have fine tufty and silky hair; while in the Siberian dog and Iceland ram, the hair is long and rigid. In still warmer regions than those which we have mentioned, the fur becomes so very thin, that the animals may be considered as naked. This is strikingly illustrated in the dogs of Guinea, and in the African and Indian sheep.

The clothing of animals living in cold countries, is essentially different from that of the animals of warm regions in another respect. If we examine the fur of the swine of warm countries, it consists entirely of bristles or hair of the same form and consistency; but those which live in colder districts possess not only common bristles or strong hair, but a fine frizzled wool next the skin, over which the long hairs project. This statement may easily be verified, by a comparison of the fur of the swine of the south of England with that which is found on those of the Scottish Highland breed. The same observation may be made on the sheep of warm and cold countries. The fleece of those of England consists entirely of wool; while those of Zetland, Iceland, and other northern regions, besides the wool, contains a number of long hairs, which at first sight give to the fleece while on the back of the animal, the appearance of great coarseness. The living races of rhinoceros and elephant of southern regions have scarcely any fur on their bodies; while those which have formerly resided in the middle and northern parts of Europe, now only found in a fossil state, have been covered with long hair, and a thick coating of short frizzled wool.

Climate in this case exercises a powerful influence over the secretions of these animals, in the increase or diminution of their clothing. Were such changes not to take place, the inhabitants of cold countries would perish by the inclemency of the weather, while those of warmer regions would be exhausted by a profuse perspiration.

The effects which climate is here represented as producing on the clothing of animals, are also observable as the annual result of the season of the year in all the temperate and cold regions of the earth. There is always an increase in the quantity of covering during the winter season, and not unfrequently a change in its colour. Let us now attend to each of these changes.

Increase in the quantity of clothing.—If we attend to the condition of the clothing of our domestic animals previous to winter, we shall witness the changes which take place. The fur is not merely renewed, but it is increased in quantity and length. This is very plainly exhibited in those quadrupeds which are kept out of doors, and exposed to the vicissitudes of the weather. But even with those animals kept in houses during the winter, the length and thickness of the fur vary according to the warmth of their habitations; and as the temperature of these habitations depends in part on the elevation, so we find the cattle living on farms near the level of the sea, covered with a shorter and thinner fur than those which inhabit districts of a higher level. Hence if we look at the horses, for example, of the farmers in a market day in winter, we might determine the relative temperature of their respective farms, from the relative quantity of clothing provided by nature for the animals which live on them.

This winter covering, if continued during the summer, would prove inconveniently warm. It is, therefore, thrown off by degrees as the summer advances; so that the animals which were shaggy during the cold months become sleek in the hot season.

This process of *casting the hair* takes place at different seasons, according to the constitution of the animal with respect to heat. The mole has, in general, finished this operation before the end of May. The fleece of the sheep, when suffered to fall, is seldom cast before the end of June. In the northern islands of Scotland, where the *shears* are never used, the inhabitants watch the time when the fleece is ready to fall, and pull it off with their fingers. The long hairs, which likewise form a part of the covering, remain for several weeks, as they are not ripe for casting at the same time with the fine wool. This operation of pulling off the wool, provincially called *rooing*, is represented by some writers, more humane than well-informed, as a painful process to the animal. That it is not even disagreeable, is evident from the quiet manner in which the sheep lie during the pulling, and from the ease with which the fleece separates from the skin.

We are in general inattentive with respect to the annual changes in the clothing of our domestic animals; but when in search of those beasts which yield us our most valuable *furs*, we are compelled to watch these operations of the seasons. During the summer months the fur is thin and short, and is scarcely ever an object of pursuit; while during the winter, it possesses in perfection all its valuable qualities. When the beginning of winter is remarkable for its mildness, the fur is longer in *ripening*, as the animal stands in no need of the additional quantity for a covering; but as soon as the rigours of the season commence, the fleece speedily increases in the quantity and length of hair. This increase is sometimes very rapid in the hare and the rabbit, whose skins are seldom ripe in the fur until there is a fall of snow, or a few days of frosty weather; the growth of the hair in such instances being dependent on the temperature of the atmosphere.

The *moulting* of birds is another preparation for winter, which is analogous to the casting of the hair in quadrupeds. During summer, the feathers of birds are exposed to many accidents. Some of them are torn off during their amorous quarrels; others are broken or damaged; while in many species they are pulled from their bodies to line their nests. Previous to winter, however, and immediately after the process of incubation and rearing of the young is finished, the old feathers are pushed off by the new ones, and in this manner the whole plumage of the bird is renewed. During this process of moulting, the bird seems much enfeebled, and, if previously in a weak state, is in danger of dying during the process. In consequence of this complete renewal of the feathers, the winter covering is rendered perfect, and the birds prepared for withstanding all the rigours of the season.

Change in the colour of the clothing.—The difference in point of colour between the summer and winter dress of animals is very conspicuously displayed both among the quadrupeds and birds. We are not aware that it has been observed among the cold-blooded animals.

Among quadrupeds, the Alpine hare (*Lepus variabilis*) is a very remarkable example. It is found, in this country, on the high mountains of the Grampian range. Its summer dress is of a tawny grey colour; but, about the month of September, its fur gradually changes to a snowy whiteness. It continues in this state during the winter, and resumes its plainer covering again in the month of April or May, according to the season. The *ermine* is another of our native quadrupeds, which exhibits in its dress similar changes of colour according to the season. It frequents the outskirts of woods and thickets. During the summer months its hair is of a pale reddish brown colour; in harvest it becomes clouded with pale yellow; and in the month of November, with us, it is of a snow white colour. Its winter dress furnishes the valuable fur called ermine. Early in spring, the white becomes freckled with brown, and in the month of May it completely resumes its summer garb.

Among the feathered tribes such instances of change of colour in the plumage during winter are numerous. They greatly perplex the ornithologist, and have been the means of introducing into the system several spurious species. The white grous or ptarmigan (*Tetrao lagopus*) may be produced as a familiar example of this kind of hybernation. This bird, like the Alpine hare, inhabits the higher Grampians, and is never found at a great distance from the limits of the snow. In summer its plumage is of an ash colour, mottled with small dusky spots and bars. At the approach of winter the dark colours disappear, and its feathers are then found to be pure white. In remarkably mild winters the change is sometimes incomplete, a few dusky spots of the summer dress remaining. In spring its winter garb becomes again mottled, and the bird loses much of its beauty. Even the young birds in their first dress resemble their parents in their mottled plumage, and like them become white at the approach of winter.

Among the aquatic birds similar changes in the colour of the plumage have been observed. The black guillemot (*Uria grylle*), so common on our coasts, is of a sooty black colour during the summer, with a white patch on the wings. During winter, however, the black colour disappears, and its plumage is then clouded with ash-coloured spots on a white ground. In the winter dress, it has been described by some as a distinct species, under the name of the *spotted guillemot*. In the more northern regions, as in

Greenland, for example, this bird, in winter, becomes of a pure white colour. This is a decided proof of the influence of temperature in producing this change of colour. There is a fine example of this bird in its white winter dress in the collection of the Dublin Society, where we saw it a few months ago. It was brought from Greenland by that intelligent and enterprising naturalist Sir Charles Giesecké.

These changes of colour, which we have already mentioned, extend throughout the whole plumage of the bird; but in other instances, the change extends to only a small part of the plumage. Thus the little auk (*Alca alle*) during summer has its cheeks and throat of a black colour, but in winter these parts become dirty white. In this its winter garb, it is often shot on our coasts. Its summer dress induced Pennant to consider it as a variety, and as such to figure it. The black headed gull (*Larus ridibundus*) has a black head during summer, as its trivial English name intimates. During the winter, however, the black colour on the head disappears; and, when in this dress, it has been regarded by many as a distinct species, under the name of the *red-legged gull*.

In many other birds there is a remarkable difference in point of colour between the summer and the winter plumage, although not so striking as those which we have noticed. The colours of the summer feathers are rich and vivid; those of the winter obscure and dull. This is well illustrated in the Dunlin, (*Tringa alpina*,) whose summer plumage has much black and rufous colour, but whose winter plumage is dull and cinereous. In its winter dress it has been described as a distinct species, under the trivial name of *T. cinclus*, or Purre. Similar instances might be produced in the case of the Wagtails, Linnets, and Plovers, and a great many other birds.

From the preceding statements, we are naturally led to inquire, in what manner these changes in the colour of the dress are produced? It has been supposed by some, that those quadrupeds, which, like the alpine hare and ermine, become white in winter, cast their hair twice in the course of the year; at harvest, when they part with their summer dress, and in spring, when they throw off their winter fur. This opinion does not appear to be supported by any direct observations, nor is it countenanced by any analogical reasonings. If we attend to the mode in which the hair on the human head becomes grey as we advance in years, it will not be difficult to perceive, that the change is not produced by the growth of new hair of a white colour, but by a change in the colour of the old hair. Hence there will be found some hairs pale towards the middle, and white towards the extremity, while the base is of a dark colour. Now, in ordinary cases, the hair of the human head, unlike that of the inferior animals, is always dark at the base, and still continues so during the change to grey; hence we are disposed to conclude from analogy, that the change of colour, in those animals which become white in winter, is effected, not by a renewal of the hair, but by a change in the colour of the secretions of the rete mucosum, by which the hair is nourished, or perhaps by that secretion of the colouring matter being diminished, or totally suspended.

As analogy is a dangerous instrument of investigation in those departments of knowledge which ultimately rest on experiment or observation, so we are not disposed to lay much stress on the preceding argument which it has furnished. The appearances exhibited by a specimen of the ermine now before us are more satisfactory and convincing. It was shot on the 9th May, (1814,) in a garb intermediate between its winter and summer dress. In the belly, and all the under parts, the white colour had nearly disappeared, in exchange for the primrose yellow, the ordinary tinge of these parts in summer. The upper parts had not fully acquired their ordinary summer colour, which is a deep yellowish brown. There were still several white spots, and not a few with a tinge of yellow. Upon examining those white and yellow spots, not a trace of interspersed new short brown hair could be discerned. This would certainly not have been the case, if the change of colour is effected by a change of fur. Besides, while some parts of the fur on the back had acquired their proper colour, even in those parts numerous hairs could be observed of a wax yellow, and in all the intermediate stages from yellowish brown, through yellow, to white.

These observations leave little room to doubt, that the change of colour takes place in the old hair, and that the change from white to brown passes through yellow. If this conclusion is not admitted, then we must suppose that this animal casts its hair at least seven times in the year. In spring, it must produce primrose yellow hair; then hair of a wax yellow; and, lastly, of a yellowish brown. The same process must be gone through in autumn, only reversed, and with the addition of a suit of white. The absurdity of this supposition is too apparent to be farther exposed.

With respect to the opinion which we have advanced, it seems to be attended with few difficulties. We urge not in support of it, the accounts which have been published of the human hair changing its colour in the course of a single night; but we think the particular observations on the ermine warrant us in believing that the change of colour in the alpine hair is effected by a similar process. But how is the change accomplished in birds?

The young ptarmigans are mottled in their first plumage similar to their parents. They become white in winter, and again mottled in spring. These young birds, provided the change of colour is effected by moulting, must produce three different coverings of feathers in the course of ten months. This is a waste of vital energy, which we do not suppose any bird in its wild state capable of sustaining; as moulting is the most debilitating process which they undergo. In other birds of full age, two moultings must be necessary. In these changes, the range of colour is from blackish grey, through grey, to white, an arrangement so nearly resembling that which prevails in the ermine, that we are disposed to consider the change of colour to take place in the old feathers, and not by the growth of new plumage; this change of colour being independent of the ordinary annual moultings of the birds.

Independent of the support from analogy which the ermine furnishes, we may observe that the colours of other parts of a bird vary according to the season. This is frequently observable in the feet, legs, and bill. Now, since a change takes place in the colouring secretions of these organs, what prevents us from supposing that similar changes take place in the feathers? But even in the case of birds, we have before us an example as convincing as the ermine already mentioned. It is a specimen of the little auk, (*Alca alle*,) which was shot in Zetland in the end of February, 1810. The chin is still in its winter dress of white, but the feathers on the lower part of the throat have assumed a dusky hue. Both the shafts and webs have become of a blackish grey colour at the base and in the centre, while the extremities of both still continue white. The change from black to white is here effected by passing through grey. If we suppose that in this bird the changes of the colour of the plumage are accomplished by moulting, or a change of feathers, we must admit the existence of three such moultings in the course of the year—one by which the white winter dress is produced, another for the dusky spring dress, and a third for the black garb of summer. It is surely unnecessary to point out any other examples in support of our opinion on this subject. We have followed nature, and our conclusions appear to be justified by the appearances which we have described.

Having endeavoured to ascertain the manner in which this change of colour takes place, we are now ready to investigate the causes by which it is produced. As this change of colour in winter is peculiar to the animals which inhabit cold countries, we may safely conclude, that temperature exercises over it a powerful influence. This supposition is countenanced by the slowness of the process of change of colour in a mild autumn, and its imperfect accomplishment during a mild winter. Besides, in some animals, such as the black guillemot, the change is never complete in the more temperate regions, but becomes more perfect as we proceed northwards, until at Greenland the bird is of a pure white. If this change of colour proceeds from a renewal of feathers, here at least the colour of the feathers must be considered influenced by the temperature, and consequently a corresponding influence must be exercised on the secreting organs.

The distribution of colour in the animal kingdom in general seems to follow the same law; the deep and bright colours prevailing in the warm regions, while the tints of the colder regions are pale and dull. Are we to conclude, that cold diminishes the action of the vessels which furnish the colouring matter, and, when intense, entirely suspends their functions? or are we to consider light as in part concerned in producing the effect? In general, the fur of quadrupeds, and the feathers of birds, are darkest where exposed to the light, and are pale coloured towards the base; but in the instances before us this difference disappears, and a complete uniformity in all the parts of the covering prevails. Besides, the change does not take place on all parts of the body at the same time, but appears in spots, or on single hairs or feathers. Light therefore has little influence.

There is another agent besides cold apparently concerned in the change in the colour of the feathers of birds. In all birds the feathers become more vivid in spring, and certain spots appear which are not observable at other seasons. This brightness of plumage and these spots continue only during the season of love; and hence, instead of supposing them the production of new moultings, we consider them as resulting from the action of the generative impulse on the colouring secretions.

In attempting to account for these phenomena of nature, it has generally been supposed, that these periodical changes of colour take place, to enable the animals more readily to escape from their prey during the winter season. Thus Montagu, in reference to this subject, has the following reflections: "Here we perceive the ptarmigan invariably effect this curious, and, we may add, most providential change; for if the young of those birds at first assumed their snowy winter plumage, while yet the surface of the ground was not consonant with their colour, few would escape the piercing eye of the falcon or the eagle, in the lofty and exposed situations they are found to inhabit." To suppose that in winter the ptarmigan is rendered white, to cause it to resemble the snow and deceive birds of prey, and that the alpine hare undergoes similar changes for the same purpose, would be to yield our assent to public opinion. But all our conclusions concerning final causes ought to be the result of very extended observations; and if our observations on this subject are extended, some difficulties will present themselves. If this white colour yields protection to the ptarmigan and alpine hare, it must enable the ermine, an animal well qualified to provide for its wants at all times, by its determined boldness, extreme agility, and exquisite smell, to prey with greater certainty upon its defenceless neighbours. What protection, we would ask, is afforded to the black guillemot, during the winter, by its mottled plumage, or to the little auk by its white chin, since the whiter they become, so much the more unlike the dark colour of the water? Protection from foes, therefore, cannot be considered as the object of nature in these curious changes, especially as the change of colour, always from dark to white, does not differ, however different the habits and even stations of the animals may be.

Perhaps the laws of chemistry may furnish us with a more consistent and plausible explanation. If the radiating power of bodies with regard to heat be inversely as their reflecting power, a conclusion very generally admitted, then the white winter dress of these animals must be better calculated for retaining the heat generated in their bodies by the vital principle, than any other coloured dress which would possess greater radiating power, and, consequently, would more readily contribute to the reduction of their temperature. It is probable, therefore, that these changes in the quantity and colour of the clothing of animals, are designed by nature to regulate their temperature in the different seasons of the year.

## CHAP. II.

### Hybernating Animals which lay up a Stock of Provisions.

The kind of hybernation of which we treated in the last Chapter, is of more frequent occurrence than that which we are now to consider. In common with those animals, they obtain an addition to their clothing, while they differ from them in being provident of futurity. They collect with care the superabundant productions of autumn, and dispose of them in such a manner, as to furnish a supply of food when the fruits and flowers are destroyed by the frost. Such may with propriety be termed *storing animals*, as they all possess the industry so beautifully expressed by Virgil.

*Venturæque hiemis memores æstate laborem.*
*Experiuntur, et in medium quæsita reponunt.*

This class of hybernating animals contains but few species. These are all phytivorous, and, without exception, belong to the natural tribe of Glires or Gnawers. All the animals of this tribe do not possess this *storing* inclination, although it is certainly observable in many of them.

Of all those animals, whose industry in collecting, and wisdom in preserving a winter store, have attracted the notice of mankind, the beaver stands pre-eminently conspicuous. But, as the habits of that singular animal have been detailed under the article Beaver, we forbear in this place to reconsider the subject. And, as we rather wish to confine our remarks to British animals, wherever the subject will permit, we select as an example of this kind of hybernation, the common squirrel, (*Sciurus vulgaris*). This active little animal prepares its winter habitation among the large branches of an old tree. After making choice of the place where the timber is beginning to decay, and where a hollow may be easily formed, it scoops out with its teeth a suitable magazine. Into this storehouse, acorns, nuts, and others fruits are industriously conveyed, and carefully concealed. This granary is held sacred until the inclemency of the weather has limited the range of its excursions, and consequently diminished its opportunities of obtaining food. It then begins to enjoy the fruits of its industry, and to live contentedly in its elevated dwelling. All the species of mice seem to possess the inclination to lay up provisions; even the house mouse and the rat; but the field mouse is the most remarkable instance. Says the pious and intelligent Derham, "I have in autumn, not without pleasure, observed, not only the great sagacity and diligence of swine, in hunting out the stores of the field mice, but the wonderful precautions also of those little animals, in hiding their food before hand against winter. In the time of acorns falling, I have, by means of the hogs, discovered that the mice had, all over the neighbouring fields, treasured up single acorns in little holes they had scratched, and in which they had carefully covered up the acorn. These the hogs would, day after day, hunt out by their smell."

Among birds, reptiles, and fishes, no examples are known of this kind of hybernation. The bee, among insects, is an interesting example, but requiring no explanation. No instances occur among the animals which compose the inferior classes.

Since all these storing animals are destined to live on the productions of the vegetable kingdom, we witness the wise provisions of nature in assigning to them such propensities. By this faculty, existence is comfortably maintained, under circumstances which would prove fatal without it. The seeds of many plants are translated by them from the places of their growth, and more extensively disseminated. But how are we to account for the conduct of those animals, in thus providing for a futurity, who have never suffered from former inexperience, as must be the case with young animals—that in autumn, when the bounties of nature are scattered so profusely, they should subject themselves to much labour, in heaping up a treasure for supplying the deficiencies of a winter, of whose accompanying privations they are ignorant. Part of this industry may, in those animals which are gregarious, be the result of education; but in other instances, we must confess our inability to offer any explanation.

Such baffled searches mock man's prying pride,
The God of Nature is your secret guide.

## CHAP. III.

### Hybernating Animals which Migrate.

This subject has long occupied the attention of naturalists; and several important observations have been published by different authors. It is chiefly, however, as it regards birds, that the subject is deserving of particular consideration. We are acquainted with but few circumstances connected with the migration of quadrupeds. Limited in their powers of locomotion, their range of travelling is confined, so that other means are provided for their safety and sustenance during winter. The cheiroptera are well fitted for migrating; and accordingly we find that some species are known to do so. In Italy, the common bat (*Vespertilio murinus*) abounds; but it migrates southwards at the approach of winter, and is not found in any of the caves in a torpid state. The *V. noctula*, however, arrives annually to winter, although it retires to spend the summer in more northern regions. Dr Barton informs us, that some species of dipus migrate from the northern to the southern parts of America during winter. Many of the ruminating animals shift their habitations according to the changes of the year. Thus, the stag and the roebuck leave the alpine regions at the approach of winter, and seek protection in the more sheltered plains. More extensive migrations are performed by the palmated quadrupeds, particularly the *seals*. These shift their stations to reach safe breeding places, in whatever country they live in. But the common seal (*Phoca vitulina*) often performs regular migrations in quest of food. In the Statistical Account of the parish of North Knapdale, we are told that the lake called Lochow, about twenty miles in length, and three miles in breadth, "abounds with plenty of the finest salmon; and, what is uncommon, the *seal* comes up from the ocean, through a very rapid river, in quest of this fish, and retires to the sea at the approach of winter." Another species, the *P. Groenlandica*, seems to seek more temperate regions during the winter. Seals of this kind, says Horrebow in his History of Iceland, "arrive annually in the month of December, especially about the northern parts of the country, and generally stay till May, at which time those that escape the Icelanders depart." A few curious facts regarding the migrations of the Cetacea may be found under the article Greenland. Several kinds of small whales visit the coasts of Scotland, chiefly during the autumnal months; but we are ignorant of the places from whence they come, and unacquainted with the laws of their migration.

### *Migration of Birds.*

The migrations of the feathered race, as connected with their hybernation, have been the subject of popular observation since the days of the prophet Jeremiah. "Yea, the stork in the heaven knoweth her appointed times; and the turtle, and the crane, and the swallow, observe the time of their coming," (ch. viii. v. 7.) Many important facts have been ascertained, and a few general conclusions have been established. But the subject is still far from being exhausted; nay, without fear of contradiction, we may venture to assert, that it is but very imperfectly understood by naturalists in general. Popular errors have gained admittance as scientific documents, and the well authenticated facts have been suffered to remain in their original detached form, destitute of connection and arrangement.

It is not our intention to enter into any minuteness of detail regarding the migrations of the different species of birds. This has already been done under the article Birds, where the reader will find a statement of several facts connected with the migration of our native species. And he may also consult at his leisure, the ornithological productions of Pennant, White, and Montagu. Our observations in this place will be of a general nature, and will have for their object to ascertain the laws of migration, and the circumstances under which it takes place.

Migrating birds may be divided into two classes, from the different seasons of the year in which they arrive or depart. To the first class will belong those birds which arrive in this country in the spring, and depart in autumn, and are termed *Summer Birds of Passage*. The second will include those which arrive in autumn, and depart in spring, and are called *Winter Birds of Passage*.

The Summer Birds of Passage are not confined to any particular order or tribe; nor are they distinguished by similarity of habits. Some of them belong to the division of *Water Fowls*, as the terns and gulls; while others are *Land Birds*, as the swallow and rail. They differ also remarkably with regard to their food. Thus, the hobby is carnivorous; the gulls and terns, piscivorous; the swallow, insectivorous; and the turtle dove and the quail, granivorous.

In many particulars these summer birds of passage exhibit very remarkable differences. They, however, present one point of resemblance. All of them, during their residence in this country, perform the important offices of pairing, incubation, and the rearing of their young, and hence may with propriety be termed the natives of the country. We hail their arrival as the harbingers of spring, and feel the blank which they leave on their departure, although it is in some measure supplied by another colony of the feathered race, who come to spend with us the dreary months of winter.

The Winter Birds of Passage have more points of resemblance among themselves than those of the former division. They chiefly belong to the tribe of water-fowls. None of them are insectivorous, and very few are granivorous. They chiefly frequent the creeks and sheltered bays of the sea, and the inland lakes, or they obtain their food in marshy grounds, or at the margins of springs. When the rigours of the season are over, and when other birds which are stationary are preparing for incubation, these take their departure, to be again succeeded by our summer visitants.

We have stated generally, that our summer and winter birds of passage visit us at stated seasons of the year; that the summer visitants arrive in spring and depart in autumn; and the winter visitants arrive in autumn and depart in spring. But the different species do not all observe the same periods of arrival and departure. Thus, among the summer birds of passage, the wheat-ear always precedes the swallow, while the swallow arrives before the martin, and the martin before the landrail or cornerake. Among the winter birds of passage, similar differences in the time of arrival are observable. Thus the woodcock precedes the fieldfare, and the fieldfare the redwing. The time of departure has not been observed with so much attention, as the subjects have then lost their novelty, so that we do not so readily perceive their absence. It is probable, however, that in their departure, as well as their arrival, each species has its particular period.

The periods of arrival and departure, even in the same species, do not always take place at exactly the same day, or even month of the year. In different years these vary from one to four weeks, and evidently depend on very obvious circumstances. The meanest rustic, in regard to the summer birds of passage, is aware, that cold weather prevents the arrival of these messengers of spring; and that the early arrival of our winter birds of passage indicates a proportionally early winter. The same circumstances which retard our summer visitants also check the progress of vegetation. Hence, in all probability, we might be able to prognosticate the arrival of these birds, by attending to the time of the leafing or flowering of particular trees or plants. As the state of vegetation depends on the temperature of the season, and the life of insects on the state of vegetation, we may safely conclude, that the movements of the phytivorous and insectivorous birds must be dependant on these circumstances.

Linnæus bestowed some attention on these connected circumstances, in his Calendar of Flora for Sweden; and Stillingfleet in that of England. Linnæus observed, that the swallow returned to Sweden when the bird-cherry came into leaf, and when the wood-anemone flowered. He also found the arrival of the nightingale accompanied with the leafing of the elm. Stillingfleet says, that the swallow returns to Norfolk with the leafing of the hazel, and the nightingale with the leafing of the sycamore. It has also been observed, that the cuckoo sings when the marsh-marigold blows. It would tend greatly to increase our knowledge of this subject, were observations of this sort multiplied. We earnestly recommend the subject to the attention of the practical naturalist.

Having thus offered a few observations on the periods of arrival and departure of migrating birds, let us now enquire after *the places from whence they come, and to which they return.* In doing this, it will be proper to bestow some attention on those birds whose migrations are only partial, and which merely shift from one part of the island to another. The movements of these birds, though confined within narrow bounds, are probably regulated by the same laws which with other species produce more extensive migrations.

In the inland districts of Scotland, the lapwing makes its appearance about the end of February or the beginning of March, and, after performing the purposes of incubation, hastens to the sea-shore, there to spend the winter, picking up the small crustacea from among the rejectamenta of the sea. These birds seldom however remain all winter on the Scottish shores, though they are always to be found at that season on the southern English shores. In that part of the island they do not perform such extensive migrations, but may with propriety be considered as resident birds. The curlew arrives at the inland districts along with the lapwing, and they depart in company about the beginning of August. The curlew, however, remains on the Scottish shores during the winter. The oyster-catcher, though it breeds in Scotland, retires to the English shores during the winter, and joins those which have remained there during the breeding season. The black-headed gull breeds both in England and Scotland; but it retires from the last mentioned country, while it continues resident in the former.

From the examples quoted, it appears that some birds, which are stationary in one district, are migratory in another. But that which chiefly merits our consideration is the circumstance of those birds, whose annual migrations are confined to our own shores, forsaking the high grounds when the purposes of incubation have been accomplished, and seeking for protection at a lower level, and in a warmer situation. When these migrations become more extensive, they forsake the bleak moors and shores of Scotland for the warmer and more genial climate of England. Hence it happens, that some of our Scottish summer visitants come from England, while some of the English winter visitants come from Scotland: the summer birds of passage coming from the south, and the winter passengers from the north. Do those birds, whose migrations are more extensive, obey the same laws?

As the summer birds of passage are more interesting to us, since they perform the great work of incubation in our country, than the winter birds of passage, which are the harbingers of storms and cold, and only wait the return of spring to take their leave of us, we will endeavour to find out the winter residence of the former, before we attempt to discover the summer haunts of the latter. Natural history, it is true, is still in too imperfect a state, to enable us to point out with certainty the retreats of those birds which visit us during summer. But enough appears to be known to enable us to ascertain the laws by which these migrations are regulated in a number of birds, and as the points of resemblance in the movements of the whole are numerous, we can reason from analogy on safer grounds with regard to the remainder.

The swallow, about whose migrations so many idle stories have been propagated and believed, departs from Scotland about the end of September, and from England about the middle of October. In the latter month M.

Adanson observed them on the shores of Africa after their migrations from Europe. He informs us, however, that they do not build their nests in that country, but only come to spend the winter. The nightingale departs from England about the beginning of October, and from the other parts of Europe, about the same period. During the winter season it is found in abundance in Lower Egypt, among the thickest coverts in different parts of the Delta. The birds do not breed in that country, and to the inhabitants are merely winter birds of passage. They arrive in autumn and depart in spring, and at the time of migration are plentiful in the islands of the Archipelago. The quail is another of our summer guests, which has been traced to Africa. A few indeed brave the winters of England, and in Portugal they appear to be stationary. But in general they leave this country in autumn, and return in spring. They migrate about the same time from the eastern parts of the continent of Europe, and visit and revisit in their migrations the shores of the Mediterranean, Sicily, and the islands of the Archipelago. When speaking of this subject, the intelligent Willoughby adds, that "when he sailed from Rhodes to Alexandria in Egypt, many quails from the north towards the south were taken in our ship; whence I am verily persuaded that they shift places: for formerly also, when I sailed out of the isle of Zante to Morea, or Negropont, in the spring time, I had observed quails flying the contrary way, from south to north, that they might abide there all summer. At which time also there were a great many taken in our ship." *Ornith.* p. 170.

While these birds perform those extensive migrations which we have here mentioned, others are contented with shorter journies. Thus the razor-billed auk (*Alca torda*) and the puffin (*Alca arctica*) frequent the coast of Andalusia during the winter season, and return to us in the spring.

These facts, and many others of a similar nature, which might have been stated, enable us to draw the conclusion, that our summer birds of passage come to us from southern countries, and after all the purposes of incubation are accomplished, return again to milder regions. A few of our summer visitants may winter in Spain or Portugal; but it appears that in general they migrate to Africa, that unknown country, possessing every variety of surface, and consequently great diversity of climate. It is true that we are unacquainted with the winter retreats of many of our summer birds of passage, particularly of many small birds; but as these arrive and depart under similar circumstances with those whose migrations are ascertained, and as the operations which they perform during their residence with us are also similar, we have a right to conclude, that they are subject to the same laws, and execute the same movements. What gives weight to this opinion, is the absence of all proof of a summer bird of passage retiring to the north during the winter season.

In proof of the accuracy of the preceding conclusion, we may observe, that it is a fact generally acknowledged, that the summer birds of passage visit the southern parts of the country a few days, or even weeks, before they make their appearance in the northern districts. Thus the common swallow (*Hirundo rustica*) appears in Sussex about the beginning of the third week of April; while in the neighbourhood of Edinburgh it is seldom seen before the first of May. The cuckoo appears in the same district about the last week of April; in Edinburgh seldom before the second week of May. The reverse of this holds true with these summer visitants at their departure. Thus dotterels (*Charadrius morinellus*) forsake the Grampians about the beginning of August, and Scotland by the end of that month; while they return to England in September, and remain there even until November. A difference of nearly a month takes place between the departure of the goatsucker (*Caprimulgus Europæus*) from Scotland and from the south of England.

Having thus ascertained the winter haunts of our summer birds of passage, let us now endeavour to find out the summer retreat of our winter visitants. The conclusions which we have already established dispose us to look for these birds in countries situated to the northward. And as we are much better acquainted with the ornithology of those countries than of Africa, it will be in our power to prosecute our researches with greater certainty of success.

The snow bunting, (*Emberiza nivalis*), which is among the smallest of our winter guests, retires to the hoary mountains of Spitzbergen, Greenland, and Lapland, and there performs the purposes of incubation, making its nest in the fissures of the rocks. In these countries it is therefore a summer visitant, as it retires southwards in autumn, to spend the winter in more temperate regions. To the sea coasts of the same regions the little auk (*Alca alle*), and the black-billed auk (*Alca pica*), repair for similar purposes as the snow-flake. The *woodcock* winters with us, but retires in the spring to Sweden, Norway, and Lapland. Eckmark says of this bird, as a Swedish summer bird of passage, "Pullis in sylvis nostris exclusis, mare transmigrans, in Angliam avolat; ut ex Austria in Italiam. Vere autem novo, dum blatire incipit Tetrao tetrix, illinct descedunt, matrimonio junctæ ad nos revertentes." The fieldfare and the redwing resemble the woodcock in their migrations, depart at the same season, and retire for similar purposes to the same countries.

These instances may suffice to support the conclusion, that all our winter birds of passage come from northern countries, and that the winter visitants of the south of Europe become the summer visitants of its northern regions. This is evidently an arrangement depending on the same law by which the African winter birds of passage are summer birds of passage in Europe.

In support of this conclusion it may be mentioned, that, in their progress southward, the winter birds of passage appear first in the northern and eastern parts of the island, and gradually proceed to the southward and westward. Thus the snow-bunting arrives in the Orkney islands about the end of August, and often proves destructive to the corn fields. It then passes into the mainland of Scotland, and is seldom seen in the Lothians, even in the high grounds, before November. In like manner, the woodcock, which crosses the German Ocean, is first observed on the eastern side of the island, and then by degrees disperses towards the west.

Having now ascertained the period and the direction of these migrations, let us next attend to the act of migration itself, and the circumstances attending the flight.

Migrating birds, before they take their departure, in general collect together in flocks. This is very obviously the case with the swallow, and is even still better known with woodcocks. These last arrive in this country in great flocks about the same time; and should adverse winds occur at the period of their departure, they accumulate in such numbers on the eastern shores, as to furnish the fowler with excellent sport. Geese too, during their migratory flights, always keep in company; and the picture which the poet draws of the movements of the crane is equally just when applied to them, only we do not vouch for the truth of their geometrical precision, and their knowledge of the power of the wedge.

> ————In figure wedge their way,
> Intelligent of seasons; and set forth
> Their airy caravan, high over seas
> Flying, and over lands: so steers the prudent crane
> Her annual voyage, borne on winds: the air
> Floats as they pass, fann'd with unnumbered plumes.
> MILTON.

But there are many migrating birds which have never been observed to congregate previous to their departure. Thus the cuckoo, seldom seen in company with his mate even during the breeding season, is to all appearance equally solitary at the period of migration. These birds are supposed by naturalists to go off in succession.

It is certainly a very curious, and perhaps unexpected occurrence, that the males of many species of migrating birds appear to perform their migrations a few days before the females. This is remarkably the case with the nightingale. The bird catchers in the neighbourhood of London obtain only males on the first arrival of this bird. The females do not make their appearance for a week or ten days after. Similar observations have been made with respect to the wheatear (*Motacilla œnanthe.*)

Those birds which feed during the night, may be expected to perform their migrations during the same interval, it being the season of their activity; while those birds which feed during the day, may be expected to migrate with the help of light. The migrations of the woodcock and quail confirm this conjecture. The woodcocks arrive in this country during the night, and hence they are sometimes found in the morning, after their arrival, in a neighbouring ditch, in too weak a state to enable them to proceed. Poachers are aware that they migrate during the night, and sometimes kindle fires on the coast, to which the woodcocks, attracted by the light, bend their course, and in this manner great numbers are annually destroyed. Quails, on the other hand, perform their migrations during the day, so that the sportsman in the islands of the Mediterranean can use his dog and gun.

It has often excited surprise in the minds of some, how migrating birds could support themselves so long on wing, so as to accomplish their journies, and at the same time live without food during their voyage. These circumstances have induced many to deny the existence of migration, and has excited others to form the most extravagant theories on the subject, to account for the preservation of these birds during the winter months. But the difficulties which have been stated, are only in appearance, and vanish altogether if we attend to the rapidity of the flight of birds.

The rapidity with which a hawk and many other birds occasionally fly, is probably not less than at the rate of one hundred and fifty miles in an hour. Major Cartwright, on the coast of Labradore, found, by repeated observations, that the flight of an eider duck (*Anas mollissima*) was at the rate of ninety miles an hour. Besides, it is generally known, that a falcon which belonged to Henry the Fourth of France, escaped from Fontainbleau, and in twenty-four hours afterwards was found at Malta, a distance computed to be no less than thirteen hundred and fifty miles; a velocity nearly equal to fifty-seven miles an hour, supposing the falcon to have been on wing the whole time. But as such birds never fly by night, and allowing the day to be at the longest, his flight was perhaps equal to seventy-five miles an hour. It is probable, however, says Montagu, that he neither had so many hours of light in the twenty-four to perform his journey, nor that he was retaken the moment of his arrival. But if we even restrict the migratory flight of birds to the rate of fifty miles an hour, how easily can they perform their most extensive migrations! And we know, in the case of woodcocks, and perhaps all other migrating birds, that they in general take advantage of a fair wind with which to perform their flights. This breeze perhaps aids them at the rate of thirty or forty miles an hour; nay, with three times greater rapidity, even in a moderate breeze, if we are to give credit to the statement of aërial navigators, who seem to consider the rate of the motion of winds as in general stated too low.

It has been already observed, that many species do not perform their migrations at once, but reach the end of their journey by short and easy stages. There is little exertion required from such; while those who execute their movements at one flight, (if there be any that do so,) may in a very short time, perhaps a day, by the help of a favourable breeze, reach the utmost limits of their journey. Many birds, we know, can subsist a long time without food; but there appears to be no necessity for supposing any such abstinence, since, as Catesby remarked, every day affords an increase of warmth and a supply of food. Hence we need not perplex ourselves in accounting for the continuance of their flight, or their sustenance in the course of it. Such journies would be long indeed for any quadruped, while they are soon performed by the feathered tribes.

It is often stated as a matter of surprise, how these birds know the precise time of the year at which to execute their movements, or the direction in which to migrate:—

> Who calls the council, states the certain day,
> Who forms the phalanx, and who points the way?

But this is merely expressing a surprise, that a kind and watchful Providence should bestow on the feathered creation, powers and instincts suited to their wants, and calculated to supply them. How, we ask, does the curlew, when perched upon a neighbouring muir during the flowing of the tide, know to return at the first of the ebb, to pick up the accidental bounty of the waves? How are the sea fowl, in hazy weather, guided to the sea-girt isles they inhabit, with food to their young, which they have procured at the distance of many miles? "The inhabitants of St Kilda," says Martin, "take their measures from the flight of these fowls, when the heavens are not clear, as from a sure compass; experience shewing, that every tribe of fowls bend their course to their respective quarters, though out of sight of the isle. This appeared clearly in our gradual advances; and their motion being compared, did exactly quadrate with our compass."

In the course of these annual migrations, birds are sometimes overtaken by storms of contrary wind, and carried far from their usual course. In such cases, they stray to unknown countries, or sometimes are found at sea in a very exhausted state, clinging to the rigging of ships. Such accidents, however, seldom happen, as these birds, year after year, arrive in the same country, and even return to the same spot. The summer birds of passage return not, it is true, in such numbers as when they left us; but, amidst all the dangers of their voyage, the race is preserved.

Having established the principal facts regarding the periods of migration, and the circumstances by which it is accompanied, it now remains for us to ascertain those proximate causes to which these movements are to be referred. Powerful indeed must be the causes which prompt those animals to forsake the woods in which they were reared, or the rocks on which they were hatched, and undertake a perilous journey to distant countries. They must be intimately connected with the first laws of life, otherwise the movements to which they give birth would not be so constant and uniform. The procuring of a supply of food, a suitable temperature, or a safe breeding place, are probably all the proximate causes which have any concern in such migrations.

If we attend to the *food* of many of our summer visitants, we may easily perceive, that it can only be procured during those months in which they remain with us. Subsisting chiefly on insects, they are compelled to shift their quarters, and retire to warmer districts at the end of our summer, in order to procure support. Montagu, when speaking of the cuckoo, makes the following pertinent observations. "Few birds but the titmice will devour the larvæ of the cabbage butterflies; and none that we have noticed make a repast on the hairy species of caterpillars but the cuckoo, who is a general devourer of all kinds of *Lepidopterous larvæ*, more especially the rough sort. It is therefore probable, that the early remigration of this bird is the defect of this favourite food, the greater part having by that time enclosed themselves, preparatory to a change. Of the many cuckoos we have dissected in the months of May and June, the stomach has always been found to contain more or less of the hairs of caterpillars, and sometimes quite full of them."

If insects are thus the favourite food of many of our summer birds of passage, it must frequently happen that their food will be scarce, even after their arrival in this country, owing to the variableness of our climate, and the dependence of the movements of insects on the temperature of the weather. Hence it happens, that some birds disappear again, retiring to other districts where insects are to be obtained. Montagu mentions a curious fact of this kind with regard to the chimney swallow. "It makes its first appearance with us in April, sometimes as early as the first week, if the weather is mild; and it sometimes happens, that after their arrival a long easterly wind prevails, which so benumbs the insect tribe, that thousands die for want of food. We recollect, as late as the ninth of May, the swallows on a sudden disappeared from all the neighbouring villages around. The thermometer was at 42°, and we were at a loss to conceive what was become of these birds, which a day or two before were seen in abundance. But by chance we discovered hundreds collected together in a valley close to the sea side, at a large pool which was well sheltered. Here they seem to have found some species of fly, though scarce sufficient to support them; for many were so exhausted, that after a short time on wing, they were obliged to pitch on the sandy shore." In the case of the waders, which obtain their food in the neighbourhood of springs and marshes, they are compelled to leave the regions of the north, where, during winter, these are all frozen, and the extent of their migration southwards depends on the severity of the weather.

A supply of food is certainly one of the proximate causes of migration, since we can support many of our summer visitants during the winter, as the nightingale for example, by giving them a regular supply of food. But powerful as this principle may appear, it is certainly not the only one in operation; as we observe one or two species of a genus migrating, while the others are stationary; and this taking place among granivorous as well as insectivorous birds. Equally powerful as the desire to obtain food, seems to be the love of a suitable *temperature*.

If we attend to the motions of the snow bunting, which is a granivorous bird, we find, that on its first arrival in this country it is only to be met with on the high grounds. As the temperature sinks at the approach of winter, it descends to a lower level, while it occupies the higher grounds in more southern districts. Its migrations to the south, therefore, depend entirely on the state of the winter. It has been attempted to preserve these birds during the summer season in this country, but, although liberally supplied with food, they have not survived. The experiment has succeeded, however, in America, with General Davies, who informs us, (*Linn. Trans.* vol. iv. p. 157.) that the snow bird of that country always expires in a few days, (after being caught, although it feeds perfectly well,) if exposed to the heat of a room with a fire or stove; but being nourished with snow, and kept in a cold room or passage, will live to the middle of summer; a temperature much lower than our summer heat proving destructive to these birds. The swallow, on the other hand, seems to delight in the temperature of our summer, and at that heat to be able to perform the higher operations of nature. When attempted to be kept during our winter, besides a regular supply of food, care must be taken to prevent it from being benumbed with cold. It is probably owing to some constitutional difference with respect to cold, that the female chaffinches in Sweden are migratory during winter, while the males are stationary. Eckmark, when speaking of the migrations of this bird, informs us, "*Mares* inter primas sunt aviculas, quæ sonum suum hieme usitatum in cantum vertunt jucundissimum: vere primo, sub initium *mensis regelationis*, arboribus ad pagos insidentes garruli, *fæminis* adhuc *absentibus*, ver indicant adstans. Redeuntibus denique turmis maximis, quæ cœlum fere abscondunt, *fæminis*, omnes conjuges requirunt, quibus conjuncti sylvas petunt, ibi ut nidulos construant et multiplicentur. Initio *mensis defoliationis* mares suos, apud nos remanentes, *fæminæ* deserunt mutabiles, solæ regiones petentes peregrinas." The same cause, namely temperature, renders some birds migratory in one country, while they are stationary in another. No separation of this kind takes place between the sexes of the chaffinch in this country. The linnet, which is a summer bird of passage in Greenland, is always stationary with us.

But, independent of these two causes, we presume, that the desire of obtaining a *safe breeding place* is likewise intimately connected with the movements of many species. "Of the vast variety of water fowl," says Pennant, "that frequent Great Britain, it is amazing to reflect how few are known to breed here: the cause that principally urges them to leave this country, seems to be not merely the want of food, but the desire of a secure retreat. Our country is too populous for birds so shy and timid as the bulk of these are. When great part of our island was a mere waste, a tract of woods and fens, doubtless many species of birds (which at this time migrate) remained in security throughout the year. *Egrets*, a species of heron, now scarce known in this island, were in former times in prodigious plenty; and the *Crane*, that has totally forsaken this country, bred familiarly in our marshes, their place of incubation, as well as of all other *cloven-footed water-fowl* (the heron excepted) being on the ground, and exposed to every one. As rural economy increased in this country, these animals were more and more disturbed; at length, by a series of alarms, they were necessitated to seek, during the summer, some lonely safe habitation. On the contrary, those that build or lay in the most inaccessible rocks that impend over the British seas, breed there still in vast numbers, having little to fear from the approach of mankind; the only disturbance they meet with, in general, being from the desperate attempts of some few to get their eggs." It happens, in consequence of this desire of safety during incubation, that the same species may be stationary at one place, while it is migratory at another. Thus, in the Western Islands, the common plover is stationary, while on the Grampians it is migratory. Herons may be met with along all the British shores during the winter season, while they are found congregated to breed in but few places. The turnstone is migratory in England, but stationary in the northern islands of Scotland. The same remark is applicable to the hooded crow, a few of which pass from us during the winter months into England, but return during the breeding season.

None of these causes, taken singly, may be able to account for the migrations of the feathered race; but, when viewed in connection, they seem to include all those proximate causes which operate in the production of these curious, and to us in some respects useful voyages. These migrations extend our knowledge of birds, by making us acquainted with the productions of the shores of Greenland, the mountains of Norway, and the marshes of Lapland. They also contribute to enliven the scenes of winter, and occasionally add to the delicacies of our table; while, in their movements, we discern the marks of benevolence in preserving their existence, increasing their happiness, and extending their usefulness.

We cannot dismiss this subject of migration without recommending it to the attentive consideration of our readers. To those who pass their time in the sweets of retirement in the country, it will prove a never-failing source of amusement; and to a reflecting mind, will yield no small portion of delight. The field of observation is extensive, the subject curious. "Quis non cum admiratione videat ordinem et polititiam peregrinantium avium, in itinere, turmatim volantium, per longos terrarum et maris tractus absque acu marina.—Quis eas certum iter in aëris mutabili regione docuit? Quis preteritæ signa, et futuræ viæ indicia? Quis eas ducet, nutrit, et vitæ necessaria ministrat? Quis insulas et hospitia illa, in quibus victum reperiat, indicavit, modumque ejusmodi loca in peregrinationibus suis inveniendi? Hæc sane superant hominum captum et industriam, qui non nisi longis experientiis, multis itinerariis, chartis geographicis—et acus magneticæ beneficio—ejusmodi marium et terrarum tractus conficere tentant, et audent."

As we descend in the scale of being, the instances of actual migration diminish in number. The locomotive powers of these animals, are too limited to enable them to undertake extensive journies, and when necessary to be protected from the cold of winter, nature employs, with respect to them, a more simple process, by subjecting them to a temporary lethargy. This is the case with reptiles, which present no instances of migration.

The migrations of fishes have long been the subject of keen discussion among naturalists. An agreement of opinion, however, has not been produced, although many observations have been published on the subject. Many of these observations, we fear, are the result of prejudiced inquiry, and ought therefore to be received with caution.

The movements of fishes are not performed with the same regularity and precision as the migrations of the feathered tribes. Shoals of haddocks, for example, frequent for several years a particular part of the coast, and, without any apparent cause, take their departure, accompanied with all those animals which feed on them. The movements of those fish which approach our shores, for the purpose of depositing their spawn, are more regularly performed. But these migrations can scarcely be considered as instances of hybernation. They have but little relation to the seasons of the year, as the fry of these fish may be found in almost every season in our rivers, and as their movements are known to depend on their condition with respect to fecundation. In our article Ichthyology, a particular account will be given of the migratory movements of the different species of British fishes.

Among the Mollusca, Cirrhipedes, and Annelides, no examples of a migrating hybernation have occurred. In the class Crustacea there is one very curious instance of migration, which the reader will find given in detail under the species *Ocypode uca*.

## CHAP. IV.

### Hybernating Animals which become Torpid.

This is one of the most curious subjects in zoology, and has long occupied the attention of the natural historian and the physiologist. All animals we know require stated intervals of repose to recruit exhausted nature, and prepare for further exertion,—a condition which we term sleep. But there are a few animals, which, besides this daily repose, require annually some months of continued inactivity, to enable them to undergo the common fatigues of life during the remaining part of the year. These animals exhibit, therefore, two kinds of sleep—that which they enjoy daily during the season of their activity, and that which they experience during their brumal retirement. This last kind of sleep is generally termed *torpidity*, and is also known by the term *hybernation*.

As the phenomena which torpid animals exhibit are somewhat different according to the classes to which they belong, it will be more convenient for us to treat of the animals of each class separately, beginning with Quadrupeds.

The quadrupeds which are known to become torpid belong exclusively to the digitated order. Some species are found among the *primates*, as the different kinds of bats; among the *feræ* we find the hedgehog and the tanric; while among the *glires* the torpid species are numerous, and their habits have been studied with the greatest attention, as the marmot, the hamster, and the dormouse.

The *food* of these animals is very different, according to the orders or genera to which they belong. The bats support themselves by catching insects, and those chiefly of the lepidopterous kinds; the hedgehog lives on worms and snails; while others, as the marmot and hamster, feed on roots, seeds, and herbs.

It is usually supposed that torpid animals are confined to the cold regions of the earth. That they abound in such regions, must be admitted; but their range of latitude is not so limited as to prevent their occurrence even in warm countries. Thus the *Dipus sagitta*, which is found from the 53d degree of north latitude to the tropics, is equally torpid during the winter months in Egypt as in Siberia. In the former country it is more easily revived by a very slight increase of temperature, its lethargy not being so profound. The Tanric (*Tanric caudatus*,) which is an inhabitant of India and Madagascar, becomes torpid even in those countries, and continues so during nearly six months of the year.

The precise period of the year in which these animals retire to their winter quarters and become torpid, has not been ascertained with any degree of precision. The jumping mouse of Canada (*Gerbillus Canadensis*) is said to retire to its torpid state in September, and is again restored to activity in the month of May. The torpid animals of this country usually retire in October, and reappear in April. It appears probable, however, that the different species do not all retire at the same time, but, like the migrating birds, perform their movements at separate periods. It is also probable that the time of retirement of each species varies according to the mildness or severity of the season. In general, however, they retire from active life when their food has become difficult to obtain, when the insects have fled to their hiding places, and the cold has frozen in the ground the roots and the seeds on which they subsist At the period of their reviviscence, the insects are again sporting in the air, and the powers of vegetable life are exerted in the various processes of germination and vegetation. In short, during the *dead season* of vegetable life, these animals pass their time in this lethargic state. We see the coincidence, but we cannot well account for the connection.

Previous to their entrance into this state of lethargy, these animals select a proper place, in general assume a particular position, and even in some cases provide a small stock of food.

All these torpid animals retire to a *place of safety*, where, at a distance from their enemises, and protected as much as possible from the vicissitudes of temperature, they may sleep out, undisturbed, the destined period of their slumbers. The bat retires to the roof of gloomy caves, or to the old chimnies of uninhabited castles. The hedge-hog wraps itself up in those leaves of which it composes its nest, and remains at the bottom of the hedge, or under the covert of the furze, which screened it, during summer, from the scorching sun or the passing storm. The marmot and the hamster retire to their subterranean retreats, and when they feel the first approach of the torpid state, shut the passages to their habitations in such a manner, that it is more easy to dig up the earth any where else, than in such parts which they have thus fortified. The jumping mouce of Canada seems to prepare itself for its winter torpidity in a very curious manner, as we are informed by Major-General Davies, in the *Linnean Transactions*, vol. iv. p. 156, on the authority of a labourer. A specimen which was found in digging the foundation for a summer-house in a gentleman's garden about two miles from Quebec, in the latter end of May 1787, was "enclosed in a ball of clay, about the size of a cricket ball, nearly an inch in thickness, perfectly smooth within, and about twenty inches under ground. The man who first discovered it, not knowing what it was, struck the ball with his spade, by which means it was broken to pieces, or the ball also would have been presented to me."

Much stress has been laid upon the *position* which these animals assume, previous to their becoming torpid, on the supposition that it contributes materially to produce the lethargy. In describing this position, Dr Reeves (in his Essay on the Torpidity of Animals) observes, "that this tribe of quadrupeds have the habit of rolling themselves into the form of a ball during ordinary sleep; and they invariably assume the same attitude when in the torpid state, so as to expose the least possible surface to the action of cold: the limbs are all folded into the hollow made by the bending of the body; the clavicles and the sternum are pressed against the fore part of the neck, so as to interrupt the flow of blood which supplies the head, and to compress the trachea: the abdominal viscera and the hinder limbs are pushed against the diaphragm, so as to interrupt its motions, and to impede the flow of blood through the large vessels which penetrate it, and the longitudinal extension of the cavity of the thorax is entirely obstructed. Thus a confined circulation is carried on through the heart, probably adapted to the last weak actions of life, and to its gradual recommencement." Professor Mangili of Pavia, (*Annales du Museum*, tom. ix.) with greater simplicity of language, says, that the marmot rolls itself up like a ball, having the nose applied contrary to the anus, with the teeth and eyes closed. He also informs us, that the hedge-hog, when in a torpid state, in general reposes on the right side. The bat, however, during the period of its slumbers, prefers a very different posture. It suspends itself from the ceiling of the cave to which it retires, by means of its claws, and in this attitude outlives the winter. This is the natural position of the bat when at rest, or in its ordinary sleep. In short, little more can be said of the positions of all these torpid animals, than the correspondence with those which they assume during the periods of their ordinary repose.

It is also observable, that those animals which are of solitary habits during the summer season, as the hedgehog and dormouse, are also solitary during the period of their winter torpidity; while the congregating social animals, as the marmot, the hamster, and the bat, spend the period of their torpidity, as well as the ordinary terms of repose, collected together in families or groups.

Many of those animals, particularly such as belong to the great natural family of *gnawers*, make provision in their retreats, during the harvest months. The marmot, it is true, lays up no stock of food; but the hamsters fill their storehouse with all kinds of grain, on which they are supposed to feed, until the cold becomes sufficiently intense to induce torpidity. The *Cricetus glis*, or migratory hamster of Pallas, also lays up a stock of provision. And it is probable that this animal partakes of its stock of provisions, not only previous to torpidity, but also during the short intervals of reviviscence, which it enjoys during the season of lethargy. The same remark is equally applicable to the dormouse.

Having thus made choice of situations where they are protected from sudden alterations of temperature, and assumed a position similar to that of their ordinary repose, they fall into that state of insensibility to external objects, which we are now to examine more minutely. In this torpid state they suffer a diminution of temperature; their respiration and circulation become languid; their irritability decreases in energy; and they suffer a loss of weight. Let us now attend to each of these changes separately.

1. *Diminished temperature.* When we take in our hand any of these hybernating torpid animals, which we are now considering, they feel cold to the touch, at the same time that they are stiff, so that we are apt to conclude, without farther examination, that they are dead. This reduction of temperature is not the same in all torpid quadrupeds. It varies according to the species. Hunter, in his "Observations on certain parts of the Animal Economy," informs us, on the authority of Jenner, that the temperature of a hedgehog at the diaphragm was 97° of Fahrenheit, in summer, when the thermometer in the shade stood at 78°. Professor Mangili states the ordinary heat of the hedgehog a little lower, at 27° of Reaumur, or about 93° of Fahrenheit. In winter, according to Jenner, the temperature of the air being 44°, and the animal torpid, the heat in the pelvis was 45°, and at the diaphragm 48½°. When the temperature of the atmosphere was at 26°, the heat of the animal in the cavity of the abdomen, where an incision was made, was reduced so low as 30°. The same animal, when exposed to the cold atmosphere of 26° for two days, had its heat at the rectum elevated to 93°, the wound in the abdomen being so much diminished in size as not to admit the thermometer. At this time, however, it was lively and active, and the bed in which it lay felt warm. As this animal allowed its heat to descend to 30°, when in its natural state of torpidity, and when there was no necessity for action, the increased temperature cannot be attributed to the cold, but to the wound, which called forth the powers of the animal to repair an injury, which reparation could not be effected at a temperature below the standard heat of the animal. The sources of error in making experiments where the living principle is concerned are so numerous, that attention

ought to be bestowed on every circumstance likely to influence the result.

The zizel, (*Arctomys citillus*), according to Pallas, usually possesses a summer temperature of 103° Fahr. but during winter, and when torpid, the mercury rises only to 80° or 84°. The temperature of the dormouse (*Myoxus muscardinus*) during summer, and in its active and healthy state, is 101°. When rolled up and torpid during winter, the thermometer indicates 43°, 39°, and even 35°, on the external parts of the body. When introduced into the stomach, the temperature was found to be 67°, and sometimes 73°. Mangili found this animal torpid even when the temperature of the air was 66°. Hence he considers it as the most lethargic of animals.

The marmot (*Arctomys marmota*) possesses a summer temperature of 101° or 102°, which is gradually reduced in the torpid season to 43°, and even lower.

Bats have a temperature in summer nearly equal to that of marmots. They are soon affected by the changes of the atmosphere, and they cease to respire in a medium of 43°. In the month of July, the thermometer standing at 80°, the internal temperature of a bat was 101°, which is just the degree of heat in a group of them collected together in summer, and may therefore be considered as the natural standard. Mr Cornish applied a thermometer to a torpid bat, and found that it indicated 36°. When awakened so much that it could fly a little, he again applied the thermometer, and it then indicated 38°. Spallanzani found a bat, after being exposed an hour to a temperature of 43°, to indicate 47°, the bulb of the thermometer being placed in the chest; exposed to a temperature below the freezing point, the heat of the animal became the same as the surrounding medium, yet it always remains internally higher than the low temperature produced artificially, though the skin indicates the same.

The wood-mouse (*Mus sylvaticus*) became torpid, according to Spallanzani, when the thermometer in its cage stood at 43°. The temperature of the belly externally was 45°, but its internal temperature is not much diminished even by a degree of cold sufficient to render it very torpid.

In these experiments we observe, that the temperature of these hybernating quadrupeds is greatly reduced below the summer standard, or the ordinary temperature of the animal in health and activity. Still, however, they continue to maintain a superiority in point of temperature above the surrounding medium, in whatever circumstances they are placed. Even in this torpid state, the energies of life, though feeble, are still sufficient to the production of a certain quantity of heat.

2. *Diminished Respiration.* In this, as in all the other departments of this curious subject, accurate and varied experiments are still wanting. The following are the principal facts which we have collected on the subject.

The hedgehog, according to Professor Mangili, who has bestowed more attention on this part of the subject than any of his predecessors, respires only from five to seven times in a minute during ordinary repose. When it becomes torpid, the process of respiration is periodically suspended and renewed. Thus a hedgehog, obtained after it had revived naturally from its winter lethargy in April, was placed in a chamber whose temperature was about 54°. It refused vegetable food, and became torpid, and continued in that state to the tenth of May. At first, after every fifteen minutes of absolute repose, it gave from thirty to thirty-five consecutive signs of languid respiration. In the beginning of May, when the thermometer was about 62°, it gave from seven to ten consecutive respirations, after an interval of ten minutes of absolute repose. Upon lowering the temperature, the intervals of repose became greater, while the number of respirations increased to eighteen or twenty.

Marmots, according to the same author, when in health and active, perform about five hundred respirations in an hour, but when in a torpid state, the number is reduced to fourteen, and these at intervals of four minutes, or four minutes and a half, of absolute repose.

Bats, when kept in a chamber from 45° to 50°, were observed at the end of every two, three, or four minutes of absolute repose, to give four signs of respiration. Spallanzani, not aware of these periodical intervals of repose, could not discover any signs of respiration. Indeed, when their temperature is reduced to about 47°, this function does not appear to be exercised.

The dormouse, when in a torpid state on the 27th December, exhibited a languid respiration of one hundred and forty times in forty-two minutes. On the tenth of January, the thermometer being at 43°, it respired at intervals in the following manner, according to Mangili.

| Intervals of repose. | Number of consecutive respirations. |
|---|---|
| 5 minutes | 16 |
| 4 | 30 |
| 3 | 29 |
| 2 | 29 |
| 12 | 5 |
| 9 | 10 |
| 10 | 6 |
| 13 | 18 |
| 12 | 23 |
| 12 | 8 |

In some instances, the intervals of repose or suspended respiration lasted sixteen minutes.

Mangili also found the fat dormouse (*Myoxus glis*) when in a torpid state on the 27th December, and when the thermometer indicated 40°, to respire at intervals. After every four minutes of repose, it respired from twenty-two to twenty-four times every minute and a half. The thermometer being raised one degree of Reaumur, the intervals became only three minutes. The temperature being reduced to 37°, the intervals of repose became four minutes, and the consecutive respirations twenty to twenty-six. The cold increasing, it awoke and ate a little, and then became torpid again. On the 10th of February the intervals of repose were eighteen or twenty minutes, and then thirteen to fifteen respirations. On the 21st February, the thermometer being 48°, the intervals of repose were from twenty-eight to thirty, and the consecutive respirations from five to seven.

From the observations already made on this important subject, it appears, that respiration is not only diminished, but even in some cases totally suspended. During the severe winter of 1795, Spallanzani exposed dormice to a temperature below the freezing point, and enclosed them in vessels filled with carbonic acid and azotic gas, over mercury three hours and a half without being hurt, and the sides of the vessels were not marked by any vapour. Hence we may conclude, that they did not breathe, nor give out any carbonic acid.

Mangili placed a marmot under a bell glass, immersed in lime water, at nine o'clock in the evening. At nine next morning the water had only risen in the glass three lines. Part of the oxygen was abstracted, and a portion of carbonic acid was formed, as a thin pellicle appeared on the surface of the lime-water, which effervesced with nitric acid. Spallanzani placed torpid marmots in vessels filled with carbonic acid and hydrogen, and confined them there for four hours, without doing them the least injury, the temperature of the atmosphere being several degrees below the freezing point. But he found, that if these animals were awakened by any means, or if the temperature was not low enough to produce complete torpor, they very soon perished in the same noxious gases. A bird and rat, introduced into a reservoir containing carbonic acid gas, did not live a minute ; whereas a torpid marmot remained in it an hour, without betraying the least desire to move, and recovered perfectly on being placed in a warmer medium.

In the exhausted receiver of an air pump, a torpid bat lived seven minutes, in which another bat died at the end of three minutes. Torpid bats, when confined in a vessel containing atmospheric air, consumed six hundredths of the oxygen, and produced five hundred parts of carbonic acid. Viewing this in connection with his other experiments, this philosopher concluded, that the consumption of the oxygen, and the evolution of the carbonic acid, proceeded from the skin.

The respiration of torpid quadrupeds is thus greatly diminished, and even in some cases suspended ; and in general, instead of being performed with regularity as in ordinary sleep, the respirations take place at intervals more or less remote, according to the condition of the lethargy.

3. *Diminished Circulation.* From the experiments already detailed with regard to the reduction of the temperature and the respiration of torpid quadrupeds, we are prepared to expect a corresponding diminution of action in the heart and arteries.

In the hamster, (*Cricetus vulgaris,*) the circulation of the blood during its torpid state is so slow, according to Buffon, that the pulsations of the heart do not exceed fifteen in a minute. In its active and healthy state they amount to one hundred and fifty in the same space.

We are informed by Barrington in his Miscellanies, that Mr Cornish applied a thermometer to the body of a torpid bat, and found that it indicated 36°. At this temperature the heart gave sixty pulsations in a minute. When awakneed so much as to be able to fly a little, he again applied the thermometer, which now indicated 38°, and the heart beat one hundred times in a minute. As the torpor becomes profound, the action of the heart is so feeble, that only fourteen beats have been distinctly counted, and those at unequal intervals.

Dormice, when awake and jumping about, breathe so rapidly, that it is almost impossible to count their pulse ; but as soon as they begin to grow torpid, eighty-eight pulsations may be counted in a minute, thirty-one when they are half torpid, and only twenty, nineteen, and even sixteen, when their torpor is not so great as to render the action of the heart imperceptible.

Spallanzani and others are of opinion, that the circulation of the blood is entirely stopped in the remote branches of the arteries and veins, and only proceeds in the trunks of the larger vessels, and near the heart. But it is probable, that however languid the circulation may be, it is still carried on, as the blood continues fluid. He found, that if the blood of marmots be subjected, out of the body, to a temperature even higher than that to which it is exposed in the lungs of these animals, it is instantly frozen ; but it is never congealed in their dormant state.

4. *Diminished Irritability.* The irritability of torpid animals, or their susceptibility of being excited to action, is extremely feeble, and in many cases is nearly suspended. Destined to remain for a stated period in this lethargic state, a continuance of their power of irritability would be accompanied with the most pernicious consequences ; as thereby they would be often raised prematurely into action under a temperature which they could not support, and at a time when a seasonable supply of food could not be obtained. In their torpid state, therefore, they are not readily acted upon by those stimuli, which easily excite them to action during the period of their activity. Parts of their limbs may be cut off without the animal shewing any signs of feeling. Little action is excited, even when their vital parts are laid open. When the hamster is dissected in this torpid state, the intestines discover not the smallest sign of irritability upon the application of alcohol or sulphuric acid. During the operation, the animal sometimes opens its mouth, as if it wanted to respire, but the lethargy is too powerful to admit of its reviviscence.

Marmots are not roused from their torpid state by the electric spark, strong enough to give a smart sensation to the hand, and a shock from a Leyden phial only excited them for a short time. They are insensible to pricking their feet and nose, and remain motionless and apparently dead. Bats are also equally insensible to the application of stimuli.

The most curious experiments on this subject are those of Mangili. Having killed a marmot in a torpid state, he found the stomach empty and collapsed, the intestines likewise empty, but there was a little matter in the cœcum and rectum. The blood flowed quickly from the heart, and in two hours yielded a great quantity of serum. The veins in the brain were very full of blood. The heart continued to beat during three hours after. The head and neck having been separated from the trunk, and placed in spirits of wine, gave signs of motion even after half an hour had elapsed. Some portions of the voluntary muscles gave symptoms of irritability with galvanism four hours after death. In a marmot killed in full health, the heart had ceased to beat at the end of fifty minutes. The flesh lost all signs of irritability in two hours ; the intercostal and abdominal muscles retaining it longer than those of any other part of the body.

5. *Diminished Action of the Digestive Organs.* The digestive faculty in torpid animals is exceedingly feeble, and in general ceases altogether. The situation, and still more the lethargic state of the system, render this process unnecessary. The intestines are in general empty, and in a collapsed state, and the secretions so small, that a supply of nourishment from the stomach is not requisite. Mr Jenner found a hedgehog, when the heat of the stomach was at 30°, to have no desire for food, nor power of digesting it. But when the temperature was increased to 93° by inflammation in the abdomen, the animal seized a toad which was in the room, and, upon being offered some bread and milk, immediately began to eat. The heat excited the action of the various functions of the animal, and the parts unable to carry on these actions, without nourishment, urged the stomach to digest.

While many torpid quadrupeds retire to holes in the earth unprovided with food, and in all probability need no sustenance during their lethargic state, there are others, as we have already mentioned, which provide a small stock of provisions. These, we are inclined to believe, eat a little during those temporary fits of reviviscence to which they are subject. This is in part confirmed by the experiments of Mangili, both on the common dormouse and the *Myoxus glis.* Whenever these awoke from their torpid slumbers, they always ate a little. Indeed he is of opinion, that fasting long produces a reviviscence, and that, upon the cravings of appetite being satisfied, they again become torpid.

6. *Diminished Weight.* All the experiments hitherto made on this subject indicate a loss of weight sustained by

these animals from the time they enter their torpid state until the period of their reviviscence. Mangili obtained two marmots from the Alps on the first of December 1813. The largest weighed twenty-five Milanese ounces, the smallest only $22\frac{3}{24}$th ounces. On the third of January the largest had lost $\frac{18}{24}$ths of an ounce, and the smallest $\frac{17}{24}$ and a half. On the fifth of February the largest was now only $22\frac{21}{24}$th ounces, the smallest twenty-one ounces. He adds, that they lose weight in proportion to the number of times in which they revive during the term of their lethargy.

Dr Monro kept a hedgehog from the month of November (1764) to the month of March (1765), which lost in the interval a considerable portion of its weight. On the 25th of December it weighed thirteen ounces and three drams, on the 6th of February eleven ounces and seven drams, and on the 8th of March eleven ounces and three drams. He observed a small quantity of feculent matter and urine among the hay, although it neither ate nor drank during that period. In this experiment there was a daily loss of thirteen grains. According to Mr Cornish, both bats and dormice lose from five to seven grains in weight during a fortnight's hybernation.

Dr Reeves endeavours to account for the lean state of the marmot when found in the spring, as occasioned by another cause than the slow but uniform exertions of the vital principle. "I have (he says) been repeatedly assured by men who hunt for these animals in winter, that they are always found fat in their holes on the mountains of Switzerland, and it is only when they come out of their hiding places before provisions are ready for them, or if a sharp frost should occur after some warm weather, that they become emaciated and weak. This testimony may be received as explaining the emaciated appearance of some marmots, but does not in the smallest degree invalidate the general conclusion, that all torpid animals sustain a loss of weight during the continuance of their lethargy.

From the experiments which we have already quoted it must appear obvious, that respiration is in general carried on, although sometimes in a very feeble manner. Carbon, consequently, must be evolved. Accordingly we find carbonic acid produced in those vessels in which these torpid animals have been confined; and hence must conclude, that a loss of weight has taken place.

Such being the preparatory and accompanying phenomena of this torpid state, let us now endeavour to discover the cause of these singular appearances.

In a subject of this kind, so intimately connected with the pursuits of the naturalist and the physiologist, it was to be expected that numerous hypotheses would be proposed to explain such interesting phenomena. Unfortunately, indeed, many hypotheses have been proposed, while few, from a connected view of the subject, have ventured to theorise. Perhaps we are not prepared to draw a sufficient number of general conclusions from the scanty facts which we possess, in order to build any theory. But the following observations may be considered as embracing the principal opinions which have been formed on the subject, and announcing the more obvious causes in operation.

In an investigation of this sort, it was natural to attempt to trace this singularity of habit in torpid animals to some peculiar conformation in the structure of the organs. Accordingly we find many anatomists assigning a peculiarity of organization as a reason why these animals become torpid, or at least pointing out a structure in torpid animals different from that which is observable in animals that are not subject to this brumal lethargy.

Pallas observed the thymus gland unusually large in torpid quadrupeds, and also perceived two glandular bodies under the throat and upper part of the thorax, which appear particularly florid and vascular during their torpidity.

Mangili is of opinion that the veins are larger in size, in proportion to the arteries, in those animals which become torpid, than in others. He supposes that, in consequence of this arrangement, there is only as much blood transmitted to the brain during summer as is necessary to excite that organ to action. In winter, when the circulation is slow, the small quantity of blood transmitted to the brain is inadequate to produce the effect. This circumstance, acting along with a reduced temperature and an empty stomach, he considers as the cause of torpidity. By analogy he infers, that the same cause operates in producing torpidity with all the other hybernating animals of the other classes.

Mr Carlisle, in his Croonian Lecture on Muscular Motion, asserts, that "animals of the class mammalia, which hybernate and become torpid in the winter, have at all times a power of subsisting under a confined respiration, which would destroy other animals not having this peculiar habit. In all the hybernating mammalia there is a peculiar structure of the heart and its principal veins: the superior cava divides into two trunks, the left passing over the left auricle of the heart into the inferior part of the right auricle, near to the entrance of the vena cava inferior. The veins usually called azygos accumulate into two trunks, which open into the branch of the vena cava superior, on its own side of the thorax. The intercostal arteries and veins in these animals are unusually large." *Phil. Trans.* 1805.

We cannot refrain from observing, that these general views do not appear to be the result of a patient investigation of a number of different kinds of torpid animals, but a premature attempt to theorise from a few insulated particulars. Passing, therefore, from these attempts of the anatomist to illustrate the phenomena in question, let us attend to those other causes which are concerned in the production of torpidity.

From the consideration, that this state of torpidity commences with the cold of winter, and terminates with the heat of spring, naturalists in general have been disposed to consider a *reduced temperature* as one of the principal causes of this lethargy. Nor are circumstances wanting to give ample support to the conclusion.

When the temperature of the atmosphere is reduced, as we have already seen, below 50°, and towards the freezing point, these animals occupy their torpid position, and by degrees relapse into their winter slumbers. When in this situation, an increase of temperature, the action of the sun, or a fire, rouse them to their former activity. This experiment may be repeated several times, and with the same result, and demonstrates the great share which a diminished temperature has in the production of torpidity. If marmots are frequently disturbed in this manner during their lethargy, they die violently agitated, and a hemorrhage takes place from the mouth and nostrils.

The circumstance of torpid animals being chiefly found in the colder regions is another proof, that a diminished temperature promotes torpidity. And, in confirmation of this, Dr Barton informs us, that, in the United States of America, many species of animals, which become torpid in Pennsylvania, and other more northern parts of the country, do not become torpid in the Carolinas, and other southern parts of the continent.

But while a certain degree of cold is productive of this lethargy, a greater reduction of temperature produces reviviscence as speedily as an increase of heat. Mangili placed a torpid marmot, which had been kept in a temperature of 45°, in a jar surrounded with ice and muriate of lime, so that the thermometer sunk to 16°. In about half an hour a quickened respiration indicated returning animation. In sixteen hours it was completely revived. It was trembling with cold, and made many efforts to escape. He also placed a torpid bat under a bell glass, where the temperature was 29°, and where it had free air. Respiration soon became painful, and it attempted to escape. It then folded its wings, and its head shook with convulsive tremblings. In an hour no other motions were perceptible than those of respiration, which increased in strength and frequency until the fifth hour. From this period, the signs of respiration became less distinct; and, by the sixth hour, the animal was found dead. He also exposed a torpid dormouse (from a temperature of 41°) to a cold of 27°, produced by a freezing mixture. Respiration increased from ten to thirty-two times in a minute, and without any intervals of repose. There were no symptoms of uneasiness, and the respirations seemed like those in natural sleep. As the temperature rose, respiration became slower. He then placed it in the sun, when it awoke. Two hours afterwards, having exposed it to the wind, respiration became frequent and painful; it turned its back to the current, without, however, becoming torpid.

That cold is calculated to produce effects similar to torpidity on man himself, is generally known. When persons in health are immersed in salt water at a temperature of 40°, the thermometer under the tongue sinks from seven to nine degrees below the standard heat. In a little time, however, it recovers its ordinary elevation, and becomes stationary. Exposure to cold has also the effect of diminishing the force of the pulse very much—of producing great exhaustion, and an accumulation of blood in the extreme vessels.

But the effects of a reduced temperature on the human system are still better illustrated in the tendency to sleep, produced by a cold atmosphere in certain situations. Those who have ascended to the summits of high mountains, have, by the exposure to cold, felt an almost irresistible propensity to lie down and sleep. Dr Solander, while exploring Terra del Fuego, though perfectly aware of the inevitable destruction attending the giving way to this inclination; nay, though he had even cautioned his companions against indulging it, could not himself overcome the desire. When this feeling is gratified, sleep succeeds, the body becomes benumbed, and death speedily arrives. How long this sleep might continue without ending in death, were the body defended from the increasing cold and the action of the air, will probably never be determined by satisfactory experiments. Partial torpor has often been experienced in the hands and feet, which is easily removed by a gradual increase of temperature. We may add, that in the case of persons exposed to great cold in elevated situations on mountains or in balloons, there are other causes in operation which may have a tendency to produce sleep. The previous exertions have reduced the body to a very exhausted state—the pressure of the atmosphere on the body is greatly diminished, and the air inhaled by the lungs is rarefied.

When these torpid animals, kept in a confined state, are regularly supplied with food, and kept in a uniform temperature, it has been observed that they do not fall into their wonted lethargy, but continue lively and active during the winter season. This experiment has often been repeated with the marmot and other animals. But when in this state they are peculiarly sensible to cold. Dr Reeves, in some experiments which he performed, says, "When I was in Switzerland I procured two young marmots in September 1805, and kept them with the view of determining the question, whether their torpidity could be prevented by an abundant supply of food and moderate heat. I carried them with me to Vienna, and kept them the whole of the winter 1805-6. The months of October and November were very mild. My marmots ate every day turnips, cabbages, and brown bread, and were very active and lively: they were kept in a box filled with hay in a cellar, and afterwards in a room without a fire, and did not show any symptoms of growing torpid. December the 18th, the weather was cold, and the wind very sharp; Fahrenheit's thermometer stood at 18° and 20°. Two hedgehogs died which were kept in the same room with the marmots; and a hamster died also in a room where a fire was constantly kept, though these animals had plenty of hay and food. The marmots became more torpid than I ever saw them before; yet they continued to come out of their nest, and endeavoured to escape: the food given them in the evening, was always consumed by the next morning. In January the weather was unusually mild and warm; my marmots ate voraciously, and were jumping about in the morning; but at four o'clock in the afternoon I examined them several times, and found them not completely rolled up, half torpid, and quite cold to the touch. They continued in this state of semi-torpor for several weeks longer, never becoming so torpid as to live many days without eating, and never so active as to resist the benumbing effects of the cold weather." Spallanzani performed similar experiments with the same result on the dormouse. He found, that although cold to the touch during the day, and completely torpid, that it awoke at night and ate a little, and fell asleep again in the morning. He shews also that dormice, kept in a situation more resembling their wild state, became torpid in the month of November, and remained till the middle of March without eating the food which was placed near them.

With some animals, at least, a *confined atmosphere* appears to be indispensibly necessary to the production of torpidity. This is very strikingly illustrated in the case of the hamster. This animal does not become torpid though exposed to a cold sufficient to freeze water, unless excluded from the action of the air. Even when shut up in a cage filled with earth and straw, and exposed to cold, he still continues awake; but when the cage is sunk four or five feet under ground, and free access to the external air prevented, in eight or ten days he becomes as torpid as if he had been in his own burrow. If the cage be brought above ground, in two or three hours he recovers, and will resume his torpid state when again sunk under ground. This experiment may be repeated several times, at proper intervals, either in the day time or during the night, the light having no apparent influence. A confined atmosphere, such as the hamster requires, does not appear necessary to the torpidity of the hedgehog, the dormouse, or the bat. But exposure to the open air seems to be equally hostile to the lethargic state, in many animals. Mangili always found that marmots awoke when taken from their nest, and exposed to the free action of the air. A current of air he found always to have the effect of producing reviviscence, both with dormice and bats. From these circumstances, we perceive the utility of the precautions of those animals in retiring to places where the air is still, and where they may enjoy a confined atmosphere.

Torpidity appears also in some cases to depend on the state of the *constitution*. Thus, in the same chambers, one marmot shall continue awake and active, while the others are in a profound lethargy. A hedgehog, during the winter season, becomes torpid upon the application of cold; but, during the summer season, or after the period of reviviscence, it resists the sedative effects of that agent. Mangili took a hedgehog, on the 21st June, and placed it in a temperature of 8° of Reaumur. It first rolled itself up; afterwards lifted its head and tried to escape. Its respiration became frequent and painful. At the end of the first hour, respiration had become feeble; at the end of an hour and a half, it had ceased to respire; and twenty minutes after, it was frozen to the heart. When examined in this condition, the flesh was found white, the veins of the neck were much swollen, and a small quantity of extravasated blood was observed in the brain and the lungs. It appears probable, that, during torpidity, the constitution experiences a change something similar to ordinary sleep, by which its exhausted energies are recruited, and it becomes better able to resist the effects of those ordinary agents with which it has to contend.

There are some circumstances in the history of these torpid animals which seem to indicate, that they possess the power of becoming torpid at pleasure, even in the absence of those disposing circumstances which we have enumerated. Spallanzani has seen bats in a torpid state even during summer, and supposes, that as these animals appear to possess some voluntary power over respiration, this torpidity may be some instinctive propensity to preserve life. Mangili, in spring, when the *Cricetus glis* was awake, and when the temperature of the air was between 66° and 68°, placed it in a vase along with nuts and other food. The animal attempted to escape, and refused to eat. It then became torpid. In this state the number of its respirations diminished. Instead of rolling itself up as usual before becoming torpid, it lay all the while upon its back, and remained in that state until the 17th of July.

By some it has been supposed, that the *fat* accumulated in torpid animals during the winter is another of those causes which produce this lethargy. The circumstance is certainly very common, but no direct experiments have hitherto been performed to warrant the conclusion. Spallanzani has indeed asserted, that among the dormice which he caught for his experiments, some were very fat, while others were lean, and yet they were equally susceptible of torpidity from the action of cold. All this may be the case; but there is certainly reason to believe, that these animals stand in need of some previous store of nourishment to enable them to support that gradual waste which takes place during the period of their slumbers.

Before concluding our account of torpid quadrupeds, it may be proper to add a few observations on their *reviviscence*. When the hamster passes from his torpid state, he exhibits several curious appearances. He first loses the rigidity of his members, and then makes profound respirations, but at long intervals. His legs begin to move; he opens his mouth, and utters rattling and disagreeable sounds. After continuing this operation for some time, he opens his eyes, and endeavours to raise himself on his legs. All these movements are still unsteady, and reeling like those of a man in a state of intoxication; but he repeats his efforts till he acquires the use of his limbs. He remains fixed in that attitude for some time, as if to reconnoitre, and rest himself after his fatigues. His passage from a torpid to an active state is more or less quick, according to the temperature. It is probable that this change is produced imperceptibly when the animal remains in his hole, and that he feels none of those inconveniences which attend a forced and sudden reviviscence.

It is evident, from the situations which some torpid animals occupy, that they must experience, in the course of their lethargy, considerable changes of temperature. It would form a very curious subject of inquiry, to ascertain the superior and inferior limits of this torpid state with respect to temperature. The *Cricetus glis* has been observed dormant from 34° to 48°; the dormouse from 27° to 66°; the marmot from 40° to 51°; and the hedgehog from 26° to 56°.

It is certainly very difficult to account for the torpidity of those animals, which, like the marmot and hamster, congregate and burrow in the earth. Previous to their becoming torpid, a considerable degree of heat must be generated, from their numbers, in their hole; and besides, they are lodged so deep in the earth, as to be beyond the reach of the changes of the temperature of the atmosphere. Their burrow, during the winter season, must preserve a degree of heat approaching to the mean annual temperature of the climate. If this is the case, how is reviviscence produced in the spring? It cannot be owing to any change of temperature, for their situation prevents them from experiencing such vicissitudes. Is it not owing to a change which takes place in their constitution? and, is not awakening from torpidity similar to awakening from sleep?

A similar remark may be made with regard to bats in their winter quarters. The caves to which they resort approach at all times the mean annual temperature. A few individuals, not sufficiently cautious in choosing proper retreats, are sometimes prematurely called into action, at a season when there is no food, so that they fall a prey to owls, and the cold of the evening. But what indications of returning spring have those who are attached to the roofs of the deeper caves? Surely no increase of temperature. Perhaps an internal change is the cause which again excites to action.

There is another very curious circumstance attending the reviviscence of quadrupeds from their torpid state, which deserves to be mentioned. As soon as they have recovered from their slumbers, they prepare for the great business of propagation. This is a proof, that torpidity, instead of exhausting the energies of nature, increases their vigour. It also indicates a peculiarity of constitution, to the preservation and health of which a brumal lethargy is indispensibly requisite.

It appears to be the general practice of modern naturalists, to treat with ridicule those accounts which have been left us of Birds having been found in a torpid state during winter. These accounts, it is true, have in many instances been accompanied with the most absurd stories, and have compelled us to pity the credulity of our ancestors, and withhold our assent to the truth of many of their statements. But are there no authenticated instances of torpidity among birds?

In treating of the torpidity of quadrupeds, we were unable to detect the cause of torpidity, as existing in any circumstances connected with structure or with circulation, respiration, or animal temperature; nor in the places which they frequent, nor the food by which they are supported. Hence we cannot expect much help from a knowledge of the anatomy, physiology, or even habits of birds, in the resolution of the present question. It has indeed been said, that as birds can readily transport themselves from one country to another, and in this manner shun the extremes of temperature, and reach a supply of food, the power of becoming torpid would be useless if bestowed on them, although highly beneficial to quadrupeds, that are impatient of cold, and cannot migrate to places where there is a supply of food. This mode of reasoning, however, is faulty, since we employ our pretended knowledge of final causes, to ascertain the limits of the operations of nature, and cannot be tolerated in a science depending entirely on fact and observations. Besides, there are many animals, as we have seen in the class *Mammalia*, which become torpid, and a similar state obtains among the reptiles. As birds, in the scale of being, hold a middle rank between these two classes, being superior to the reptiles, and inferior to the mammalia, we have some reason to expect instances of torpidity to occur among the feathered tribes.

These remarks have for their object, to prepare the mind for discussing the merits of the question, by the removal of presumptions and prejudices, as we fear preconceived opinions have already exercised too much influence.

In treating of the migrations of the swallow, we endeavoured to point out their winter residence, and even traced them into Africa. We are not however prepared to assert, that in every season all these birds leave this country. If they remain, in what condition are they found?

Many naturalists, such as Klein, Linnæus, and others, have believed in the submersion of swallows during winter in lakes and rivers. They have supposed, that they descend to the bottom, and continue there until the following spring. Many of the proofs produced in support of this opinion may be found by consulting the article BIRDS. On this subject we willingly quote the judicious note in the introduction to Bewick's *Land Birds*. "There are various instances on record, which bear the strongest marks of veracity, of swallows having been taken out of water, and of their having been so far recovered by warmth as to exhibit evident signs of life, so as even to fly about for a short space of time. But, whilst we admit the fact, we are not inclined to allow the conclusion generally drawn from it, viz. that swallows, at the time of their disappearance, frequently immerse themselves in seas, lakes, and rivers, and, at the proper season, emerge and reassume the ordinary functions of life and animation; for it should be observed, that in those instances which have been the best authenticated, it appears, that the swallows so taken up were generally found entangled amongst reeds and rushes, by the sides, or in the shallowest parts of the lakes or rivers where they happened to be discovered, and that having been brought to life so far as to fly about, they all of them died in a few hours after. From the facts thus stated we would infer, that, at the time of the disappearance of swallows, the reedy grounds by the sides of rivers and standing waters are generally dry, and that these birds, especially the later hatchings, which frequent such places for the sake of food, retire to them at the proper season, and lodge themselves among the roots, or in the thickest parts of the rank grass which grows there; that during their state of torpidity they are liable to be covered with water from the rains which follow, and are sometimes washed into the deeper parts of the lake or river, where they have accidentally been taken up; and that probably the transient signs of life which they have discovered on such occasions, have given rise to a variety of vague and improbable accounts of their immersion."—We may add, that whoever denies that swallows have been found in such situations, let his reasonings be what they may, tramples under his feet the laws of evidence, and cherishes a scepticism as unphilosophical as the most unthinking credulity.

But, independent of these instances of submersion, as it is termed, which we regard as purely accidental, there have been many instances of actual torpidity observed. Swallows, if we may credit the testimony of many who have been eye-witnesses of the fact, are often found during the winter season in a torpid state in their old nests, and in the crevices of old buildings. The belief of this kind of torpidity is very common in many parts of Scotland, and can scarcely be supposed to have originated from any other cause than the occurrence of the fact.

But besides the occurrence of the torpidity of the swallow, Bewick relates an instance of the same condition being observed in the cuckoo. "A few years ago a young cuckoo was found in the thickest part of a close whin-bush. When taken up it presently discovered signs of life, but was quite destitute of feathers. Being kept warm, and carefully fed, it grew and recovered its coat of feathers. In the spring following it made its escape, and in flying across the river Tyne it gave its usual call."— *Brit. Birds*, I. Introd. xvii.

There is a still more decided example of torpidity in birds recorded by Mr Neill, in his *Tour through Orkney and Shetland*, as having been observed in the case of the land-rail, or corncrake, as it is called in Scotland. "I made," says he, "frequent inquiry, whether corncrakes had been seen to migrate from Orkney, but could not learn that such a circumstance had been observed. It is the opinion of the inhabitants, indeed, that they are not able to undertake a flight across the sea. Mr Yorston, the farmer at Aikerness, further related a curious fact, rather leading to the conclusion that they do not migrate. In the course of demolishing a *hill-dyke*, (*i. e.* a mud wall,) at Aikerness, about midwinter, a *corncrake* was found in the midst of the wall. It was apparently lifeless; but, being fresh to the feel and smell, Mr Yorston thought of placing it in a warm situation, to see if it would revive. In a short time it began to move, and in a few hours it was able to walk about. It lived for two days in the kitchen, but would not eat any kind of food. It then died, and became putrid.—I do not assert that this solitary instance ought to be regarded in any other light than as an exception to the general rule of migration, till further observation has determined the point."

These are the only instances, with which we are acquainted of actual torpidity having occurred among the feathered tribes. They seem calculated to remove all doubt as to the fact, while they point out to us the numerous resources of nature in extreme cases to preserve existence. Thus when birds from disease or weakness, or youth, are incapable of performing the ordinary migrations of their tribes, they become dormant during the winter months, until the heat of spring restores to them a supply of food and an agreeable temperature.

Hitherto we have been considering the torpidity which warm-blooded animals experience. Several cold blooded animals observe a similar mode of hybernation.

The period of the year at which REPTILES prepare for this state of lethargy varies in the different species. In general, when the temperature of the air sinks below the 50th degree of Fahrenheit, these animals begin their winter slumbers. They adopt similar precautions as the mammalia, in selecting proper places of retreat, to protect them from their enemies, and preserve them from sudden alternations of temperature. Those which inhabit the waters sink into the soft mud, while those which live on the land enter the holes and crevices of rocks, or other places where the heat is but little affected by changes in the temperature of the atmosphere. Thus provided, they obey the impulse, and become torpid.

As the temperature of these animals depends on the surrounding medium, they do not exhibit any peculiarities with respect to it. When the air is under 50°, these animals become torpid, and suffer their temperature to sink as low as the freezing point. When reduced below this, either by natural or artificial means, the vital principle is in danger of being extinguished. In this torpid state, they respire very slowly, as the circulation of the blood can be carried on independent of the action of the lungs. Even in a tortoise kept awake during the winter by a genial temperature, the frequency of respiration was observed to be diminished.

The circulation of the blood is diminished, in proportion to the degree of cold to which these torpid reptiles are exposed. Spallanzani counted from eleven to twelve pulsations in a minute in the heart of a snake at the temperature of 48°, whose pulse in general in warm weather gives about thirty beats in the same period. Dr Reeves made some very interesting experiments on the circulation of the toad and frog. "I observed," he says, "that the number of pulsations in toads and frogs was thirty in a minute, whilst they were left to themselves in the atmosphere of which the temperature was 53°; when placed in a medium cooled to 40°, the number of pulsations was reduced to twelve within the same period of time; and when exposed to a freezing mixture at 26°, the action of the heart ceased altogether."

The powers of digestion are equally feeble during torpidity as those of respiration or circulation. Mr John Hunter conveyed pieces of worms and meat down the throats of lizards when they were going to their winter quarters, and, keeping them afterwards in a cool place, on opening them at different periods, he always found the substances, he had introduced, entire, and without any alteration; sometimes they were in the stomach, at other times they had passed into the intestines, and some of the lizards that were allowed to live, voided them toward the spring entire, and with very little alteration in their structure.

The immediate cause of torpidity in reptiles has been ascertained with more precision, than in the animals belonging to the higher classes with warm blood. This condition with them, does not depend on the state of the heart, the lungs, or the brain; for these different organs have been removed by Spallanzani, and still the animals became torpid, and recovered according to circumstances. Even after the blood had been withdrawn from frogs and salamanders, they exhibited the same symptoms of torpidity as if the body had been entire, and all the organs capable of action.

Cold, with these animals, is evidently the chief cause of their torpidity, acting on a frame extremely sensible to its impressions. During the continuance of a high temperature, these animals remain active and lively; but when the temperature is reduced towards 40°, they become torpid, and in this condition, if placed in a situation when the temperature continues low, will remain torpid for an unknown period of time. Spallanzani kept frogs, salamanders, and snakes, in a torpid state in an ice-house, where they remained three years and a half, and readily revived when again exposed to the influence of a warm atmosphere. These experiments give countenance to those reports in daily circulation of toads being found enclosed in stones. These animals may have entered a deep crevice of the rock, and during their torpidity been covered with sand, which has afterwards concreted around them. Thus removed from the influence of the heat of spring or summer, and in a place where the temperature continued below the point at which they revive, it is impossible to fix limits to the period during which they may remain in this dormant state.

Since reptiles are easily acted upon by a cold atmosphere, we find but few of those animals distributed in the cold countries of the globe; while in those countries whose temperature is always high, these animals are found of vast size, and of many different kinds, and in great numbers.

The torpidity of the *Mollusca* has not been studied with care. Those which are naked and reside on the land, retire to holes in the earth, under the roots of trees, or among moss, and there screen themselves from sudden changes of temperature. The different kinds of land Testacea, such as those belonging to the genera Helix, Bulimus, and Pupa, not only retire to crevices of rocks and other hiding places, but they form an operculum or lid for the mouth of the shell, by which they adhere to the rock, and at the same time close up even all access to the air. If they be brought into a warm temperature, and a little moisture be added, they speedily revive. In the case of the *Helix nemoralis*, the operculum falls off when the animal revives, and a new one is formed when it returns again to its slumbers. The first formed opercula contain a considerable portion of carbonat of lime, which is found in smaller quantity in the later formed ones. If the animal has revived frequently during the winter, the last formed opercula consist entirely of animal matter, and are very thin. The winter lid of the *Helix pomatia* resembles a piece of card.

All the land testacea appear to have the power of becoming torpid at pleasure, and independent of any alterations of temperature. Thus, even in midsummer, if we place in a box specimens of the *Helix hortensis*, *nemoralis* or *arbustorum*, without food, in a day or two they form for themselves a thin operculum, attach themselves to the side of the box, and remain in this dormant state. They may be kept in this state for several years. No ordinary change of temperature produces any effect upon them, but they speedily revive if plunged in water. Even in their natural haunts, they are often found in this state during the summer season, when there is a continued drought. With the first shower, however, they recover, and move about, and at this time the conchologist ought to be on the alert.

The Spiders pass the winter season in a dormant state, enclosed in their own webs, and placed in some concealed corner. Like the torpid mammalia, they speedily revive when exposed to intense cold, and strive to obtain a more sheltered spot.

Many Insects which are destined to survive the winter months, become regularly torpid by a cold exceeding 40°. The common honey bee, in a small hive, when reduced to this temperature, loses all power of motion, but may be easily revived by an increase of temperature. When the hive is large, there is always as much heat generated, as to protect them against this lethargic disposition. The house fly may always be found in the winter season torpid, in some retired corner; but exposure for a few minutes to the influence of a fire recalls it to activity. Even some of the lepidopterous insects, which have been hatched too late in the season to enable them to perform the business of procreation, possess the faculty of becoming torpid during the winter, and thus have their life prolonged beyond the ordinary period. These insects can all be preserved from becoming torpid by being placed in an agreeable temperature, as the following experiments of Mr Gough's (Nicholson's *Journal*, vol. xix.) abundantly testify. In speaking of the Hearth Cricket, (*Gryllus domesticus*,) he says, "Those who have attended to the manners of this familiar insect will know that it passes the hottest part of the summer in sunny situations, concealed in the crevices of walls and heaps of rubbish. It quits its summer abode about the end of August, and fixes its residence by the fireside of the kitchen or cottage; where it multiplies its species, and is as merry at Christmas as other insects are in the dog-days" Thus do the comforts of a warm hearth afford the cricket a safe refuge, not from death, but from temporary torpidity; which it can support for a long time, when deprived by accident of artificial warmth. "I came to the kowledge of this fact," he says, "by planting a colony of these insects in a kitchen, where a constant fire is kept through the summer, but which is discontinued from November to June, with the exception of a day, once in six or eight weeks. The crickets were brought from a distance, and let go in this room in the beginning of September 1806: here they increased considerably in the course of two months, but were not heard or seen after the fire was removed. Their disappearance led me to conclude that the cold had killed them: but in this I was mistaken; for, a brisk fire being kept up for a whole day in the winter, the warmth of it invited my colony from their hiding place, but not before the evening, after which they continued to skip about and chirp the greater part of the following day, when they again disappeared; being compelled by the returning cold to take refuge in their former retreats. They left the chimney corner on the 28th of May 1807, after a fit of very hot weather, and revisited their winter residence on the 31st of August. Here they spent the summer merely, and lie torpid at present (Jan. 1808) in the crevices of the chimney, with the exception of those days on which they are recalled to a temporary existence by the comforts of a fire."

Nothing is known with regard to the hybernation of the Intestina. Those which inhabit the bodies of torpid quadrupeds, in all probability, like them, experience a winter lethargy. If they remain active, they must possess the faculty of resisting great alterations of temperature. Among the *infusory animals*, numerous instances of suspended animation have been observed, continued not for a few months, but during the period of twenty-seven years. But such instances of lethargy do not belong to our present subject. Besides, they have been fully discussed under the article Animalcula, in this work.

There is another kind of hybernation, in some respects resembling torpidity, which deserves to be taken notice of in this place, and which merits the appellation of Quiescence. The animals which observe this condition, remain during the winter months in an inactive state, requiring but little food, without however experiencing the change to torpidity.

Of these quiescent animals, the common bear (*Ursus arctos*) is the most remarkable example. Loaded with fat, he retires in the month of November to his den, which he has rendered comfortable by a lining of soft moss, and seldom reappears until the month of March following. During this period he sleeps much, and when awake almost constantly licks with his tongue the soles of his feet, particularly those of the fore paws, which are without hair, and full of small glands. From this source it is supposed that he draws his nourishment during the period of his retirement.

This quiescence appears to differ in its kind from torpidity. This animal is always in season before he retires to his winter quarters, and the female brings forth her young, before the active period of the spring returns, and before she comes forth from her hiding place.

The common badger is supposed to pass the winter in the same manner as the bear, with which, in structure and habit, he is so nearly related. It is also probable, that many species of the genus Arvicola become quiescent, particularly the *amphibia*, or common water rat, which always leaves its ordinary haunts during the winter.

It is in this state of hybernation that many of our river fishes subsist at the season of the year when a supply of food cannot be obtained. A similar condition prevails among the fresh water mollusca, and also among many species of Annelides. But we must observe, that accurate observations on this branch of the subject are still wanting.

In concluding the subject of torpidity, it may be proper to mention a few of those questions to which it has given rise, without, however, going into detail. It has been asked, Is torpidity a condition natural to those animals, or is it a habit produced by external circumstances? Mr Gough, indeed, considers "the torpidity of these animals in a wild state, to be nothing but a custom, imposed by necessity, on a constitution which nature has intended to retain life during the cold season of winter, with but little food, and an imperfect degree of respiration, as well as a languid, or perhaps a partial action of the sanguiferous system." Since these animals, when in a natural or perfectly wild state, invariably become torpid, we must regard such a condition, not as the effect of "custom imposed by necessity," but as the effect of a law of their constitution, enabling them to accommodate themselves to circumstances natural to their condition.

Some have supposed that these torpid animals were at first natives of warmer regions, and have acquired the habit of torpidity, in consequence of having removed to colder countries. Before attempting to account for the occurrence of torpidity in such circumstances, a proof of the assertion regarding the origin of these torpid animals ought to be given. Besides, we know but little of the effects exerted by climate on this tendency to become torpid; neither do we know whether our torpid animals would remain all the year active and lively if removed to a warmer country, nor whether the animals of warmer countries would become torpid if brought to us. The fact, that torpid animals are chiefly found in cold countries, is a proof of the great influence exerted by climate on the habits of animals; but it is also probable, that this influence will be chiefly felt, where the constitution has been previously arranged, to accommodate itself to the vicissitudes of cold regions.

In all these different kinds of hybernation, we meet with difficulties in investigating the laws of animal life. We cannot account for the phenomena which present themselves, or ascertain the relation of these to external objects. But it is both easy and delightful to trace the benevolent intentions of nature in providing for the wants of her creatures, in accommodating their feelings and propensities to the circumstances in which they are placed, in removing them from situations of danger, and in continuing to them life, and health, and enjoyment. (J. F.)

HYDATIDES. See Medicine.

HYDERABAD, is a province of the Deccan, in India. It is situated between the 16th and 19th degrees of north latitude, and bounded on the north by the Godavery, on the south by the river Krishna, on the east by the province of Gundwana, and on the west by Beeder and Aurungabad. It formed a considerable portion of the ancient kingdom of Telingana, which, in its independent state as a distinct Hindoo sovereignty, comprehended the principal part of the tract between the rivers Godavery and Krishna, and of which the capital city was Warangol. It was reduced at an early period of the Mahommedan invasion, and afterwards formed part of the great Bhamenee Empire of the Deccan. On the dissolution of this state, Telingana became again the seat of an independent government, under the name of Golconda, the first sovereign of which, Kooli Kuttub Shah, established the Kuttub Shahy dynasty in 1512. One of his successors, Abdullah Kuttub Shah, who ascended the throne in 1586, became tributary to the Mogul Emperor, Shah Jehan; and in this state the kingdom remained till 1687, when the reigning sovereign, Abou Houssein, was deprived of his capital, Golconda, by the Emperor Aurungzebe, and imprisoned for life in the fortress of Dowlatabad.

It was not till after a protracted siege, and only, at length, through the treachery of one of the king's sirdars, that the Mogul Emperor obtained possession of the place; and it is related, that when some of the assailants had fought their way into the apartment, where Abou Houssien was seated at supper, he requested them, with much composure, to sit down and partake with him, and that they quietly accepted the invitation. On the destruction of the Mogul empire, after the death of Aurungzebe, Nizam ul Moolk obtained possession of the Mahommedan conquests in the Deccan, about the year 1717. Under his successors, the limits of the state experienced much fluctuation; but its power was gradually declining, and would have been totally annihilated by the Mahrattas, had not the British government interposed for its support. In 1800, a treaty of perpetual alliance was concluded with Nizam Ali by Major Kirkpatrick on the part of the British; and by this arrangement a British force of 8000 regular infantry, and 1000 regular cavalry, with their proper complement of artillery and warlike stores, is stationed in the Nizam's territories, for their protection against hostile neighbours or turbulent subjects. For the regular payment of these troops, the Nizam ceded to the East India Company all the territories which he had acquired by the treaty of Seringapatam in 1792, and by that of Mysore in 1799. In the event of a war taking place, the Nizam engaged to join the British with 6000 infantry, and 9000 cavalry of his own army, with the necessary train of artillery and stores. By this treaty it was also arranged, that all the external political relations of the parties should be exclusively managed by the British, who undertook to protect his highness's dominions from every annoyance, and particularly to procure a total exemption from all claims of Choute on the part of the Mahrattas. In 1802, a commercial treaty was negociated, by which the free use of the port of Masulipatam was granted to the Nizam, with a promise of protection to his flag on the high seas; and an equality of duties on the mutual imports and exports was stipulated, the amount of which should not exceed 5 per cent. In 1804, a considerable part of the territories of Dowlet Row Sindia was transferred to the Nizam; by which the Hyderabad sovereignty acquired a great increase of territory, and obtained for the first time a well-defined boundary. At present, the Nizam's dominions, besides the whole of Hyderabad, comprehend Nandere and Beeder, the greater part of Berar, and a portion of Arungabad and Begapoor, being divided from the Nagpoor territories by the Wurda river, and from the British by the Krishna and Toombuddra. Hyderabad, which gives the general name to the sovereignty, is about 180 miles in length, and 150 at its average breadth. The surface of the province is hilly, but not mountainous; and it is an elevated table land, much colder in its temperature than the degree of latitude would indicate. In the city of Hyderabad, and the country to the north of it, the thermometer, during three months of the year, is frequently so low as 45°, 40°, and 35° of Fahrenheit. The soil is fertile, and tolerably well watered, but indifferently cultivated, and thinly inhabited. The cultivators are wretchedly poor, and much oppressed by their Mahommedan superiors, who are subject to little restraint from their nominal sovereign. From the same cause, they are almost destitute of the benefits of commerce; and the average import of European goods into the whole of the Nizam's dominions, prior to 1809, never exceeded 25,000*l.* per annum. The principal towns in the province are Hyderabad, Golconda, Warangol, Meduck, and Niecundah; and the whole population of the district is estimated not to exceed two millions and a half.

The reigning prince, Mirza Secunda Jah, ascended the throne in 1803, and has never been more than a few miles from the city of Hyderabad since the commencement of his reign. His government is absolutely despotic in theory; but, in point of fact, his power is much limited by circumstances. He takes little direct interest in the minutiæ of the executive, which is managed almost entirely by one or other of his ministers, according as their factions prevail, or as they may be able to carry along with them the support of the Company's resident. The influence of the East India Company's government is paramount in the councils of that of their ally, and all great political points are carried with considerable facility; yet, on some late trifling occasions, a lively jealousy has been manifested. While the officer, who had been appointed to conduct the grand trigonometrical survey, was approaching Hyderabad, he had fixed small flags on some points for directing his observations. This gave rise to repeated complaints; as if, in taking a few triangles, he had been taking possession of the country. The political intercourse is carried on by means of a resident, who has a superb mansion on the north-east side of the capital across the river. His suite consists of first and second assistants, a surgeon, and the officers of an escort of two companies of Bengal native infantry. The present Nizam was entertained at the residency on the occasion of paying him his army's share of the Seringapatam prize money, which had been laid out in splendid specimens of English and Chinese manufactures. His Highness was a little alarmed on this occasion, by the accidental firing of a few thousand rockets which happened to lie pointing towards the spectators, but by which fortunately no person near himself was wounded. The entertainment was concluded by laying before him a superbly mounted sabre, which had been sent by Louis XVI. to Tippoo Sultan.

It is difficult to say what is, and what is not, to be reckoned revenue under so irregular a government. Although a very large proportion of the whole produce of the soil be claimed as its share; yet so much of this is stopped for the expences of collection and payment of sebundee, or local troops, and so much is diverted into bye channels, that the sum which finally reaches the treasury is in many cases very small. The produce of the estates granted for military service should be reckoned as part of the revenue, were it not that the service is seldom performed. When lands are not granted to Jaghiredars for specific purposes, the common mode of collection is by Tahood, a farm, in which case any person may make an offer for a lease of a district; and that person is generally preferred who proposes the largest advance of ready money to the minister. Little inquiry is made into the methods which he may use to reimburse himself; and he may do nearly as he pleases, provided he keeps a good understanding at court. Sometimes, however, complaints are listened to, if there exist a hope of squeezing a further sum from the fears of the contractor; or if there be a wish to get rid of him, to make way for some other who may have offered a sum of ready money, or a larger portion of his expected profits. The other mode is by Amaunee, and is seldom resorted to, unless when a district is in such a rebellious state that no person can be found to farm it. Some military chief is then turned into it to collect what he can, and to account to government for the amount. This, however, is a last resource, as all Indians, whether Mussulmans or Hindoos, are adepts at making up accounts so as to suit their own interests.

The army of the Nizam, in consequence of the protection afforded by the British troops against the invasions of the Mahrattas, is now on a very inefficient footing. A list of its great officers and their troops, would be merely an enumeration of persons holding estates and emoluments under a nominal agreement to perform services, which they are scarcely expected to fulfil. This is quite true, as far as regards the great military jaheridars and risaldars, or cavalry officers, who hold valuable districts in their immediate possession; but there are many corps of mutinous and ill-paid infantry, who have hard service in the collection of the revenue, which the oppressive nature of the government, and the consequent bad faith and turbulence of the zemindars, render extremely difficult. These troops are distributed to the different collectorships, as occasion may require. With the exception of a few corps patronised by the Company's resident, none of them are either regularly paid, or decently equipped; and many battalions have not one-tenth of their arms in a serviceable state.

By a supplementary article in the treaty between the Nizam and the Company's government, it was agreed, that all the forts in the Hyderabad dominions should, in time of a joint war, be open to the British. Of these fortresses, the most important are that of Dowlatabad,* and of Golconda. The former, particularly, the most singular perhaps in the world, is situated on a high conical hill, which has it sides pared away perpendicularly in such a manner, that it would now be represented by a whipping-top set upon its head. There is a fortified tower on the plain, through which a passage lies to a tunnel in the bowels of the mountain, affording an ascent to the conical surface above, and opening to the day near the edge of the precipitous side. This upper opening is covered by an iron grating, on which a fire is kept burning when any danger is apprehended. Even after overcoming this obstacle, an enemy would still be required to advance in a path exposed to the whole fire of the fort on the summit. In this fort are lodgments cut in the solid rock for the garrison and their provisions. The fort of Golconda, about five miles west from Hyderabad, though very strong in some places, is, by a strange arrangement, most assailable on the side, which at the same time commands all the others. In a piece of broken ground, on the north-west side of the fort, are situated, in an irregular manner, the tombs of the Kootub Shahy kings, which are of such solid masonry, that they would afford bomb-proof lodgment for several battalions, though some of them are within battering-distance of the walls. In the lifetime of the late Nizam ul Moolk, the garrison used to make a great show of watchfulness and jealousy of any armed party approaching their walls; and, on one occasion, actually fired on some ladies and gentlemen, who were amusing themselves in looking at the tombs. Some years ago, a detachment of the Company's troops with a convoy of provisions having halted near them, the Killidar, or commandant, sent out a message to the officer in charge, desiring him to remove his encampment to a greater distance, and threatening that the guns on the works would be used to enforce compliance. The officer replied verbally, that he would not decamp until the next morning; and, pointing to a line of spirit carts, added, that if a single shot were fired at him from the fort, he was ready to return the compliment. The regularity of his line of carriages, and their compact form, made them be mistaken for so many mortars and battering guns, and immediately produced a more conciliatory tone, with quiet possession of the ground.

A great part of the province is occupied by Jaghiredars, some of whom are military officers in the service of the Nizam, as already mentioned; and the rest are Hindoo Rajahs or Zemindars, whose ancestors have long possessed their estates, and over whom the Nizam exercises a very uncertain and undefined authority. As Hyderabad is one of the few remaining Mogul governments, a greater proportion of Mahommedans are to be found among the higher and middle classes of the inhabitants; but the great mass of the lower classes are still Hindoos in the proportion of above ten to one. In the colder season of the year, the lower classes use a coarse woollen blanket made in the country, while the higher ranks wear shawls and quilted silks. A few of the noblemen and military chiefs clothe themselves in broad cloth, as a piece of fashionable luxury; and the regular infantry, as well as the troops of the principal Jaghiredars, are dressed in British red cloth.

HYDERABAD, the capital of the above province, and of the Nizam's dominions, is situated in 17° 15′ N. Lat. and 78° 42′ E. Long. on the Moossee Nuddee, below its junction with the Moossah, which flows pass the walls of Golconda. It was founded about the year 1585 by Mahommed Kooli Kootub Shah, and in consequence of its vicinity to the river, soon acquired the ascendancy over the neighbouring city of Baugnuggin, of which nothing now remains, except a few traces of the strongest buildings. It was taken and pillaged by the army of Aurengzebe in 1687, its principal inhabitants having retired to the neighbouring fortress of Golconda. The late Nizam Ali, father of the reigning prince, made it the seat of the royal residence in place of Aurungabad, which had hitherto been the capital, but which, by the fluctuation of his terriries, had become less centrical, and too adjacent to the Mahratta frontier. The new capital has been exempt from plunder and every hostile molestation, ever since it became the residence of the court, (a circumstance rarely paralleled in India for so long a period) and has rapidly increased in wealth and population. It is surrounded by a stone wall, which would afford no defence against artillery, but which serves as a protection from the incursions of cavalry. It is about four miles in length within the walls, and three in breadth. There are large magazines in the city belonging to the Nizam, in which are deposited the presents received at various times from the different native and European powers. The rooms are filled, almost from the floor to the ceiling, with bales of woollens, cases of glass, glass-ware, china-ware, clocks, watches, and other articles of European manufactures, which always continue locked up in the magazines. The houses and gardens of the Company's civil and military officers, and of a few other European gentlemen resident in the place, form the principal ornament of the environs. Hyderabad, having long been the principal Mahommedan station in the Deccan, contains a considerable number of mosques, and exhibits more of the old forms and ceremonies of the Mogul government than any other metropolis in Hindostan. The noblemen of the place have been bred either as soldiers or courtiers; and, as hoarded treasures would expose them to the avaricious machinations of their superiors, they generally spend their fortunes freely, in keeping up large retinues, or in the fashionable profligacy of their court. When any property is laid up, it is commonly in the form of ornaments for their females and children, which are always more remarkable for their weight than workmanship. A few of the wealthier Mahommedans, especially the Nizam's ministers, are fond of furnishing their houses richly with articles of European and Chinese manufacture, such as porcelain, crystal, lustres, chintz sofa covers, and some articles of plate. A favourite piece of luxury among them is to have an Aeena Khana, a room of which the roof and sides are entirely covered with mirror plates.

His Highness's ministers frequently entertain the resident and his suite at their palaces. The amusements at these parties are troops of dancing girls (kunchinees,)

* Doulut-abad, " wealth's abode."

wrestlers (puhlwauns,) mimics (bhans,) and musicians of various kinds, who afford some diversion to a newly-arrived European, but soon become tiresome, and often disgusting. A dinner, partly in the English style, and a magnificent display of fireworks, commonly close the day's entertainments. Some of the Mahommedan chiefs sit at table, and partake of the same fare with the Europeans, from which pork, in every shape, it may be supposed, is carefully excluded. The inhabitants of the city, both Mahommedans and Hindoos, though very polished in their manners, are both ignorant and profligate. Crimes are here committed every day with impunity, and even without notice, which would strike with wonder and horror the inhabitants of any country in Europe. A father, who had murdered his wife for not quietly acquiescing in his preference of his daughter, observed, that "no one had a better right to the fruit than the planter of the tree." The government derives a current revenue from licences to carry on the most horrid practices. Amongst such a people, and with such a government, truth and morality, as it may be supposed, are very rare qualities. The present number of inhabitants, including those of the suburbs, is estimated at 120,000, The distance of the city from Calcutta is 900 miles; from Madras, 391; from Bombay, 480; from Seringapatam, 406; from Delhi, 923. See Orme's *History of Military Transactions in India*; *Asiatic Annual Registers*; Sir John Malcolm's *Political History of India*; Ferishta's *History of the Deccan, translated by* J. Scott, Esq.; Rennel's *Memoir of a Map of Hindostan*; and Hamilton's *East India Gazetteer*.* (q)

HYDRAULICS. See HYDRODYNAMICS.

HYDROCELE. See SURGERY.

HYDROCEPHALUS. See MEDICINE.

# HYDRODYNAMICS.

HYDRODYNAMICS, from the Greek Ὑδωρ, *water*, and Δυναμις, *power* or *force*, is that branch of natural philosophy which embraces the phenomena exhibited by water and other fluids, whether they are at rest or in motion. It treats of the pressure, the equilibrium, the cohesion, the motion, and the resistance of fluids; and of the construction of the machines by which water is raised, and in which it is the first mover, or the primary agent. This science is generally divided into *Hydrostatics* and *Hydraulics*, the former of which considers the pressure, equilibrium, and cohesion of fluids; and the latter, their motion, the resistance which they oppose to moving bodies, and the various machines in which they are the principal agent.

## HISTORY.

ALTHOUGH Hydrodynamics is but a modern science, and was studied by the ancients only in its most general principles, yet many of the leading doctrines and phenomena upon which it is founded are familiar to the rudest nations, and must have been well known in the very earliest ages of society. Even at that remote period when man first trusted himself to the waves, the pressure of fluids, and the phenomena of floating bodies, were undoubtedly known to him; and in the more advanced stage of navigation, when the Phenicians were able to colonise the most distant regions of the globe, the directing power of the helm, the force and management of the oars, the action of the wind upon the sail, and the resistance opposed to the motion of the vessel, were well known facts, which implied practical acquaintance with some of the most important doctrines of Hydrodynamics.

The motion of fluids, as affected by the size of the aperture from which they issued, and by the height of the superincumbent column, formed the fundamental principle of the *Clepsydræ* (from κλεπτω, *to steal*, and ὑδωρ, *water*) or water clocks, which were employed in the earliest ages, before the invention of sun dials, to measure time. The simplest, and probably the earliest form in which the Clepsydræ appeared, is that of two inverted cones, as represented in Plate CCCXIII. Fig. 1. This species of Clepsydra consisted of a hollow cone A, perforated at its vertex, and of a solid cone B, which was made to fill A with the greatest exactness. The aperture of A was so adjusted to the size of the cone, that, when filled with water, it emptied itself in the course of the shortest day in winter. The length of the cone was divided into 12 equal parts, which indicated the hours by the descent of the fluid, or the same result was obtained by divisions upon the vessel into which the water flowed. When the days lengthened, and the hours became longer, the solid cone B was introduced into the hollow cone A, and, according to the depth of its penetration, the water flowed from the aperture with less facility. A graduated index BC enabled the observer to accommodate the position of the solid cone to the varying length of the day.

Another Clepsydra, of a more ingenious construction, is represented in Plate CCCXIII. Fig. 2. The water is first received into the reservoir A, which is always kept full, and descends by the pipe B into a hole in the great drum MN. This hole corresponds to one of the openings in the groove round the circumference of the small drum LO, which is drawn out in the figure for the purpose of showing it, but when the machine is in use, it is fitted into the drum MN. The apertures of the groove in LO are of different sizes, so as to admit different quantities of water, according to the length of the day, and the proper aperture for the given day is found by placing the index L opposite the sun's place in the zodiac shewn at N, the index O being used for the night hours. The water which descends through the openings in the drum LO is conveyed by the pipe F, and falls through the aperture at G into the reservoir H. As the water rises in the reservoir, the inverted vessel I, suspended by a chain which passes over the axis R, and balanced by a counterweight P, ascends, and consequently the hour hand X, fixed upon the extremity of the axis, is made to revolve, and indicate the hours upon the dial plate.

Notwithstanding the ingenuity of these inventions, and the hydrodynamical knowledge which they indicated, the doctrine of fluids may still be considered as deriving its origin from the discoveries of Archimedes. The history of these discoveries has been rendered ridiculous by vul-

* In drawing up the two preceding articles, we have been indebted for much important information to John Robison, Esq. F. R. S. E. who spent many years in the Nizam's service. ED.

gar fables, which have long been discredited; but it appears unquestionable, that they originated in the detection of a fraud committed by the jeweller of Hiero, king of Syracuse. Archimedes was applied to by the king to ascertain, without injuring its workmanship, whether or not a new crown, which had been made for him, consisted of pure gold: The method of solving the problem is said to have occurred to him when in the bath, and he applied it successfully in detecting the fraud. The hydrostatical doctrines to which Archimedes was thus conducted, were illustrated in a work consisting of two books, and entitled *περι οχȣμενων, de insidentibus in Fluido*. He maintained, that every particle of a fluid mass in equilibrio is pressed equally in every direction. He examined the conditions, in consequence of which a floating body assumes and preserves its position of equilibrium, and he applied it to bodies that have a triangular, a conical, and a paraboloidal form. He shewed that every body plunged in a fluid loses as much of its own weight as the weight of the quantity of water which it displaces; and upon this beautiful principle is founded the process which he employed for ascertaining the impurity of Hiero's crown. When the result was communicated to the king, he exclaimed, *Nihil non dicenti Archimede, credam!* The screw of Archimedes, which is still used in modern times for raising water, is said to have been invented by him when in Egypt, for the purpose of enabling the inhabitants to free themselves of the stagnant water which was left in the low grounds after the inundations of the Nile; and Atheneus informs us, that navigators held the memory of Archimedes in the highest honour, for having furnished them with the means of carrying off the water in the holds of their vessels.

Hydraulic machinery appears to have been first invented in the Alexandrian school, which flourished under the patronage of the Ptolemies. Hippocrates, who was the first person that constructed tables of the sun's motion, enabled astronomers to carry the construction of Clepsydræ to a high degree of perfection; and it was probably in his time that the Anaphorical Clepsydræ were invented. Scipio Nasica, the cousin of Scipio Africanus, is said to have invented Clepsydræ about 200 years before Christ; but it is probable that he only introduced them into Rome, for the Egyptians had used them for many purposes at a much earlier period. This invention was carried to a still higher degree of perfection by Ctesibius, who flourished during the reign of Ptolemy Physcus, near the beginning of the second century before the Christian era. When he was one day amusing himself in the shop of his father, who was a barber in Alexandria, he observed, that, during the descent of a mirror, which was counterbalanced by a weight contained in a cylindrical frame, a musical sound was emitted from the narrow space between the roller and its frame. Hence he was led to conceive the idea of a hydraulic organ, which should operate by means of air and water. Having succeeded in this attempt, he applied the same principles to the construction of Clepsydræ, and invented the very ingenious machine represented in Plate CCCXIII. Figs. 3 and 4, which is probably the first machine to which toothed wheels were applied. Fig. 3. represents the outside of the machine, which consists of a cylinder standing upon a pedestal, and of two figures of children, one of which allows the water to fall drop by drop from his eyes, while the other rises and indicates the hour with a wand upon the vertical line AB. The cylinder AB turns round its axis once in a year, and the inequality of the hours in different days is marked by the unequal distances of the horizontal curve lines on the surface of the cylinder. In Fig. 4, which shews the internal construction of the machine, the water rises through the tube A into the figure of the infant on the right hand, and is discharged from its eyes into the square reservoir M, from which it passes, by a hole near M, into the pipe BCD. In this pipe a piece of wood floats upon the surface, and by its ascent, as the pipe fills, it raises the small pillar CD, on which the left hand figure is made to rest, so that the wand points to different hours as the float rises in the pipe. At the end of 24 hours the vessel BCD is filled, and also the arm FB of the inverted syphon FBE, which communicates with it. The water is therefore drawn off by the syphon, and falling in its descent into the buckets of the wheel K, it puts it in motion. This wheel has six buckets, and therefore performs a revolution in six days. Its axis carries a pinion N of six teeth, which works into the wheel I with 60 teeth; and this wheel, carrying a pinion of ten teeth, drives the wheel GO with 61 teeth, which, by its axis OL, turns the pillar L once round in 366 days.

The subject of Hydrodynamics was successfully cultivated by Hero, the friend and disciple of Ctesibius. Besides his treatise on mechanics, in three books, in which he treated at length of the different mechanical powers, and reduced them all to the lever, he wrote a work entitled *Spiritalia* or *Pneumatica*,* which contains an account of the Forcing Pump, and of the Fountain of Compression, commonly called *Hero's Fountain*, in which water was raised above its level by the elasticity of the air, which had been condensed by the water. The idea of the forcing pump was probably suggested by the Noria, or Egyptian wheel, which consisted of a number of earthen pots carried round upon the circumference of a wheel.

Although it has been believed, on the authority of an epigram in the Greek anthology, that water mills were invented in the reign of Augustus, yet there is reason to think that they belonged to a much earlier period; for Vitruvius, who flourished under Augustus, and who has given a description of these mills, does not speak of them as a recent invention. The Clepsydra of Ctesibius indeed, which we have already described, contains all the machinery of an overshot water mill. The wheel K is put in motion by the water, which is delivered into its buckets; and the force of the wheel is employed, through the intervention of wheels and pinions, to give a rotatory motion to the vertical pillar.

The first experiments on the motion of fluids seem to have been made by Sextus Julius Frontinus, who was inspector of the public fountains at Rome under the emperors Nerva and Trajan. His work consists of two short books, and is entitled, *Sexti Julii Frontini viri Consularis de Aqueductibus Urbis Romæ Commentarius*. It contains a full account of the different waters which flowed into Rome, of the nature and form of the aqueducts by which they were conveyed, of the times when they were erected, of the quarters of the city which they supplied, the number of public and private fountains from which they were distributed, and the laws which were ordained by the emperors for the management of the public fountains. After fixing the measures which were then used at Rome for ascertaining the quantity of water which flowed from different adjutages, he shews, that the water which flows in a given time from a given orifice does not depend merely upon the magnitude or superficies of the orifice itself, but

* See Heronis *Spiritalia* cura Fred. Commandini 1575, 4to. and 1647 cura N. Alleoti.

also upon the height of the fluid in the containing vessel; and that a pipe employed to carry off a portion of the water of an aqueduct should, according to circumstances, have a position more or less oblique to the direction of the current. Although Frontinus was unacquainted with the true law of the velocity of running waters, as depending upon the height of the reservoir, yet we may consider the foundation of the science of Hydrodynamics as having been laid by his experiments. As the civil engineer will naturally study with a deep interest the first account which has been given of one of the most important branches of his profession, we would recommend, as an accompaniment to the work of Frontinus, the three learned dissertations of Raphael Fabrettus, *De Aquis et Aqueductibus veteris Romæ*, which were published in 1679, and are illustrated by copious maps and engravings.*

Although the science of Hydrodynamics is so intimately connected with the wants and comforts of man, even in a state of considerable barbarity; yet, during the dark ages, it seems to have been treated with the same indifference as the more abstract sciences; and when physics revived under the auspices of Galileo, in the 17th century, the doctrine of fluids was in the same state in which it had been left by Julius Frontinus.

The attention of Galileo was in no respects particularly directed to the doctrine of fluids; but his discovery of the uniform acceleration of gravity paved the way for the rapid progress of this branch of science. In the *Systema Cosmicum* of this great astronomer, we find some occasional observations on the oscillation of fluids, which are marked with his usual sagacity; and in the first dialogue of his Mechanics, Sagredo enters into a very very interesting inquiry respecting the ascent of water in pumps. Galileo had studied the operation of a sucking pump, which had been erected to raise water out of a cistern. He describes the pump as having its piston raised high above the surface of the fluid, and he remarks, that in this case the water ascends by the attraction of the piston, whereas in pumps, where the piston is in the lower part of the tube, the water rises by the impulse of the piston. He was surprised, however, to find, that, when the water descended to a certain point, the pump ceased to act, and continued to lose its power, by any further subsidence of the fluid. Being quite satisfied that the pump was broken, he immediately sent for the pump-maker, who, after examining the machine, assured him, "that the water would not suffer itself to rise to a greater height than 18 cubits, whatever were the dimensions of the pump." After reflecting upon this singular fact, Galileo satisfies himself with the following explanation. When a rod of any solid substance whatever is suspended by one end, it may be made of such a length as to break by its own weight; and, in like manner, if a rod or column of water is raised in a pump to the height of 18 cubits, its weight overpowers the attraction of the piston, and the mutual cohesion of the fluid particles.†

This extraordinary explanation of the ascent of water in pumps attracted, no doubt, the attention of his pupil Evangelista Toricelli, by whom the fact was afterwards completely explained; and having learned from his master that the air possessed weight like all other bodies,‡ he entered upon the study of this branch of Hydrodynamics with very singular advantages. In the year 1643, the year after the death of his master Toricelli, being desirous of making an experiment on a small scale in the vacuum left between the piston of a pump and the column of water which it raised, it occurred to him, that, if he substituted in place of the water a denser fluid, such as mercury, the same cause which supported the water would support a column of mercury of the same height. He communicated this idea to his friend Viviani, who performed the experiment with success, and Toricelli afterwards repeated it with considerable modifications. He accordingly provided a glass tube about three feet long, and hermetically sealed at one end, and having filled it with mercury, he closed it at the open end with his finger, and inverted it in a basin of mercury. Upon withdrawing his finger, the column of mercury descended, and settled at the height of about twenty-nine inches in the tube. Toricelli was not immediately aware of the cause of this singular result; but a little reflection convinced him that it was owing to the pressure of the external air, and that the weight of the atmospherical column was balanced by the 29 inches of mercury in the tube, and by the 33 feet of water in the bore of the sucking pump. When this explanation was fully impressed upon his mind, Toricelli is said to have regretted, with a feeling of generosity of which there is no other example, that it had not fallen to the lot of his master to complete a discovery, of which he had the merit of laying the foundation.

The labours of Toricelli were not confined to Hydrostatics. Having observed, that when a *jet d' eau* was formed by the ascent of water through a small adjutage, it rose nearly to the same height as the reservoir from which it came, he sagaciously conjectured, that it ought to move with the velocity which it would have acquired by falling through the same height. Hence he deduced the fundamental proposition, that, abstracting all resistances, the velocities of fluids in motion are in the subduplicate ratio of the pressures. This result was published in 1643, at the end of his treatise *De Motu Gravium naturaliter accelerato*, and though true only in small orifices, it was confirmed by

* The works of Julius Frontinus and Raphael Fabrettus will be found in Grævii *Thesaurus Antiquitatum Romanorum*, tom. iv. p. 1630—1780. A new edition of Frontinus was published by the Marquis Poleni, with copious notes.

† As a very different account of this interesting anecdote is given in all the Histories of Hydrostatics and Pneumatics, we have subjoined the account of it given by Galileo himself, in his *Discursus et Demonstrationes Mathematicæ*. Dial. vol. i. p. 15.

"Sagr. Et ego hujus discursus ope causam invenio cujusdam effectus, qui diutissime mentem meam admiratione plenam, intellectu vero, vacuam reliquit. Observavi Cisternam, in qua ad extrahendam aquam constructa erat Antlia cujus ope minori cum labore eandem aut majorem aquæ quantitatem, quam urnis communibus, forsan (sed frustra) attolli posse credebam: Habetque hæc Antlia suum Epistomium et lingulam in alto positam, ita ut per attractionem non vero per impulsum adscendat aqua, sicut istæ Antliæ faciunt, quæ a parte inferiori suum opus exercent. Hæc autem magna copia aquam attrahit, donec ea in cisterna ad determinatam quandam constiterit altitudinem; ultra quam si subsederit inutilis est Antlia. Ego, cum prima vice accidens istud observarem, instrumentum fractum esse credens, Fabrum accersivi, ut illud repararet; qui nulli rei istum defectum adscribendum esse mihi respondebat, præterquam ipsi aquæ, quæ nimis depressa ad tantam altitudinem attolli se non patiebatur; subjungens nec Antlia, nec quavis allia machina, quæa quam per attractionem elevat, eam nequidem. pili latitudine altius attolli quam octodecim cubitos; et sive largior sive angustior sit Antlia, hanc maxime definitam ejus esse altitudinem. Et ego, licet jam pernoscam, chordam, massam ligneam et virgam ferream eousque prolongari posse, ut in altum erecta proprio diffringatur pondere, ejus imprudentiæ hucusque reum me feci, ut idem in chorda aut virga aquæ multo facilius evenire posse non meminerim: et quid illud quod per Antliam attrahitur, est aliud, quam Cylindrus aqueus qui superne affixus cum magis magisque prolongetur, ad eum tandem attingit terminum ultra quem elevata, a pondere suo excessivo ad instar chordæ disrumpitur."

‡ This important doctrine is demonstrated by Galileo from two experiments, which he describes in his *Discursus et Demonst. Mathemat.* Dial. vol. i. p. 71, 72.

the experiments of Raphael Magiotti, and paved the way for the discovery of the more complex law, which regulates the motion of fluids, when the area of the orifice has a considerable magnitude compared with the horizontal section of the vessel.

The subject of running water had been previously studied by Benedict Castelli, the disciple of Galileo, and the first master of Toricelli. Pope Urban VIII. had requested him to devote his attention to this interesting subject, when he was employed in teaching mathematics at Rome; and in order to discharge the duty which was thus imposed upon him, he made numerous experiments, of which he published a full account in a small treatise, *Della Mesura dell' acque correnti*, which appeared in 1628. In this work he explains several phenomena relative to the motion of fluids in rivers and canals of any shape, and he shews, that when the water has come to a state of permanent motion, the velocities at different sections of the river or canal are inversely as their areas. He applies these general propositions to the course of some rivers, and he explains several phenomena in a manner tolerably satisfactory. The conclusions which he draws are generally correct; but he has committed a mistake in making the absolute velocity proportional to the declivity of the canal, or to the height of the water.*

As soon as the curious results obtained by Toricelli were known in France, the celebrated Pascal, who was then residing at Rouen in Normandy, repeated them with great care, and under various modifications, in the year 1646; and in 1647 he published his *Experiences Nouvelles touchant le vuide*, from which he concluded, that the upper part of the tubes of glass which he used did not contain air similar to that of the atmosphere, nor any portion of water or mercury, and that it is entirely void of every material substance with which we are acquainted. He inferred also, that all bodies have a repugnance to separate into parts, and that this repugnance, which does not vary with the magnitude of the vacuity, is equivalent to the weight of a column of water 33 feet high. This little work was vehemently attacked by Father Noel; and Pascal was led, by the views and experiments of which we have given a detailed account in our article on the BAROMETER, to demonstrate the important principle in Hydrodynamics, that the rise of water in pumps was owing to the pressure of the atmosphere.

The researches of Pascal on the gravity of the air naturally led him to the examination of the laws which regulate the equilibrium and pressure of fluids. Stevinus had already observed, that the force exerted upon the bottom of a vessel by the superincumbent fluid was equal to the weight of a column of fluid, whose base was equal to that of the vessel, and whose height was the height of the fluid, and the quaquaversus pressure of fluids had been generally known; but it was reserved for Pascal to deduce from these principles the general laws of the equilibrium of fluid bodies. He supposes, that two apertures are made in a vessel full of fluid, and enclosed on all sides, and that two pistons applied to these apertures, are pushed with forces proportional to the areas of the apertures; and he demonstrates, in two different ways, that, under these circumstances, the fluid will remain in equilibrium. In the first demonstration he shews, that the pressure of the piston is communicated to every particle of the fluid, so that if the one piston advances through a certain space, the other must retreat; and, as the volume of water continues invariable, the spaces described by the two pistons will be reciprocally proportional to the area of their bases, or to the forces which impel them. Hence it follows, from the principles of mechanics, that the two pistons are in equilibrium. This general theorem conducts its ingenious author to the different cases of the equilibrium and pressure of fluids, which flow from it as so many corollaries. These fine results were not published during the life of Pascal, but were found after his death in a MS. entitled *Sur l'Equilibre de Liqueurs*, which appeared in 1663, a year after the death of the author.

Although Descartes is not entitled to be considered as the discoverer of the pressure of the atmosphere, yet it is obvious from one of his letters, which is dated in 1631, that he considered the suspension of the mercury in a glass tube as arising from the pressure of the superincumbent column of air; and by the same cause he accounts for the force with which a glass filled with air rarefied by heat adheres to the palm of the hand when it is quickly inverted upon it. In another of Descartes' letters, of a date only a little posterior to the publication of Galileo's Mechanics, he criticises this work with unjust severity, and, rejecting the idea of a vacuum as entertained by Galileo, he ascribes the adhesion of two polished surfaces to the pressure of the atmosphere, and attributes to the same cause the elevation of water in the sucking pump; and in another letter he maintains, that, in reservoirs kept full of water by the superior aperture being shut, the fluid is not suspended by the dread of a vacuum, but by the weight of the air.†

M. Mariotte, who was the first person that introduced experimental philosophy into France, contributed greatly to the progress of practical Hydrodynamics. Possessing the rare talent of contriving and performing experiments, he embraced the opportunity which circumstances presented to him, of executing a great number of experiments on fluids at the splendid water-works of Versailles and Chantilly. An account of the results which he obtained was published in 1684, after his death, in his *Traité du mouvement des Eaux*. In this work Mariotte employs the theorem of Toricelli; and though he treated some important points very superficially, and committed considerable errors in the discussion of others, yet it contains many valuable materials. He was unacquainted with the diminution of efflux, which arises from the *vena contracta*, when the adjutage is a perforation in a thin plate; but he had the honour of being the first who ascribed the discrepancies between the theory and experiment to the effect of friction. Having observed that water suffered considerable retardation even when moving in the smoothest glass tubes, he supposed the retardation to arise from the friction of the particles upon the sides of the tube, in the same way as the velocity of solid bodies is diminished by the friction of the surfaces over which they move. The particles or filaments immediately adjacent to those which rub upon the sides of the tube, outstrip them in velocity, and have their own velocity diminished in a less degree; so that the diminution of velocity arising from friction grows less towards the axis of the tube. Hence the medium velocity of the fluid from which the quantity of efflux is determined, is much smaller than it would have been had there been no friction to retard its motion.

The motion of rivers, or of water in open pipes and canals, is perhaps one of the most interesting subjects in which science can lend her aid, to relieve the wants and necessities of man. In Italy, where the fertility of the

* Several letters from Galileo to Castelli on the motion of fluids, but relating principally to Castelli's opinions, have been published in the *Nuova Raccolta*, tom. iv.

† See *Recueil des Lettres* de M. Descartes, tom. iii. sect. 3. p. 602; tom. ii. lett. 91. *L'eau ne demeure pas dans les vaisseaux par la crainte du vuide, mais a cause de la pesanteur de l'air*, tom. ii. lett. 94.

soil is not more owing to her genial climate than to the numerous canals and rivers with which it is traversed, the attention of her philosophers was imperiously called to the study of moving water. To protect themselves from the inundations with which they were often threatened, it became necessary to divert their rivers into new channels; and the ravages which were thus accidentally made on the territories of their neighbours gave rise to those fierce contentions which never fail to spring from contending interests. The defence of their persons and properties, and the necessity of adjusting the opposing interests of neighbouring states, rendered the cultivation of Hydrodynamics a matter of indispensable necessity among the different states of Italy, and hence a great number of valuable works were produced by the Italian engineers.

The most eminent of these engineers was Dominic Guglielmini, who was inspector of the rivers and canals in the Milanese, and who obtained such eminence in his profession, that a new chair on *Hydrometry* was erected for him in the university of Bologna. In his principal work, entitled *La Misura dell' acque Correnti*, he adopts the theorem of Toricelli, and founds upon it a system of Hydraulics sufficiently beautiful in theory, but utterly repugnant to experiment. He regards every point in a mass of fluid as an orifice in the side of a vessel, and as tending to move with the same velocity with which it would issue from the orifice. Hence it follows, that, since the velocities are as the square roots of the depths of the orifices, the velocity must be greatest at the bottom of a stream, and least at its surface; and that the velocity of a river must continually increase as it moves. These results were so hostile to established facts, that Guglielmini himself attempted to reconcile them. He had applied his theory to cases which occurred in the Milanese, and to the motion of the Danube, and he had seen, that the regular progress of the current was often opposed by transverse motions, and by a sort of boiling or tumbling motion which arises from ascending masses of fluid. Hence he supposed that these causes were sufficient to account for the errors of the parabolic theory. Guglielmini had now become acquainted with the labours of Mariotte, and in his work entitled *Della natura dell' Fiumi*, the first part of which appeared in 1697,* and acquired great celebrity to its author, he takes into account the retardation produced by friction and other causes. This work consists of 14 chapters, the three first of which contain definitions and general notions respecting the equilibrium of fluids, and the origin of springs and fountains. In the 4th chapter he treats of the motion of water falling vertically, or descending along an inclined plane; and he examines the various causes, such as friction, the resistance of the air, &c. which extinguish a part of its velocity, and render the theory inconsistent with experiment. The 5th chapter treats of the beds of rivers, their depth, their width, and their declivity. The 6th chapter is an application of the principles laid down in the 5th to the directions which are taken by the beds of rivers. In the 7th chapter he examines the various motions which are observed under different circumstances in the waters of rivers, and he thus follows the current from its source to its embouchure. In chapter 8. he treats of the embouchure of rivers, either when they fall into one another, or into the sea. In chapter 9. he considers the union of several rivers, and the effects which result from it. Chapter 10. treats of the increase or diminution of rivers. Chapter 11. relates to the formation of temporary currents in times of rain. Chapter 12. treats of regular canals, and the methods of deriving them from rivers or reservoirs of water. Chapter 13. treats of the drainage of wet land; and chapter 14. of the precautions which are necessary in changing the bed of a river.

In order to demonstrate the inconsistency of the Cartesian system of vortices with the laws of Hydraulics, Sir Isaac Newton directed his particular attention to the investigation of the manner in which the fluid vortices could be produced and preserved, and he has given the results of his inquiries in the 9th section of the second book of the *Principia*, entitled *De Motu Circulari Fluidorum*. In these elegant propositions, which are the 51st, 52d, and 53d, he lays down the hypothesis, that the resistance which arises from the want of perfect lubricity in fluids is *cæteris paribus* proportional to the velocity with which the parts of the fluid are separated from each other; and he demonstrates, that if a solid cylinder of infinite length revolves, with an uniform motion, round a fixed axis in an uniform and infinite fluid, the periodical times of the parts of the fluid, thus put into an uniform motion, will be proportional to their distances from the axis of the cylinder; whereas, if a solid sphere is made to revolve in a similar manner, the periodical times of the fluid particles will be proportional to the squares of their distances from the centre of the sphere. Hence it follows, from the equality of action and reaction, that the velocity of any stratum of the circulating fluid is a mean between the velocities of the strata by which it is bounded. In considering, therefore, the velocity of water in a pipe, as affected by viscidity and friction, it is obvious that the filaments immediately adjoining to the pipe will be greatly retarded. The contiguous filaments will be kept back by their adhesion to the others, and the velocity will thus increase towards the centre of the pipe, according to a law which is easily deducible from the principle, that the velocity of any filament is a mean between the velocities of the filaments which surround it. M. Pitot was the first person who took advantage of this important principle, and, in the Memoirs of the Academy for 1728, he shewed, that the total diminution of velocity in pipes of different kinds is inversely as the diameters of the pipes.

In the second book of the *Principia*, (See Prop. 36.) Newton has investigated the motion of fluids when issuing from an orifice made in the bottom of a vessel, without limiting himself to the hypothesis of an infinitely small orifice. Supposing the water to be always kept at the same height in the vessel, he considers the cylindrical mass of fluid as divided into two parts, one of which is in the centre of the vessel, and moveable; while the other, which is immoveable, is formed by the part of the fluid in contact with the sides of the vessel. The central portion, which Newton calls the *Cataract*, is supposed to have the form of a hyperboloid, formed by the revolution of a hyperbola of the 4th degree round the axis of the cylinder. The horizontal strata of the cataract are always in a state of gradual descent; while all the rest of the fluid is absolutely at rest, as if it had been converted into ice. From this manner of considering the subject, it followed, that the water ought to issue with a velocity equal to that which it would acquire by falling through the height of the fluid; but when Newton came to investigate the subject experimentally, he concluded, that the velocity of efflux was only that which was due to half the height of the fluid. This result, however, was in direct opposition to the known fact, that jets of water rise to nearly the same height as their reservoirs, and the error arose from his not having

* The second part of this work did not appear till after his death in 1712. The whole was published with notes by Manfredi, in the *Nuova raccolta di autori che trattano del moto dell' acque*, tom. ii.

attended to the contraction of the fluid vein, (or *vena contracta*) which he afterwards found to take place in such a manner, that, at the distance of nearly a diameter of the orifice from the orifice itself, the section of the vein of issuing fluid is reduced or contracted in the ratio of 1 to the square root of 2, or of 1 to 1.4142. He accordingly corrected this error in the edition of the *Principia* which appeared in 1714; and considering the area of the section of the *vena contracta* as the true area of the orifice from which the water should be conceived to flow, he made the velocity equal to that of the height of the fluid, and obtained results more agreeable to experience. Notwithstanding this additional accuracy to which Newton had brought his theory, it was still liable to the very serious objections which have been urged against it by succeeding authors. Giannini has written a dissertation against it in his *Opuscula*, and John Bernoulli, in the 4th volume of his works, has demonstrated, that, if such a *cataract* existed, the part of the fluid without the cataract would be stagnant, and consequently would exert a pressure, in virtue of its gravity, against the cataract itself in which the fluid ought to experience no pressure. But, independent of this species of argument, it may be shewn, as Bossut has done, by direct experiment, that when a vessel of water empties itself by an orifice in the bottom, every fluid particle descends vertically, whether it is situated near the axis or the side of the vessel; and that this vertical motion is not changed into a lateral one till the particles are very near the orifice itself.

The subject of the resistance of fluids, one of the most important and difficult in Hydrodynamics, was likewise investigated by Sir Isaac Newton. He first considers the fluid as a rare medium, composed of equal parts, situated at equal distances from each other, and possessing the property of perfect intermobility, so that one particle may strike the solid, without being prevented by any of the adjacent ones. Hence he finds, that if a globe and a cylinder, of equal diameters, move in such a medium with equal velocities, the resistance of the globe will only be one half of that of the cylinder. He next proceeds to determine the absolute resistance which the globe will experience, whether the parts of the fluid are perfectly elastic, or absolutely inelastic. In the case of perfect elasticity he shews, that the resistance of the globe is to the force by which its total motion may be produced or destroyed in the time that it takes to describe two-thirds of its diameter by a uniform velocity, as the density of the medium is to the density of the globe. In the case of absolute inelasticity, he shews that the resistance is twice as small. After examining the resistance in different mediums, as water, mercury, oil, &c. he advances another theory, suited to those mediums in which the globe does not immediately strike all the resisting parts of the fluid, but only communicates to the neighbouring particles a pressure which is transmitted to all the rest. From this theory it follows, that the resistance of a globe is equal to that of the circumscribed cylinder. This hypothetical theory, though it exhibits much of Newton's characteristic ingenuity, it still founded on false principles, and is radically inconsistent with the results of experiment.

With the exception of a few observations by Galileo in his *Systema Cosmicum*, we are indebted to Sir Isaac Newton for all that was known in his time respecting the oscillation of waves. In order to investigate this difficult subject, he considers the fluid as at rest in the two vertical branches of a syphon connected by a horizontal branch. If the one column is raised to a greater height than the other, and is then permitted to descend, it will obviously fall below its original level, and raise the other column to a greater height than that at which it formerly stood. This column will in like manner descend, and the opposite column will rise, till, after a certain number of oscillations, the fluid will return to a state of rest. In order to determine the time in which these oscillations are performed, Newton considered the water as in the same state with a pendulum vibrating in a cycloid, and he shews by a very simple demonstration, that a pendulum, whose length is equal to half the length of the column of water in the syphon, will perform its oscillations in the same time with the fluid. Hence it follows, that all the oscillations of the fluid will be isochronous, whatever be the intensity of the motions of the fluid; and that the velocity of waves will vary as the square roots of their breadth.

The motion of fluids was treated, both experimentally and theoretically, by Michelotti, a celebrated Italian physician, in his work, entitled *De Separatione Fluidorum in Corpore Animalia*, published in 1719 or 1720. He rejects Newton's idea of a cataract, and considers the water in a vessel as all frozen, excepting a small part of it immediately above the orifice. This thin plate of water is pressed by the superincumbent solid, which is supposed to melt gradually as the water is discharged. In this work Michelotti criticises, with rather too much severity, a paper "On the Motion of Running Water," published by Dr Jurin in the *Philosophical Transactions* for 1718. Jurin replied to this criticism in the *Phil. Trans.* for 1722, and successfully defended Sir Isaac Newton against the charge of inconsistency, which was rashly brought against his doctrine of effluent water by the Italian philosopher.

A series of valuable experiments on the motion of water in conduit pipes, were made on a very large scale by M. Couplet, on the water-pipes at Versailles. These experiments, though not sufficiently varied, shew the great effect which is produced by friction on the motion of water. A full account of them is published in the Memoirs of the Academy for 1732, in the paper entitled *Des Recherches sur le mouvement des Eaux dans les tuyaux de conduite.* The theory which he has founded upon his experiments, and also that which M. Belidor has substituted in its place, are not deserving of notice.

Italy produced about this time several authors on Hydrodynamics, that have acquired considerable celebrity. The most distinguished of these was Guido Grandi, who wrote a geometrical treatise on the motion of water, deduced from the theorems of Galileo and Toricelli. He invented also a method of measuring the velocity of a river at different depths by a tin parallelopiped, which had an aperture that could be opened and shut by a moveable plate. The box was sunk to the required depth, and the orifice opened. After a certain time had elapsed, the orifice was again shut, and the velocity was determined from the quantity of water in the box. Grandi was also the author of several dissertations on the river Æra, and on other small Italian rivers. All these works are published in the *Nuova Raccolta*, already referred to. Eustachio Manfredy, another Italian author, contributed to the progress of Hydrodynamics. He added valuable notes to Guglielmini's work on rivers. He published a dissertation in conjunction with Zendrini, on the means of preventing the inundations of the Ronco and the Montone in the town of Ravenna; and he was the first person who proved, by decisive experiments made on several of the ancient buildings of Ravenna in 1731, that the bottom of the Adriatic Sea was continually rising. The names of Zendrini and Frisi deserve to be mentioned among the Italian writers on Hydrodynamics. Bernard Zendrini, a Venetian mathematician, wrote a very ample work, both theoretical and practical, entitled *De Motu Aquarum*, which contains many excellent practical observations. Frisi composed a work on the method of regulating rivers and torrents, in which he has endeavoured to prove that gravel and sand are original productions, and not the detritus of pre-existing materials. A selection of practical observations from the work of Zendrini will be found in the 5th volume of the *Nuova Raccolta*, and the whole of Frisi's work in the 7th volume of the same collection.

One of the most celebrated writers on Hydraulics that Italy produced, was the Marquis Poleni, professor of mathematics at Padua. In the year 1695 he published a treatise in 4to. entitled *De Motu Aquæ mixto*, which, though it contains nothing that possesses much novelty, yet the reader will find in it many observations both of local and general utility. He supposes, that the bed of a river is a rectangular canal, and regarding any perpendicular section of it as an orifice, he gives the name of *dead water* to that which is comprehended between the surface, and a point in relation to which all the fluid molecules would have equal *momenta*, and would therefore be in equilibrium, according to the laws which are observed in the equilibrium of solid bodies: The rest of the water which is comprehended between this centre of equilibrium and the bottom of the canal or orifice, he calls the *living water*. He then considers the motion of the water that flows through the orifice as partly produced by the action which the *living water* derives naturally from its fall, and partly by the pressure which the *dead water* exerts upon the *living water*. Hence arises the title of Poleni's work, *De motu mixto Aquæ*. After detailing a number of experiments, and comparing the results with the theory, he applies the same principles to the motion of rivers, and to the lakes of Venice. His principal work, however, appeared at Padua in 1718, under the title of *De Castellis per quæ derivantur fluviorum aquæ*. This work contains many important observations and experiments. From an extensive series of experiments on the quantity of water discharged by an orifice in the bottom of a vessel, he concluded, that, instead of being proportional to 2 A H, A being the area of the orifice, and H the height of the reservoir in the vessel, it was proportional to $2\text{AH}\times\frac{0.571}{1.000}$, which is only a little more than one half of what is discharged, upon the supposition that the water issues with a velocity due to the altitude H. Poleni was the first person who observed, that a greater quantity of water issued from a small cylindrical tube, fitted into the orifice in the bottom or sides of a vessel, than from a simple orifice of the same diameter. This remarkable fact may be explained by supposing that the fluid vein, instead of suffering a contraction, flows out in a column of the same diameter as the orifice, from the viscidity of the water, and its capillary adhesion to the sides of the tube. We are indebted also to Poleni for a new edition of the works of Julius Frontinus, which he enriched with ample notes. Poleni is likewise the author of a dissertation on dikes, and of another on the measure of running waters, both of which, along with his first work, are republished in the 3d volume of the *Nuova Raccolta*.

Hitherto the science of Hydrodynamics was founded upon vague and uncertain principles; but it was now destined to receive a more scientific form from the labours of Daniel Bernoulli. So early as the year 1726, he communicated to the academy of St Petersburgh a memoir, entitled *Theoria Nova de Motu Aquarum per Canales quoscunque fluentes*. In this memoir he informs us, that his father having shewn, that the principle of the *vires vivæ* was of great use in the resolution of problems incapable of being solved by more direct methods, it had occurred to him to employ this principle in discovering a true theory of the motion of running waters, and that he had found it to answer his utmost expectations. After the publication of this memoir, which contains merely the germ of his theory, he made a great number of experiments at St Petersburgh, in order to illustrate his theoretical views, and was thus enabled to produce his great work, entitled *Hydrodynamica seu de viribus et motibus fluidorum Commentarii*, which was published at Strasburg in 1738. In considering the efflux of water from an orifice in the bottom of a vessel, he conceives the fluid to be divided into an infinite number of horizontal strata, which are supposed to move in such a manner, that the upper surface of the fluid always preserves its horizontality; that the fluid forms a continuous mass; that the velocities vary by insensible gradations, like those of heavy bodies; and that every point of the same stratum descends vertically with the same velocity, which is inversely proportional to the area of the base of the stratum. By the aid of these assumptions, which are conformable to experience, Bernoulli obtains an equation from the principle that there is always an equality between the actual descent of the fluid in the vessel, and its vertical ascension, which is the principle of the conservation of living forces. In those cases, where sudden irregularities in the shape of the vessel, or other causes, produce rapid changes in the velocity of the fluid strata, he then considers that there is a loss of living force, and therefore the equations founded on the entire conservation of this force require to be modified. In the whole of this investigation, Bernoulli displays the greatest sagacity and originality of thought, though he has taken it for granted, without sufficient evidence, that the law of the conservation of living forces is really applicable to the motion of fluids (a point which it was reserved for D'Alembert to demonstrate); yet his work will be long regarded as one of the finest specimens of mathematical genius.

The important subject of the resistance of fluids was likewise indebted to the genius of Daniel Bernoulli. In the *Commentaria Petropolitana* for 1727, he modestly proposed a new method of determining the resistance of fluids, founded upon principles different from those of Sir Isaac Newton; but having found that it gave results quite hostile to experiment, he afterwards called his determination in question in his treatise on Hydrodynamics, and in the year 1741, in the eighth volume of the commentaries of St Petersburgh, he proposed a very ingenious and elegant method of determining the impulse of a column of fluid falling perpendicularly upon a plain surface infinitely extended. He considers the curve described by every filament of fluid as a canal in which a body moves, which experiences at each point the action of a centrifugal force, and which he supposes also to be subjected to the action of a tangential force, varying according to a given law. He then calculates all these forces, and finds that the impulsion against the horizontal plane is equal to the weight of a column of fluid whose base is equal to the section of the fluid vein, and whose altitude is twice the height of the fall due to the velocity of the fluid. Although there are cases, in which this proposition may be safely and advantageously used in practice, yet it does not easily apply either to oblique impulses, or to impulses against curved surfaces, and it is of no service whatever in determining the resistance of fluids, when the resisting body is completely submerged. In order to put this theory to the test of experience, Daniel Bournoulli, and his pupil, Professor Krafft, instituted a series of experiments on the impulse of a stream of water against a plain surface placed horizontally. These experiments, which are highly valuable, are published in the 8th and 11th volumes of the Commentaries of St Petersburgh. The stream of water was received on a plain surface fixed on the arm of a balance, which had a scale suspended at the opposite extremity. The weights in the scale were made to balance the resistance produced by the impulse on the surface, and the velocity of the issuing fluid was determined from the distance to which it was projected on a horizontal plane. These results were wonderfully conformable to the deductions of theory. The experimental was always a little less than the theoretical resistance, as appears from the following results.

| | | | | | | |
|---|---|---|---|---|---|---|
| Resistance by theory | 1701 | 1720 | 1651 | 1602 | 1520 | 1072 |
| Resistance by experiment | 1403 | 1463 | 1486 | 1401 | 1403 | 1021 |

John Bernoulli, the father of Daniel, was occupied with the subject of Hydrodynamics at the same time with his son; and there is reason to believe, that so early as the year 1726, he was in possession of the chief part of his theory of running water. The work which he composed upon this subject remained in MS. till his death, when it appeared in 1742 in the fourth volume of his works, under the title of *Hydraulica nunc primum detecta et directe demonstrata ex principiis pure mecanicis.* It was also published in the Memoirs of the Academy of St Petersburgh for 1737 and 1738. The method of John Bernoulli is founded upon an assumption not very unlike to the Newtonian cataract; and the principal results of his theory did not differ very widely from those of his son. In the opinion of the celebrated La Grange, it is defective in perspicuity; but Euler, who had seen the MS. congratulates Bernoulli, in a letter prefixed to the work, for having discovered the true principles of Hydrodynamics. In his discourse on the laws of the communication of motion, John Bernoulli has determined, on the same supposition, the resistance of fluids; but the formula, by which he represents the resistance, though sufficiently simple, is still insufficient.

About the same time, our Countryman, Colin Maclaurin, objected to the theory of Daniel Bernoulli, in so far as he employed the doctrine of the conservation of living forces, and endeavoured to solve the problem of the motion of fluids that are discharged from reservoirs by a more direct method. This method, which is only an extension of the theory of Newton, was published in his Treatise on Fluxions, which appeared in 1742. It is given under two sections, one of which treats of the motion of water issuing from a cylindric vessel, and the second of the motion of water issuing from any vessel; but the method has not been considered as sufficiently rigorous.

The science of hydraulics was now destined to receive the most important accessions from the genius of the celebrated D'Alembert. When he was employed in generalising the theory of pendulums given by James Bernoulli, he discovered his famous dynamical principle for determining the motion of a system of solid bodies which act upon each other. He considers the velocity with which each body tends to move as composed of two other velocities, one of which is destroyed, while the other does not obstruct the motion of the adjacent bodies. In applying this principle to hydraulics, he first enquires what ought to be the motion of the particles of a fluid, in order that they may not obstruct one another's movements. He shews, both from theory and experiment, that when a fluid issues from a vessel, its upper surface always preserves its horizontality, from which he concludes that the velocity of all the points of any horizontal stratum, when estimated in a verticial direction, is the same, and that this velocity, which is that of the stratum, ought to be in the inverse ratio of the area of the base of the stratum itself, in order that it may not obstruct the motions of the other strata. By combining this principle with the general one, D'Alembert has reduced all the problems relative to the motion of fluids to the ordinary laws of hydrostatics. The problems which relate to the pressure of fluids against the sides of vessels in which they run, and to the motion of a fluid which escapes from a vessel moveable and carried by a weight, though they had formerly been solved only by indirect method, flow as corollaries from D'Alembert's general principles. This theory has also the great advantage of enabling us to demonstrate, that the doctrine of the conservation of living forces applies to the motion of fluids as well as to that of solids; and the principles of the theory are applicable to elastic as well as inelastic fluids, and to the determination of the motion of fluids in flexible pipes, a case which applies to the mechanism of the human frame. These fine views were first published at the end of D'Alembert's Dynamics in 1743, and they were afterwards more fully developed in his *Traité de l'equilibre et du Mouvement des Fluides*, which appeared at Paris in 1744.

After having established the laws of the equilibrium and motion of fluids, D'Alembert next directed his attention to the resistance which they oppose to the motion of solid bodies. This eminent mathematician attributes the slow progress of discovery in this branch of hydrodynamics to those unphilosophical investigations, in which a greater fondness was shewn for the calculus than for the physical principles on which it is founded; and he does not scruple to say, that the choice of these principles was often made, more from their forming a good ground work for the application of the calculus, than from their having a real foundation in nature. In order to avoid this error, D'Alembert first investigated the principles upon which he was to proceed, before he thought of the analysis which he was to apply to them; and by this truly philosophical mode of enquiry, he has established a theory founded upon no arbitrary suppositions. He merely supposes that a fluid is a body composed of very small particles, detached, and capable of moving freely among one another. D'Alembert regards the resistance which one body suffers from another as nothing more than the quantity of motion which it loses; and when the motion of a body is changed, he considers this motion as composed of that which the body will have in the following instant, and of another which is destroyed. This principle he found applicable to the resistance of fluids, and the investigation of this resistance he reduces to the laws of equilibrium between the fluid and the solid body. He supposes at first, that a body is by some external means kept at rest in the middle of a fluid which is about to strike it. When the filaments of the fluid strike the solid, they bend themselves round it in different directions, and that part of the fluid which covers the anterior part of the body is, to a certain extent, stagnant. The pressure experienced by the solid, or the resistance which it opposes to the motion of the fluid particles, is occasioned by the loss of velocity which each of these particles sustains. The problem is then reduced to this, to find the velocity of the fluid which slides immediately over the surface of the body, which D'Alembert has done by two different methods, and he then obtains a formula exhibiting the pressure exerted upon the solid. By a little modification of the general method, D'Alembert determines the action of a vein of fluid which strikes a plain surface, and he finds it to be a little less than the weight of a cylinder of fluid, the area of whose base is equal to that of the section of the vein, and whose altitude is double of that which is due to the velocity of the fluid; a result which agrees most wonderfully with the experiments of Bossut, who found that it was always a little less than that which was due to twice the height which produces the velocity.* The results of this enquiry were published in 1752, in D'Alembert's *Essai d'une nouvelle theorie sur la resistance des Fluides*, and the theory was afterwards extended in his *Opuscules Mathematiques*.

The celebrated Euler, to whom every branch of science owes such deep obligations, did not fail to exhibit the wonderful resources of his genius on a subject of such difficult investigation as the theory of running water. In the Memoirs of the Academy of St. Petersburgh, for 1768, 1769, 1770, and 1771, he has published a new and complete theory of the motion of fluids, which is founded on the laws of mechanics and hydrostatics, and occupies no less than 513 quarto pages. The first of these memoirs is entitled *De Statu Equilibrii Fluidorum*, and is divided into four sections: 1. *De Natura et varietate Fluidorum.* 2. *De Equilibrio Fluidorum, remota gravitate aliisque similibus viribus.* 3. *De Equilibrio Fluidorum a viribus quibuscunque sollicitatorum*; and, 4. *De Equilibrio Fluidorum a sola gravitate sollicitatorum*, in which he applies his reasonings both to compressible and incompressible fluids. The second memoir is entitled *De Principiis Motus Fluidorum*; the third, *De Motu fluidorum lineari potissimum aquæ*, and the fourth, *De Motu aeris in Tubis*. In the third memoir, he deduces, from his general theory, explained in the preceding memoir, the solution of a great number of beautiful problems upon a particular species of the motion of fluids, which he calls *linear*. The same general theory is applied in his memoir *De Motu Aeris* to the linear motion of air. In these memoirs, he reduces the whole theory of the motion of fluids to two differential equations of the second order, and he applies the general principles to the discharge of water from orifices in vessels, to its motion in conduit pipes, whether their diameters be constant or variable. In extending his investigation to elastic fluids, and particularly to air, he obtains very simple formulæ respecting the propagation of sound, and its formation in flutes and in the pipes of an organ. It is much to be lamented, that in all these researches, Euler has proceeded on the hypothesis of a mathematical fluidity, which has no existence in nature. Had he only treated the subject in reference to those resistances, such as cohesion and friction, which modify the action of gravity, the solutions which he has given might have been advantageously applied to the motion of water in pipes and canals.

In the year 1765, a very complete work on the theory and practice of hydrodynamics was published at Milan, by P. Lecchi, a celebrated Milanese engineer. It was entitled, *Idrostatica esaminata ne' suoi principi, e stabilita nelle sue regole della mesura delle acque correnti*, and contains a complete examination of all the different theories which have been proposed to explain the phenomena of effluent water, and the doctrine of the resistance of fluids. The author treats of the velocity and the quantity of water, whether absolute or relative, which issues from orifices in vessels or reservoirs, according to their different altitudes, and he afterwards enquires if this law is applicable to large masses of water, which flow in canals and in rivers, and he demonstrates the rules which have been found most useful in practice for the division and the mensuration of running water. This work contains several pieces by the celebrated Italian geometer Father Boscovich, by whom the work was revised and corrected. The extensive and successful practice of Lecchi as an engineer, has stamped a high value upon his work.

A very extensive series of experiments on the motion of water in pipes and canals, was made at Turin by professor Michelotti, and at the expence of the King of Sardinia. These experiments were performed upon a splendid scale, and with every attention to accuracy. The water issued from orifices and tubes of various shapes and sizes, from a tower of the finest masonry, twenty feet high and three feet square, supplied by a canal two feet wide, and under pressures, which varied from five to twenty-two feet. A huge reservoir, whose area was 289 feet square, built of masonry, and lined with stucco, received the effluent waters, which were conveyed in canals of brickwork, lined with stucco, and having various forms and declivities. Michelotti's experiments on the motion of water in pipes, are the most numerous and exact that have yet been performed. The trials which he made in open canals are still more numerous, but they are complicated, with many unnecessary circumstances, and seem to have been made more with the view of examining some disputed points in hydraulics, than of furnishing us with rules for cases which are likely to occur in practice. A full account of these experiments was published at Turin in 1774, in Michelotti's *Sperienze Idrauliche*. Michelotti published also a memoir on the impulse of a vein of fluid, in which he describes some experiments which do not agree with the common theory. It appeared in the Memoirs of the Academy of Turin for 1778.

One of the most zealous and enlightened cultivators of hydrodynamics, was the late Abbé Bossut, who has published a full account of his theoretical and experimental investigations, in his *Traité Theorique et Experimental d'Hydrodynamique*, in 2 vols. 8vo. The first edition was published in 1771; the second edition appeared in 1786, considerably enlarged; and a third edition, with very considerable alterations, was published in 1796. The experiments of Bossut, though made on a much less scale than those of Michelotti, have, in as far as they coincide, afforded similar results; and while they have the merit of equal accuracy, they are much more applicable than those of the Italian philosopher to cases which are likely to occur in practice. In order to determine the motion of the particles of a fluid which was in the act of being discharged from an orifice, Bossut employed a glass cylinder about eight inches high, and six inches diameter, to the bottom of which he fitted different adjutages for the efflux of the water. Whether this vessel was kept constantly full, or emptied itself without any supply, he observed that all the particles descended at first vertically, but at a certain distance from the orifice the lateral particles began to turn from their vertical direction towards the orifice; so that they entered the orifice near its circumference with an oblique motion, which continuing during a certain time, caused the effluent vein of fluid to have the form of a truncated conoid, whose greatest base was the orifice itself, the smaller base being a vertical section of the fluid, at a certain distance from the orifice. Beyond this section, which Newton called the *vena contracta*, the fluid vein preserved its cylindrical form. Bossut found the height of the conoid to be nearly equal to the radius of the orifice, and its bases to be in the ratio of three to two. He expected to have been able to employ this conoid as one of the elements for determining the quantity of water discharged; but subsequent experiments convinced him that this was impracticable. The contraction of the fluid vein, which Bossut has so well explained, cannot be removed, as Daniel Bernoulli maintained, by applying a small tube to the orifice; for though the quantity of water discharged is thus increased, yet it is never so great as if all the filaments of the fluid had issued in lines perpendicular to the plane of the orifice. Bossut's next object was to perform a complete set of experiments on the quantities of water discharged by

* See Bossut's *Hydrodynamique*. Chap. xiv. Exp. 5, 6, 7, 8.

orifices in thin plates, and by additional tubes fitted to these orifices. When the orifice was very small in comparison with the size of the vessel, he found that the theoretical law —that the quantity of water discharged was as the product of the line by the orifice, and the square root of the height of the reservoir—was sufficiently correct, and might be employed in ordinary practice. But when the water flowed through an orifice in a thin plate, the contraction of the vein of fluid diminished the theoretical discharge in the ratio of sixteen to ten; and when the fluid was discharged through an additional tube, two or three inches long, so as to follow the sides of the tube, the theoretical discharge was diminished only in the ratio of sixteen to thirteen. In examining the effects of friction and contraction, Bossut found, that small orifices discharged less water in proportion than great ones, on account of friction; and that as the height of the reservoir augments, the contraction of the fluid vein also augments, and consequently the quantity of water discharged diminishes. By combining these two circumstances, he has furnished us with the means of measuring with precision the quantities of water delivered, either by simple orifices or tubes, whether the vessel is kept constantly full, or allowed to empty itself without any supply.

Bossut next proceeds to consider the motion of jets of water. He determines the most suitable form that can be given to the adjutages, and the best proportion between the diameter of the adjutage and that of the pipe in which the water is conveyed. Hence we are able to obtain the best possible effects for the decoration of gardens or public buildings.

As the conducting of water is one of the most important and useful branches of hydraulics, Bossut made a great variety of experiments on the motion of water in canals and pipes. The effect of friction, and of sinuosities or bendings in the pipes, is so remarkable, that the quantity of water actually delivered may be twenty or thirty times less than what might have been expected from theory. M. Bossut has shewn, that when the height of the reservoir is increased, the diminution in the discharge of the water is less sensible. He points out the law, according to which the discharge diminishes as the pipe becomes longer, or as the number of its bendings is increased. In considering the motion of water in open canals, he first examines the law, according to which the friction diminishes the velocity of the stream in rectangular canals; and he shews, that in an open canal, with the same height of reservoir, the same quantity of water is always discharged, whatever be its declivity and its length; whereas in pipes there is a very remarkable variation, by a variation in its declivity and its length. He found, that the velocities in a canal are not as the square roots of the declivities; and that at an equal declivity and an equal depth of the canal, the velocities are not as the quantities of water discharged. The subject of rivers next occupies the attention of our author. He considers the variations which take place in the velocity and level of the waters when two rivers unite, and the manner in which rivers form and establish their beds. He next treats of the formation of bars at the mouths of rivers, or at the junction of two rivers; he points out the means which may be successfully employed, either in removing wholly or in part these dangerous banks; and he concludes this part of his work, by determining the change which takes place in the depth of a river, when any change takes place in the width of its bed, as happens from the construction of a bridge; and by ascertaining the depression of its level when a part of the river is turned aside for any useful purpose.

The experiments of Bossut, on the resistance and percussion of fluids, were made with singular care. His first trials, which were published in 1771, related chiefly to the impulse of a vein of fluid against a plain surface; but he afterwards extended them to many more useful questions. In the year 1775, the celebrated Turgot, comptroller-general of the finances of France, appointed Bossut, D'Alembert, and Condorcet, as a commission, for the purpose of executing a new set of experiments on the resistance which fluids oppose to the motion of bodies of various forms. These experiments were made almost solely by Bossut, within the grounds of the Ecole Militaire at Paris, in a basin of water 100 feet long, 53 feet wide, and 6½ feet deep; and the results which they obtained were published in 1777, in a separate work, entitled *Experiences sur le resistance des Fluides*. According to theory, the impulse upon a plane surface is equal to the area of the surface multiplied by the square of the velocity of the fluid, and the square of the sine of the angle of incidence. Bossut found that this measure of the resistance was sensibly correct, when the fluid impinged perpendicularly upon the surface; that the deviation from the theory increased with the angle of incidence; but that the theory might still be employed when this angle was not less than 50°. As the funds intrusted to the commission had been managed with the utmost economy, Bossut employed the surplus in determining the resistance experienced by all kinds of prows, whether plane, angular, or curvilineal. These experiments were performed in 1778, and were published in the Memoirs of the Academy for that year. He next made a number of experiments on the effects of undershot and overshot water wheels. The former he found to give a maximum effect, when the velocity of the stream was to that of the wheel as five to two, while the effect of the latter increased with the slowness of their motion. The valuable labours of Bossut were recompensed by M. Turgot, who established for him in the Louvre a professorship of Hydrodynamics, to which he was appointedin 1775.

We have already seen, that Newton was the first philosopher who investigated the laws of the motion of waves. His theory was, however, only an approximation to the truth, and, as he himself was aware, was suited only to the hypothesis, that the particles of the fluid ascended and descended vertically in the course of their vibrations. When the ascent and descent is made in curve lines, the velocity of the waves cannot be accurately determined by Newton's method. It is only by means of the general laws of the motion of fluids that this subject can be properly treated. M. De La Place was the first who applied this mode of investigation to reclineal undulations, in the Memoirs of the Academy of Sciences for 1776. This investigation is contained in a separate section, *Sur les ondes*, published in his paper, entitled *Suite des Recherches sur plusieurs points du Systeme du Monde*. He supposes the water to be shut up in a canal infinitely narrow, and of an indefinite length, but of a constant depth and breadth. He imagines that the wave is produced by immersing a curve in the fluid to a very small depth. The curve being kept in its place till the water has recovered its equilibrium, it is then drawn out, and waves are formed by the water while it recovers its equilibrium. When the curve is plunged more or less deep into the fluid, the time of the propagation of the waves to a given distance will be always the same, as the oscillations of a pendulum are constant, whatever be the length of the arcs which they describe, provided they are very small. If the depth of the canal is very great, in proportion to the radius of curvature of the curve at its lowest point, the times of the propagation of waves generated by different curves, or by the same curves in different situations, are reciprocally as the square roots of the radii of curvature; and the velocities of the waves are directly as the same roots. Hence La Place concludes, that the velocity of waves is not like that of sound, independent of the primitive agitation of the air.

The subject of the oscillation of waves was now examined experimentally by M. Flaugergues, who endeavoured to overturn the opinions of Sir Isaac Newton. In a memoir on the motion and figure of waves, of which an abstract is given in the *Journal des Sçavans* for October 1789, Flaugergues gives an account of a series of experiments which he made upon this subject. He combats the opinion of Newton, that waves arise from a motion of the particles of the fluid, in virtue of which they ascend and descend alternately in a serpentine line, while they move from their common centre; and he attempts to prove, that they are a kind of intumescence raised round the common centre, by the depression which the impulse has occasioned; and that this intumescence is afterwards propagated circularly from the centre of impulse. A portion of the intumescence, or elevated water, flows, as he conceives, from all sides into the cavity formed at the centre of impulse; and this water being, as it were, heaped up, produces another intumescence, which occasions a new wave, that is propagated circularly as before. M. Flaugergues proceeds to determine the figure of a wave, and gives the equation of it, and also the equation of the curve which the centre of gravity of a vessel describes from the motion of waves. From this theory he deduces the conclusion, that all waves, whether great or small, have the same velocity; whereas Newton made their velocity proportional to the square roots of their breadth. In order to examine this result, our author made the following experiment on a branch of the Rhone, shut up at one end to make the water stagnant. Having measured a distance or base of thirty feet, he threw into the water small stones at the end of this base, and he found that the waves which they produced, whether they were great or small, occupied exactly twenty-one seconds in moving over the space of thirty feet.

In the Memoirs of the Academy of Berlin for 1781 and 1786, and also in his *Mecanique Analytique*, M. De La Grange, one of the most distinguished mathematicians of the last century, has endeavoured to determine the oscillation of waves in a canal. He found that it is the same as that which a heavy body would acquire by falling through a height equal to half the depth of the water in the canal. Hence, if the depth of the canal is 1 foot, the velocity of the wave will be 5.495 feet, and, at greater or less depths, the velocity will be as the square roots of the depth, provided it is not very great. If it is admitted, that when waves are formed, the water is affected only to a small depth, the theory of La Grange will give tolerably correct results, whatever be the depth of the water in the canal, and the figure of its bottom; but although this supposition is countenanced by experience, and derives probability from the viscidity of water, yet La Grange's theory does not harmonize with experiment. Dr Wollaston observed, that in a place where the depth of the water was said to be 50 fathoms, a bore, or large wave, moved at the rate of one mile in a minute; whereas La Grange's theory gives only 40 fathoms as the depth which corresponds with the velocity. Dr Thomas Young has also observed, that the waves, or oscillations of water in a cistern, always move with a velocity smaller than that of a body falling through half the depth, but nearly in the same proportion.

The first engineer who examined experimentally the motion of water in canals, in reference to the resistances arising from the cohesion of water, and to that kind of friction of which fluids are capable, was M. Chezy, the predecessor of M. Prony, in the direction of the School of Roads and Bridges. Towards the year 1775, when he was working with Perronet on the subject of the canal of Yvette, he was anxious to determine from observation and calculation, the relation which subsisted between the declivity and length of a canal, the width and figure of its transverse section, and the velocity of the water which it conveyed. In the course of this investigation, he obtained a very simple expression of the velocity, involving these different variable quantities, and capable, by means of a single experiment, of being applied to all currents whatever. He assimilates the resistance of the sides and bottom of the canal to known resistances, which follow the law of the square of the velocity, and he obtains the following very simple formula,

$V=\sqrt{\frac{gd}{\beta s}}$, where $g$ is $= 16.087$ feet, the velocity acquired by a heavy body after falling one second; $d$, the hydraulic mean depth, which is equal to the area of the section divided by the perimeter of the part of the canal in contact with the water; $s$, the slope or declivity of the pipe; and $\beta$, an abstract number to be determined by experiment.

The attention of the Chevalier Buat, Lieutenant Colonel of the Royal Corps of Engineers, was called to the subject of hydraulics by the publication of Bossut's *Hydrodynamique* in 1771. In studying the motion of canals and rivers, it occurred to him, that if water possessed perfect fluidity, and flowed in a channel infinitely smooth, its motion would be constantly accelerated like that of heavy bodies descending upon an inclined plane. But as the velocity of a river is not accelerated *ad infinitum*, but soon arrives at a state of uniformity, and is not afterwards increased without some cause, it follows that there is some obstacle which destroys its accelerating force, and prevents it from impressing upon the water new degrees of velocity. This obstacle must therefore be the viscidity of the water, which gives rise to two kinds of resistance, one, namely, which proceeds from the intestine motion of an imperfect fluid, and the other from the natural adhesion of its parts to the channel in which it flows. Our author, therefore, found it to be a general principle, "that when water runs uniformly in any channel, the accelerating force which obliges it to run is equal to the sum of all the resistances which it experiences, either from its own viscidity, or from the friction of its channel." Encouraged by the discovery of this principle, and by its application to the solution of many important problems, it occurred to M. Buat, that the motion of water in a conduit pipe had a great analogy to the uniform motion of a river, and upon this idea he composed a formula founded on the experiments of Bossut on conduit pipes and artificial canals. The result of this investigation was published in 1779, in the first edition of his *Principes d'Hydraulique*. M. Buat, however, was speedily convinced that a theory so new, and which led to results so different from the common theory, required the sanction of new experiments, more direct and varied than those which had hitherto been made. Through the influence of M. de Fourcroy, director of the Royal Corps of Engineers, the French Minister ordered an annual sum to be put at the command of the Chevalier Buat, for the purpose of performing a set of experiments upon this important subject; and during the years 1780, 1781, 1782, and 1783, he was constantly occupied with these experiments, with the assistance of Messrs Dobenheim and Benezech de St Honoré, two officers of the Royal Engineers. The latter took a particular interest in these researches, and from his great mathematical knowledge, he was of particular service to M. Buat, not only by the general aid which he gave him, but from the number of beautiful problems and important researches which he communicated to the work.

As the experiments of Bossut had been made only on pipes of moderate declivity, M. Buat supplied this defect by using declivities varying from 90° to the 40,000th part of a right angle, and channels which varied from a line and a half in diameter to areas of seven or eight square toises. Experiments were also made with syphons and pipes bent at various angles, and on the resistance both of compressible and incompressible fluids. In this way our author has collected an immense number of facts, which he classed according to their resemblance in one particular point; and by studying the cause of the differences which accompanied their differences in other circumstances, he was led to general rules, by which these differences formed a regular series. The experiments were again classed under another point of resemblance, and the same method followed; and by pursuing this plan, he obtained the following general formula, which represents, in a most surprising manner, the great variety of facts which he has collected: namely,

$$V = \frac{\sqrt{n\,g}\,(\sqrt{d} - 0.1)}{\sqrt{s} - \text{Log.}\sqrt{s + 1.6}} - 0.3\,(\sqrt{d} - 0.1)$$ in which

V is the mean velocity in inches per second.

$d$ the hydraulic mean depth, or the quotient which arises from dividing the area of the section of the canal in square inches by the perimeter of the part in contact with the water in linear inches.

$s$ the slope or declivity of the pipe, or of the surface of the water.

$g = 16.087$, the velocity in inches per second which a heavy body acquires by falling in one second.

$n$ An abstract number, which was found by experiment to be $= 243.7$.

In 1783, when M. Buat's experiments were finished, they were submitted to the Academy of Sciences through the minister of war, and were afterwards published in 1786, under the title of *Principes d'Hydraulique verifiés par un grand nombre d'experiences faites par ordre du gouvernment*. A third volume of this work was published in 1816, under the title of *Principes d'Hydraulique et Pyrodynamique*. It relates chiefly to the phenomena of heat and elastic fluids.

In the year 1784, M. L'Espinasse, corresponding member of the Academy of Thoulouse, published two memoirs in the Transactions of that society, which contain very interesting observations on the motion of water through large orifices, and on the junction and separation of rivers. The experiments which are contained in these two memoirs were made in the Fresquel and Aude, two rivers in the department of the Upper Garonne, and on part of the *Canal du Midi*, which is below the lock of Fresquel, towards the point where it meets with the bed of that river.

Don George Juan D'Ulloa, an eminent mathematician, and inspector of the naval academies of Spain, proposed a new physico-mathematical theory of collision, in his *Examen Maritimo*, a work which was published at Madrid in 1771, in 2 vols. 4to. This theory includes all the circumstances of motion, both during the continuance of the shock and after the shock, and embraces the laws of the collision of hard bodies, of soft bodies, and of bodies perfectly or imperfectly elastic, whether they are moved in virtue of constant velocities and accelerating forces, or by both of these causes combined. This theory is however not applicable, as might at first sight have been expected, to the impulse of fluids; but the same author has favoured us with a new theory of the resistance of fluids, which has been adopted by Prony and several other French writers. This theory has, in Prony's opinion, been confirmed by very good experiments, and also by its conformity with the progress and other motions of vessels. It has also, as Prony has remarked, the advantage of presenting the discussion of the question with the different physical circumstances which it involves, an advantage which is not possessed by the ordinary theory. In order to confirm his theory, Don George Juan made the following experiments: He exposed a plane surface of the form of a parallelogram a foot wide, to the action of a current of water which moved with the velocity of two feet per second. When it was immersed just one foot under the water, it supported a weight of $15\frac{1}{2}$ pounds (English measure). When the same plane was sunk two feet in a current of water moving with the velocity of one foot four inches in a second, it supported a weight of $26\frac{1}{2}$ pounds. The following Table shews the theoretical and practical results.

| | Velocity of Water. | Depth of Submersion. | Observed Resistance. | Calculated Resistance. |
|---|---|---|---|---|
| Exp. 1. | 2—0 feet. | 1 foot. | $15\frac{1}{2}$ pounds. | $20\frac{1}{2}$ pounds. |
| Exp. 2. | 1—4 | 2 | $20\frac{1}{4}$ | $39\frac{1}{4}$ |

The ratio of the observed resistance is as $15\frac{1}{2} : 26\frac{1}{2}$, while that of the calculated results is as 15 to 28. Don George Juan has printed two appendices at the end of his first volume, in one of which he applies his theory to the resistance of elastic fluids; and in the other he examines the experiments of our countryman Smeaton on the maximum effect of water mills. He shews, from this theory, that the velocity of the floatboards ought to be a little less than one half of the velocity of the water, in order to produce a maximum effect; a result which is almost exactly the same which Smeaton found from experiment. It is a singular circumstance, that the experiments of Don George Juan give resistances much greater than those of Bossut, D'Alembert, and Condorcet, which were made under great pressures; so that his theory will differ very widely from the best experiments which have been made on the resistance of fluids. Dr Robison has remarked, (see his *System of Mechanical Philosophy*, vol. ii. art. *Resistance of Fluids*, which contains an examination of this new theory), that Don George Juan's equation exhibits no resistance in the case of a fluid without weight. A new edition of the *Examen Maritimo*, with copious notes and additions, was published at Paris in 1783, by M. L'Eveque, entitled *Examen Maritime, Theorique et Pratique, ou Traité de Mecanique, appliqué a la Construction et a la Manœuvre des vaisseaux et autres batimens*.

In the year 1798, M. J. B. Venturi, Professor of Natural Philosophy at Modena, published his experiments and observations on fluids, in a work, entitled *Sur la communication laterale du Mouvement dans les Fluides*, which was some time afterwards translated into English by Mr Nicholson. This work contains many new and valuable results, of which the following are the most important. He found, that in any fluid, the parts which are in motion carry along with them the lateral parts which are at rest. This proposition he established by introducing a current of water, with a certain velocity, into a vessel filled with stagnant water. The current, after passing through a portion of the fluid, was received in a curvilineal channel, the bottom of which gradually rose till it passed over the rim of the vessel; and in a short time there remained in the vessel only that portion of the fluid which was originally below the aperture at which the current was introduced. By the aid of this principle, which he calls the lateral communication of motion in fluids, and which he thinks is not sufficiently accounted for by the cohesion of the fluid particles, he explains many facts in hydraulics. In examining the effect of additional tubes, Venturi found, that if the part of an additional tube, near the orifice, has the form of the *vena contracta*, the quantity of water discharged will be the same as if there was no contraction; that atmospherical pressure increases the expenditure through a simple cylindrical tube, compared with that which is seen through an orifice in a thin plate; that in descending cylindrical tubes, whose upper ends have the form of the *vena contracta*, the expenditure corresponds with the height of the fluid above the lower end of the tube; that, with additional conical tubes, the expenditure is increased by the pressure of the atmosphere, in the ratio of the exterior section of the tube to the section of the contracted vein; that cylindrical pipes discharge less water than conical pipes which have the same exterior diameter, and diverge from the place of the contracted vein; that, by suitable adjutages applied to a horizontal cylindrical tube, the expenditure may be increased in the ratio of 24 to 10, the head of water remaining invariable; that the expenditure by a straight tube, a quadrantal arc, and a rectangular tube, each of which is placed horizontally, is nearly as the numbers 70, 50, and 45; and that the expenditure is diminished by the internal roughness of a pipe,—an effect which he conceives is not produced by the friction of the water against the asperities themselves.

Although, as M. Prony has remarked, "the results obtained by the Chevalier Du Buat, and his sagacious mode of classifying the different kinds of resistances which appear in the motion of fluids, might have conducted him to express the sum of these resistances by a rational function of the velocity composed of two or three terms only, yet the glory of this discovery was reserved for M. Coulomb." This eminent philosopher, who had applied the doctrine of torsion with such distinguished success in investigating the phenomena of electricity and magnetism, entertained the idea of examining in a similar manner the resistance of fluids; and in the year 1800 he laid before the National Institute of France his memoir upon this subject, entitled *Des Experiences destinées a determiner la coherence des Fluides, et les lois de leurs resistances, dans mouvemens tres lents*, which was published in the third volume of the *Memoires de l'Institut*. In determining the resistance of the air to the oscillations of a globe, Sir Isaac Newton employed a formula of three terms, one of which varied as the square of the velocity; the second, as the $\frac{3}{2}$ power of the velocity; and the third, as the simple velocity: and in another part of the *Principia* he reduces his formula to two terms, one of which is constant, while the other is as the square of the velocity. Daniel Bernoulli* has employed a formula similar to this of Newton's; and M. S'Gravesende† makes the presssure of a fluid in motion against a body at rest, partly proportional to the simple velocity, and partly to the square of the velocity; while, when the body moves in a fluid, he makes the resistance in proportion to a constant quantity, and to the second power of the velocity. M. Coulomb, however, has proved, by many fine experiments, that there is no constant quantity of sufficient magnitude to be detected, and that the pressure sustained by the moving body is represented by two terms, one of which varies with the simple velocity, and the other with its square. The apparatus by which these results were obtained, consisted of discs of various sizes, which were fixed to the lower extremity of a brass wire, and were made to oscillate under a fluid by the force of torsion of the wire. By observing the successive diminution of the oscillations, the law of the resistance was easily found. The oscillations which Coulomb found to be best suited for this kind of experiments, continued for twenty or thirty seconds; and the amplitude of the oscillations that gave the most regular results, was between 480, the entire division of the disc, and 8 or 10 divisions, reckoned from the zero of the scale. The following are the principal results which Coulomb has obtained:

1. That in extremely slow motions, the part of the resistance proportional to the square of the velocity is insensible, and therefore the resistance is proportional merely to the simple velocity.
2. That the resistance is not sensibly increased by increasing the height of the fluid above the resisted body.
3. That the resistance arises solely from the mutual cohesion of the fluid particles, and not from their adhesion to the body upon which they act. This result was obtained by covering the oscillating disc with grease, and at other times with coarse sand. In these cases the oscillations suffered no particular change.
4. That the resistance in clarified oil, at the temperature of 69° of Fahrenheit, is to that in water as 17.5 to 1; which expresses the ratio of the mutual cohesion of the particles of oil to the mutual cohesion of the particles of water.

M. Coulomb concludes his experiments, by ascertaining the resistance experienced by cylinders that move very slowly and perpendicular to their axes; but for an account of the results which he obtained, we must refer the reader to the memoir itself, or to the subsequent part of the present article.

The first person who thought of applying the law of the resistance of fluids, discovered by Coulomb, to the determination of the velocity of water flowing in natural or artificial channels, was M. Girard, chief engineer of roads and bridges, and director of the works on the canal of Ourcq. In his *Essai sur le mouvement des Eaux Courantes*, and his *Rapport sur le Canal de l'Ourcq*, he adopts as a measure of the resistance the product of a constant quantity, by the sum of the first and second powers of the velocity; and after determining the value of the constant quantity, from twelve experiments of Chezy and Du Buat, he obtains a formula much more simple than that of Du Buat, but representing the experiments with equal precision. Considering that the water which moves over the wetted sides of the channel, or over the film of water which adheres to these sides (*paroi mouillée*) is at first retarded by the viscidity, which tends to keep it upon this film, he concludes, that from this cause the water will experience a retardation proportional to the simple velocity. From the roughness of the channel he deduces a second retardation, (analogous to friction in solid bodies, but differing from it in so far as it does not vary with the pressure,) which is proportional to the second power of the velocity, as it is in the compound ratio of the force and number of impulsions which the asperities receive during a given time. He then expresses the resistance produced by cohesion by $R \times p\,V$; R being a quantity to be determined by experiments; $p$, the perimeter of the fluid section in contact with the channel; and V, the velocity; and considering the adhesion of the asperities to the wetted sides of the channel as the same with that of the fluid par-

* *Comment. Petropol.* tom. iii. and v.

† *Physices Elementa Mathematica*, tom. i. § 1911.

ticles to each other, he makes the resistance due to these asperities equal to $R \times p V^2$, whence he obtains the formula $\frac{g}{\beta}\frac{d}{s} = R(V + V^2)$. M. Prony is of opinion, that the adhesion of the asperities to the *paroi mouillée*, or wetted sides of the channel, ought to be supposed greater than that of the fluid particles; for if the two adhesions were equal, the asperities would have no more tendency to unite to the wetted sides than to the mass of fluid in motion.

Such was the state of hydrodynamics, when M. Prony published, in 1804, his *Recherches Physico-Mathematiques sur la Theorie des Eaux Courantes*. In order to establish the theory of running waters on a proper foundation, this eminent mathematician collected the best experiments that had been published on the motion of water in conduit pipes, and in natural and artificial channels. Out of this collection he selected 82 of the best, viz. 51 on conduit pipes, and 31 on open canals; and he endeavoured to combine these data with the principles of physics and mechanics, so as to deduce from them general formulæ, from which the velocity might in every case be obtained by calculation. By these means he has been able to express the velocity of water, whether it flows in pipes or open canals, by a simple formula, free of logarithms, and requiring merely the extraction of a square root. The formula, which is applicable both to pipes and canals, is

$$V = -0,0469734 + \sqrt{0,0022065 + 3041,47 \times G},$$

which gives the velocity in metres; or, when reduced to English feet,

$$V = -0.1541131 + \sqrt{0,023751 + 32806,6 \times G}.$$

When this formula is applied to pipes, we must take

$G = \frac{1}{4}DK$, which is deduced from the equation

$$K = \frac{H + Z = H}{L}.$$

When it is applied to canals, we must take $G = RI$,

Which is deduced from the equation $I = \frac{Z}{L}$, R, being equal to the mean radius of Buat, or the hydraulic mean depth, as already explained.

M. Prony has drawn up extensive tables, in which he has compared the observed velocities with those which are calculated from the preceding formulæ, and from those of Du Buat and Girard; and it is surprising to observe their agreement with the observed results, and their decided superiority to those of Du Buat and Girard. The progress of hydrodynamics has likewise been greatly indebted to the *Nouvelle Architecture Hydraulique* of M. Prony, which appeared in the year 1790. This able work is divided into two parts; the first of which is a treatise on mechanics, in which the author has explained the general principles of equilibrium and motion, which are necessary for engineers. The second part is divided into four sections: The first section treats of statics, the second of dynamics, the third of hydrodynamics, and the fourth of machines and first movers, considered under the different physical circumstances which have an influence upon their equilibrium and motion. In the chapter on hydrodynamics, he resolves the general problem of the efflux of water through an orifice in one of the sides of a vessel, upon the supposition that the fluid strata preserve their parallelism, and that their particles descend with the same velocity; and from this he deduces, as a corollary, all the ordinary theory of the motion of fluids. He next gives an account of the experiments of Bossut on the efflux of water, and deduces formulæ, by which the results may be expressed with all the accuracy that practice requires. In treating of the impulse and resistance of fluids, he adopts and explains the theory of Don George Juan, and afterwards gives an account of the ordinary theory of resistance, with the experiments by which it has been corrected and rendered applicable to practice. M. Prony then proceeds to give an account of the general and rigorous theory of the motion of fluids, and he applies the equations to the motion of fluids in narrow pipes. In the 5th section, which contains much valuable practical information, the author has treated at great length the subjects of friction and of the strength of men, and has given a detailed account of the history and construction of the steam engine, from the rude form in which it came from the hands of the Marquis of Worcester to the almost perfect state to which it has been brought by our celebrated countryman Mr. Watt.

In the year 1795, Mr. Vince of Cambridge published in the Philosophical Transactions, his *Observations on the Theory of the motion and resistance of Fluids, with a Description of the Construction of Experiments in order to obtain some fundamental principle*; and in the year 1798, he published, in the Transactions of that year, another paper, entitled, *Experiments on the Resistance of Bodies moving in Fluids*. The experiments contained in the first of these papers were made chiefly with the view of ascertaining how far the theory of the motion of fluids could be applied to the discharge of water from vessels. Mr. Vince has concluded, from the results of this inquiry, that the great difference between the experimental and theoretical results, in most of the cases which respect the times in which vessels empty themselves through pipes, leads us to suspect the truth of the theory of the action of fluids under all other circumstances. In the second memoir, he gives an account of a variety of experiments on the resistance of fluids, when the resisted body is immersed at some depth in the fluid made with a particular apparatus which he contrived for this purpose. The results which he obtained differ widely from those obtained by Bossut with bodies floating on the fluid, which Mr. Vince explains, by supposing, that at the surface, the fluid from the end of the body may escape more easily than when the body is immersed below the surface.

The late Dr. Matthew Young, Bishop of Clonfert, made a number of experiments on the efflux of fluids from orifices of different kinds, of which he has published an account in the 7th volume of the *Transactions of the Royal Irish Academy*. In order to explain the increase in the discharge by inserting an additional tube in an orifice in the bottom of a vessel, he filled a cylindrical vessel with mercury to the height of six inches, and inserted in its bottom a tube 7.8 inches long. Having closed the orifice of the pipe, he placed the apparatus under the receiver of an air pump, when the barometer was at 30 inches, and the gauge at $28\frac{1}{2}$, the time of the efflux was in this case 26 seconds; but when the experiment was repeated in the open air, without any variation, the time of the efflux was only 19 seconds. Unless the gauge stood higher than $22\frac{1}{2}$ inches, no difference was observed in the times of the efflux in the open air and in the receiver. When the efflux was made *in vacuo*, the pipe was not filled during the efflux, as it was when the discharge was made in the open air. Hence Dr. Young concludes, that the plate of fluid at the orifice, where the additional tube is inserted, has its perpendicular pressure increased by the weight of the column of fluid in the additional pipe, without any increase of its lateral pressure; and, consequently, the quantity of water discharged by a pipe of this kind must exceed that which is discharged by a simple orifice. The results of experiments, therefore, made with additional tubes, will be more consonant to theory than when they are made with a simple orifice, unless when the tube has such a length, that a sensible effect is produced by the friction of the fluid against the sides of the tube, or when the additional tube is so short as not to be capable of giving a vertical direction to the particles of water. Dr. M. Young found, that this view of the subject agreed remarkably well with the experiments of Mr Vince.

In the year 1801, M. Eytelwein, of Berlin, who was known to the public as the translator of Du Buat's works into German, and who was honoured with several employments and titles relative to the public architecture of the Prussian dominions, published a work, entitled *Handbuch der Mechanik und der Hydraulik*, which contains not merely an exposition of the labours of preceding writers, but an account of many new and valuable experiments made by the author himself. The second part of this work, which treats of hydraulics, is divided into 24 chapters. Chap. 1. Treats of the efflux of water from reservoirs, and of the contraction of the fluid vein. Chap. 2. Of the discharge of water from horizontal and lateral orifices in a vessel constantly full. Chap. 3. Of the discharge of rectangular orifices in the side of a reservoir extending to the surface. Chap. 4. Of the discharge from reservoirs with lateral orifices of considerable magnitude, the head of water being constant. Chap. 5. Treats of the efflux from reservoirs which receive no supply of water. Chap. 6. Of the discharge from compound or divided reservoirs. Chap. 7. Of the motion of water in rivers. In this chapter, M. Eytelwein has shewn that the mean velocity of water in a second in a canal, or river, flowing in an equable channel, is $\frac{10}{11}$ths of a mean proportional between the fall in two English miles, and the hydraulic mean depth; and that the superficial velocity of a river is nearly a mean proportional between the hydraulic mean depth and the fall in two English miles. Chap. 8. Treats of the discharge and the swell in the case of falls, weres, and contractions in rivers and canals. In Chap. 9. On the motion of water in pipes, our author expresses the velocity in English feet by the following simple formula: $v=50\sqrt{\frac{dh}{l+50d}}$, where $l$ is the length of the pipe, $d$ the hydraulic mean depth, and $h$ the height of the reservoir. If the pipe is bent into angles or sinuosities, the value of $v$ must be corrected by taking the product of its square multiplied by the sum of the sines of the several angles of inflection, and then by 0.0038. This will give the degree of pressure employed in overcoming the resistance occasioned by the angles, and by subtracting this height from that which is due to the velocity, we may thence find the corrected velocity. Chap. 10. Treats of jets of water. Chap. 11. Of the impulse or hydraulic pressure of water. Chap. 12. Of overshot water-wheels. Chap. 13. Of undershot water-wheels. Chap. 14. Of the properties of air, in so far as they are connected with hydraulic machines. Chap. 15. Of syphons. Chap. 16. Of sucking pumps. Chap. 17. Of forcing pumps. Chap. 18. Of mixed pumps, or the combination of sucking or forcing pumps. Chap. 19. Of acting columns of water. Chap. 20. Of the spiral pump. Chap. 21. Of the screw of Archimedes. Chap. 22. Of bucket wheels or throwing wheels. Chap. 23. Of cellular pumps and Paternoster works. Chap. 24. Of instruments for measuring the velocity of currents of water.*

During the year 1814, a very extensive series of experiments was made by M. Girard, on the motion of fluids in capillary tubes. We have already seen, that M. Coulomb had given a common co-efficient to the two terms of his formula representing the resistance of fluids, one of which was proportional to the simple velocity, and the other to the square of the velocity. M. Girard has, however, found, that this identity between the co-efficients, which may suit particular fluids under particular circumstances, is not generally admissible; and this idea is confirmed by the researches of M. Prony; from which it follows, that the co-efficients ought to be different. M. Prony has deduced the value of these co-efficients from a great number of experiments; but as his formula gives only the mean velocity, which is much greater than the velocity of the fluid contiguous to the pipe or canal which ought alone to enter into an expression of the retarding force, it follows that the co-efficients deduced from all the experiments hitherto made, have a value greatly inferior to what they ought to have, for the motion of the fluid contiguous to the side of the pipe. The object of M. Girard's experiments was to determine this velocity. He observes, that the velocity of the central filament in conduit pipes differs less from the velocity of the sides of pipes as the diameter of the tube is diminished; and that the theory of the linear motion of fluids, which was first given by Euler in 1770, is strictly applicable to the case where the water flows in very small tubes. Hence the experimental results obtained with tubes of a small diameter ought to accord best with the formula deduced from theory. In order to make a correct series of experiments of this kind, M. Girard constructed two sets of tubes made of copper, and of uniform calibre, and drawn upon maundrels of steel. The first series was composed of tubes 2.96 millimetres in diameter, and 2 decimetres long. These tubes were made to screw on to one another, and form as many tubes of different lengths, from 20 to 222 centimetres. The second series was composed of tubes 1.83 millimetres in diameter, and capable of being screwed together. These tubes were then fixed horizontally on the sides of a reservoir, which was a cylinder of white iron 25 centimetres in diameter, and 5 decimetres high. The reservoir was kept full by the usual contrivances; and the water discharged by the tube subjected to trial, was received into a copper vessel placed horizontally, and whose capacity had been accurately ascertained. The filling of the vessel was indicated by the instant when the water which it contained had wetted equally a plate of glass which covered almost the whole of its surface, and the time employed to fill this vessel was measured with great accuracy. The temperature of the water was also carefully noted. The results thus obtained amounted to 1200, and were arranged by M. Girard into thirty-four tables, according to the differnt circumstances of the experiment. When the capillary tube has such a length, that the term proportional to the square of the velocity disappears in the general formula, the velocity with which the fluid is discharged, is affected in a very singular manner by a variation of temperature. If the velocity is expressed by 10, when the temperature is 0° of the centigrade thermometer, the velocity will be so great as 42; or increased more than 4 times when the temperature amounts to 85°. When the length of the capillary tube is below the above mentioned limit, a variation of temperature exercises but a slight influence upon the velocity of the issuing fluid. If the length of the adjutage, for example, is 55 millimetres, and if the velocity is represented by 10 at 5° of the centigrade thermometer, it will be represented only by 12 at a temperature of 87°. In conduit pipes of the ordinary diameter, a change of temperature produces almost no perceptible change in

* This abridged Account of M. Eytelwein's work, is taken from an excellent abstract of it, drawn up by Dr Thomas Young, and published in the Journals of the Royal Institution.

the velocity of efflux. M. Girard also found, that the quantity of water discharged by capillary tubes varied, not only with the fluids which were used, but with the nature of the solid substance of which the tubes were composed. A full account of these valuable experiments will be found in the *Memoires des Sçavans Etragers* for 1815, which is not yet published.

In the year 1815, the National Institute of France proposed as the subject of one of its annual prizes for 1816, *the theory of waves at the surface of a heavy fluid of an indefinite depth.* The prize was gained by M. Augustin Louis Cauchy, a young mathematician of great promise. The differential equations which he has given apply rigorously only to the case where the depth of the fluid is infinite; and he has treated only of that species of waves which are propagated with velocities uniformly accelerated. The same subject had occupied the attention of M. Poisson, who, before he had seen the Memoir of M. Cauchy, had laid before the Institute formulæ similar to his for the case of infinite depth. M. Poisson has himself studied the subject under a more extended aspect, and has laid before the Institute other memoirs, which, we have no doubt, will throw much light upon this difficult branch of hydraulics. He supposes that the water has not received any percussion at the commencement of its motion, and that the waves have been produced in the following manner. A piston of any form is supposed to be plunged in the water to a small depth, and is left there till the equilibrium of the fluid is restored. The piston is then suddenly withdrawn, and waves are formed round the place which it occupied. In determining the propagations of these waves, whether at the surface, or in the interior of the fluid mass, M. Poisson considers only the case where the agitations of the water are so small, that the second and the higher powers of the velocities, and of the displacements of the molecules, may be neglected; for, without such a restriction, the problem would be so complicated, that no solution of it could be expected. He supposes the depth of the water constant throughout its whole extent, so that the bottom is a fixed horizontal plane, situated at a given distance below its natural level. He then treats successively in his memoir, the case of a fluid contained in a vertical canal of an invariable width, and of an indefinite length; and that of a fluid, whose surface is indefinitely extended in every direction. This valuable memoir will, we trust, be published in the Memoirs of the Institute for 1815.

Having thus given a general view of the history and progress of hydrodynamics, we shall conclude this part of the article by a list of the best works and most important memoirs which have been written on the subject.

Archimedes *De Insidentibus in Fluido*. Id. *De iis quæ in humido vehuntur.* Heronis *Spiritalia* Edit. Commandini, 1575; Sexti Julii Frontini, *De Aqueductibus Urbis Romæ Commentarius* (Poleni's edit.); Stevini *Hydrastatica;* Schotti *Mechanica Hydraulico-Pneumatica*, 1657; Baliani *De Motu Gravium*, Geneva, 1646; Toricelli *De Motu Gravium naturaliter accelerato*, 1643; Castelli *Della Mesura dell' acque correnti*, 1628; Pascal *Sur L'Equilibre des Liquers;* Descartes *Recueil des Lettres de M. Descartes.* tom. iii.; Mariotte *Traité du mouvement des eaux*, Par. 1686, and *Mem. Acad. Par.* I. 69. II.; Guglielmini *La Mesura dell' acque correnti;* Guglielmini *Della natura dell' Fiumi.* Bologn, 1697; Polenus *De Motu aquæ mixto*, Patav. 1697, 1718, 1723; Parent *Mem. Acad. Par.* 1700; Varignon *Mem. Acad. Par.* II. p. 162; *Id.* 1703, p. 238; Picard *De aquis effluentibus, Mem. Acad. Par.* VII. 323; Newtoni *Principia*, lib. ii.; Raccolta *Di Autori che trattano dell moto dell acque*, 3 vols. 4to. Flor. 1723. This collection contains the works of Archimedes, Albici, Galileo, Castelli, Michelini, Borelli, Montanari, Viviani, Cassini, Guglielmini, Grandi, Manfredi, Picard, and Narducci. Polenus *De Castellis per quæ derivantur fluviorum aquæ*, Patav. 1718; Michelotti *De separatione fluidorum in corpore animali*, 1719; Jurin, *Phil. Trans.* 1718, 1722; Couplet, *Mem. Acad. Par.* 1732, p. 113; Daniel Bernoulli *Hydrodynamica seu de viribus et motibus fluidorum commentarii.* Strasb. 1738; *Id. Comment. Petrop.* 1727, 1741; Pitot, *Mem. Acad.* 1727, p. 49; 1730, p. 306; 1732, 1738; John Bernoulli, *Opera*, tom. iv.; and *Comment. Petrop.* 1737, 1738; Cotes *Hydrostatical and Pneumatical Lectures*, 1747; S. Gravesende *Physices Elementa Mathematica*, Leid. 1719, 1742; Maclaurin's *Fluxions*, vol. ii. book ii. chap. xii. § 537—550, Edin. 1742; D'Alembert *Traite de l'Equilibre et du mouvement des Fluides*, Par. 1744; D'Alembert *Essai d'une Nouvelle Theorie sur la resistance des Fluides*, and also his *Opuscules Mathematiques*, tom. vi. Switzer's *Hydrostatics;* Euler, *Mem. Acad. Berlin*, 1752, p. 111; 1755, p. 217; Id. *Nov. Comment. Petrop.* 1768, 1769, 1770, 1771; Id. *Theorie complete de la construction et Manœuvre des vaisseaux;* Bouguer, *Mem. Acad. Par.* 1755, p. 481; Lecchi *Idrostatica esaminata ne suoi principi e stabilita nelle sue regole della mesura delle acque correnti*, 1765; Borda, *Mem. Acad. Par.* 1763, p. 358; 1766, p. 579; 1767, p. 595; Käestner *Anfangsgrunde der Hydrodynamik*, Gotting. 1769, and *Nov. Comment. Gotting.* 1769, I. 45.; *Nuova Raccolta di autori che trattano del moto dell' acque*, 7 vols. Parma, 1766. The 1st vol. of this excellent collection contains, 1. Castelli's treatise *Della Mesura*, &c. 2. Several letters of Castelli and other authors. 3. A paper by Montanari on the Adriatic Sea and its currents. 4. A discourse by Viviani on the method of preventing the filling up and the corrosion of rivers applied to the river Arno. 5. Several papers by J. D. Cassini, on the regulation of the courses of rivers; and, 6. Guglielmini's treatise, entitled *La Mesura*, &c. The 2d volume contains Guglielmini on rivers, illustrated with the notes of E. Manfredi. The 3d volume contains, 1. Guido Grandi's geometrical treatise on the motion of water; 2. Several dissertations, by the same author, on the River Era and the streams in Italy; 3. The Marquis Poleni's treatise *de motu aquæ mixto;* 4. A treatise, by the same author, on dikes, &c.; 5. A letter, by Poleni, on the measure of running waters; 6. A paper, by J. Buteon, on the same subject. Tom. IV. contains, 1. Several hydraulic dissertations by Castelli; 2. Several letters from Galileo to Castelli; 3. A paper, by E. Manfredi, on the construction of a dike upon the River Era; 4 A reply, by Manfredi, to a criticism by Ceva and Moscatelli; 5. A reply, by the inhabitants of Bologna, to those of Ferrara on the course of the Reno; 6. An examination of a book, entitled The Injurious Effects of the Reno. 7. A refutation of another work, published at Modena, on the same subject. Tom. V. contains, 1. A report, by Cardinals Adda and Barbarini, on the state of the waters in the countries of Romagna, Ferrara, and Bologna; 2. A report, by Riviera, on the state of the Reno, the Panaro, and the Po; 3. A selection of practical information from the work of Zendrini on running waters; and, 4. A memoir on preventing the inundations of the Ronco and the Montone, by Zendrini and Manfredi. Tom VI. contains, 1. A translation of Picard's book on levelling; 2. A translation of Gennete's experiments on the course of rivers; 3 Experiments of Bonati in opposition to those of Gennete; 4 Gennete's reply; 5. Remarks, by Manfredi, on the constant elevation of the bottom of the sea; 6. A discourse, by Zanotti, on the beds of rivers near their embouchure; 7. A memoir, by Bolognini, on the ancient and present state of the Pontine Marshes, and on the means of draining them;

8. A comparison of canals, by Narducci; 9. A paper, by Perelli, on a torrent called the Maroggia. Vol. VII. contains, 1. A discourse on the ancient and present state of the Valdichiana; 2. A memoir, by Lecchi, on the Tradate, the Gardaluso, and the Bozzenti; 3. A paper on the inundations of the Adige, by Lorgna; and, 5. A paper, by Frisi, on the management of rivers and torrents. Bossut et Viallet, *Recherches sur la Construction des digues*, 1764. Silberschlag, *Theorie des Fleuves, avec l'art de batir dans leur eaux et de prevenir leur ravages*, 1769; translated from the German. Michelotti, *Sperienze Idrauliche*, Turin, 1774; and *Mem. Taurinens*, 1788. Bossut, *Traité Theorique et Experimental d'Hydrodynamique*, 2 vols. 8vo. 1771, 1786, and 1796. Fontana, *Dissertazione Idrodinamica*, Mant. 1775. Chevalier Buat's *Traité d'Hydraulique et Pyrodynamique*, 2 vols. 8vo. 1786, and vol. iii. 1816. La Grange, *Mecanique Analytique*; and *Mem. Acad.* Berlin, 1781, p. 151, and 1786, p. 192. Ximenes, *Nuove Sperienze Idrauliche fatte ne canali e né fiumi per verificare le principale leggi e fenomeni delle acque correnti*, Siena, 1780. Id. *Act. Sien.* iii. 16, iv. 31, vii. 1. Lorgna, *Memorie intorno all' acque correnti*, Veron. 1777. Lorgna, *Ricerche intorno alla distributione delle velocita nella sectione de Fiumi*. Id. *Soc. Italian*, iv. p. 369, v. 313, vi. 218. Lambert, *Sur les Fluides considerées relativement à l'Hydrodynamique, Mem. Acad. Berlin*, 1784, p. 299. Langsdorf, *Theorie der Hydrodynamischen grundlehren*, Frankf. 1787. Langsdorf, *Hydraulik*, Altenb. 1794. Cousin Mem. Acad. Par. 1783, p. 665. Parkinson's *Hydrostatics*, 1789. Dr Mathew Young, *Irish Transactions*, 1788, vol. ii. p. 81, and vol. vii. p. 53. Bernhard, *Nouveaux Principes d'Hydraulique*, 1787. This work contains a historical and critical discourse upon the different works which have been published on this subject. Prony, *Nouvelle Architecture Hydraulique*, 2 vols. 4to. Paris, 1790. Prony, *Recherches Physico-Mathematiques sur la Theorie des Eaux Courantes*, 4to. Paris, 1804. Burja, *Grundlehren der Hydrostatik*, 1790. Vince, *Phil. Trans.* 1795, p. 24, 1798, p. 1. Atwood, Phil. Trans. 1796, p. 46, *On the Stability of Vessels*, 1798, p. 301. Don George Juan, *Examen Maritimo*, Madrid 1771. This work was translated into French by M. l'Evesque in 1783. La Place, *Mem. Acad. Par.* 1776, and *Mecanique Celeste*, liv. i. chap. iv. viii. liv. iii. chap. iii. iv. Flaugergues, *Journal des Sçavans*, Oct. 1789. Venturi, *Recherches experimentales sur la communication lateral du mouvement dans les Fluides*, Paris, 1797. This work was translated by Nicholson, and published separately in 1798. It appeared also in his *Philosophical Journal*, 4to, vol. ii. p. 172. Fabre, *Sur les Torrens et les Rivieres*, Paris, 1797. Mazzuchelli, *Idrodinamico*, 3 vols. Patav. 1795. Coulomb, *Experiences destinées a determiner la coherence des Fluides et les lois de leur resistance dans les mouvemens tres lents*, published in the *Memoires de l'Institut*, tom. iii. p. 246. Eytelwein's *Handbuch der Mechanik und der Hydraulik*, Berlin, 1801. An excellent abstract of this work, by Dr Thomas Young, will be found in the *Journals of the Royal Institution*, No. I. and in Nicholson's *Journal*, vol. iii. p. 25. and 79. Gregory's *Mechanics*, vol. i. Lond. 1806. Dr Thomas Young's *Elements of Natural Philosophy*, 2 vols. Lond. 1807. Mollet's *Hydraulique Physique*, Lyons, 1810. Girard, *Memoires des Sçavans Etrangers* for 1815, and *Journal des Mines*. Poisson, *Mem. de l'Institut*, 1815. Robison's *System of Mechanical Philosophy*, vol. ii. and iii. Art. *Resistance of Fluids, Rivers, and Water-works*.

## PART I. HYDROSTATICS.

HYDROSTATICS, from the Greek ὕδωρ, *water*, and ἵστημι, *I stand*, is that branch of the science of hydrodynamics which treats of the properties of fluids at rest. It comprehends the pressure and equilibrium of non-elastic fluids, the doctrine of specific gravities, the phenomena of cohesion and capillary attraction, and the equilibrium of floating bodies.

### *Definitions and Preliminary Observations.*

A *fluid* is a collection of very minute material particles, (probably of a spherical form,) which cohere so slightly to each other, that they yield to the smallest force, and are easily moved among one another in every direction.

The phenomena exhibited by fluids, whether they are at rest or in motion, afford us no reason to believe, that the particles of which they are composed possess any polarity, or any tendency to arrange themselves in one particular manner more than another. When a mass of water is in a state of perfect equilibrium, a certain point of one particle is in physical contact with a certain point of another particle; but if the equilibrium is destroyed by violent agitation, there is no ground even for conjecturing, that the same points of the particles will return into contact when the equilibrium is restored. The recent discoveries, however, which have been made in optics, decidedly prove, that in many fluids the particles assume a particular arrangement, analogous to that which is exhibited in some of the crystals of the mineral kingdom, and that they may also be made to assume another arrangement, similar to that which is produced in glass, &c. by compression and dilatation. When these fluids are inclosed in a vessel, the particles uniformly affect a certain arrangement, which is unequivocally indicated by their action upon polarised light. See OPTICS and POLARISATION.

Fluids are divided into *elastic* and *inelastic*, or *compressible* and *incompressible* fluids. The class of elastic and compressible fluids consists of atmospherical air, and the various gaseous or aëriform bodies with which chemists have made us acquainted; while the class of inelastic or incompressible fluids comprehends water, mercury, alcohol, and the various oils and liquid acids. The first class, in virtue of their elasticity, are capable of expanding themselves when they are unconfined, so as to fill any given space, or of having their bulk greatly diminished by mechanical compression;* while the second class possess this property in such a small degree, that the diminution of their bulk by mechanical force is scarcely susceptible of accurate mensuration. The science of PNEUMATICS considers the mechanical properties of the first class, and that of HYDRODYNAMICS those of the second class.

Till within the last fifty years, it was considered as an established fact, that the class of incompressible fluids could not be reduced in bulk by the application of the most powerful forces. This conclusion was deduced from an

* Air is said to have been reduced to $\frac{1}{1837}$ of its bulk in Hales's experiments.

experiment by Lord Bacon, who filled a leaden globe with water, and attempted to compress it by a great external force. The fluid, however, made its way through the pores of the metal, and stood like dew upon the surface of the globe. The Florentine academicians repeated the same experiment with a silver globe, and, by violent hammering, they succeeded in altering its form, and expelling the water through the pores of the silver. These trials seem to have established the doctrine of the incompressibility of fluids in its most strict acceptation; but Lord Bacon deduced from them the very opposite conclusion, for, after giving an account of the experiment which we have mentioned, he tells us, that he afterwards computed into how much space the water was driven by this violent pressure.*

Although the experiment of the Florentine Academy of Del Cimento was considered as decisive of this point, yet it occurred to Mr Canton, about the year 1761, that it was not hostile to the idea of a small degree of compressibility; for the academicians were unable to determine whether or not the water forced into the pores, and through the gold, was exactly equal to the diminution of the internal space by pressure. He accordingly set about a series of experiments on this subject. Having procured a small glass tube about two feet long, and $1\frac{1}{4}$ inch in diameter, and with a ball at one end of it, he filled the ball and part of the tube with mercury, brought the whole to the temperature of 50° of Fahrenheit, and observed that the mercury stood at a point exactly $6\frac{1}{2}$ inches above the ball. The mercury was then raised by heat to the top of the tube, and the tube was hermetically sealed. The mercury was then brought to the same degree of heat as before, and it now stood in the tube $\frac{32}{100}$ of an inch higher than it did before. By performing the same experiment with water exhausted of air, instead of mercury, he found that the water stood in the tube $\frac{43}{100}$ of an inch above the mark. Hence it is obvious, that the weight of the atmosphere, or 73 pounds avoirdupois, pressing on the outside of the ball, and not on the inside, had squeezed it into less compass, and that, by this compression of the ball, the mercury and the water would be equally raised in the tube. But the water rose $\frac{11}{100}$ of an inch more than the mercury, and consequently the water must have expanded so much more than the mercury by removing the weight of the atmosphere. In order to determine how much compression was produced, either by the weight of the atmosphere, or by a greater weight, he took a glass ball about 1.6 inch in diameter, joined to a cylindrical tube 4.2 inches long, and $\frac{1}{100}$ of an inch in diameter, and, by weighing the quantity of mercury that exactly filled the ball, and also the quantity that exactly filled the whole length of the tube, he found that the mercury in $\frac{23}{100}$ of an inch of the tube was the 100,000th part of that contained in the ball, and he divided the tube accordingly with the edge of a file. When the ball and part of the tube was filled with water exhausted of air, he placed it in the receiver of an air pump, and also in the receiver of a condensing engine, and he observed the degree of expansion of the water that corresponded with any degree of rarefaction, and the degree of compression that corresponded with any degree of condensation. In this way he found, from repeated trials, that, when the mercury was at a mean height, and the temperature of the air 50° of Fahrenheit, the water rose four divisions and 6-10ths, or one part in 21740, by removing the weight of the atmosphere; consequently the compressinn of water, under twice the weight of the atmosphere, is one part in 10870 of its own bulk.

In combining these experiments, Mr Canton found, that water was more compressible in winter than in summer, while, on the contrary, alcohol and oil of olives were more compressible when expanded by heat, and less so when contracted by cold. The results were, as expressed in the following Table, suited to the mean weight of the atmosphere.

| Temperature in Fahrenheit's scale. | Compression in millionth parts of their own bulk. Water. | Alcohol. |
|---|---|---|
| 34° | 49 | 60 |
| 64° | 44 | 71 |

The following Table contains all the results which Mr Canton obtained. It is suited to a temperature of 50° of Fahrenheit, and to $29\frac{1}{2}$ inches of the barometer.

| Names of fluids. | Compression in millionth parts of their own bulk by the weight of $29\frac{1}{2}$ inches of mercury. | Specific gravities at the same temperature. |
|---|---|---|
| Alcohol | 66 | 0.846 |
| Oil of olives | 48 | 0.918 |
| Rain water | 46 | 1.000 |
| Sea water | 40 | 1.028 |
| Mercury | 3 | 13.595 |

From these results it appears, that the compressions are not, as might have been imagined, in the inverse ratios of the specific gravities. If the law of compression in water is the same as that in air, it would follow, that, at a depth of 100 miles, the density of the water would be doubled, and at the depth of 200 quadrupled.

In the year 1774, the Ex-Jesuit Herbert published at Vienna a treatise, entitled *De Aquæ Elasticitate*, in which he confirmed the general result of Canton's experiments, and in 1779 M. Zimmerman published an account of similar experiments at Leipsic, under the title of *Traité de l'Elasticité de l'eau et d'autres fluides*. He found, that sea water, when inclosed in the cavity of a strong iron cylinder, and pressed by a force equal to a column of sea water 1000 feet high, was compressed $\frac{1}{340}$th part of its own bulk, a result much greater than we should have expected from the experiments of Canton. A number of results similar to these were obtained by the Abbé Mongez, who has printed an account of them in the 9th volume of Rozier's Journal.

As the doctrine of the compressibility of water has long been considered as a fact rigorously established, we were surprised to find its incompressibility stated by the Abbé Hauy, without the slightest reference to any of the preceding experiments. "One of the experiments," he observes, "which has served to shew the incompressibility of water, consists in charging that liquid with a column of mercury, by employing a bent tube in the form of a syphon, the shortest branch of which is closed at its superior part, and contains water, at the same time that the longest branch is occupied by the mercury, which presses the surface of the

* See Bacon's *Works*, by Shaw, vol. ii. p. 521, or the *Novum Organum*, Part II. Sect. ii. Aphorism 45, § 222. Bacon seems to have considered all bodies as in some measure elastic; for after having explained what he calls the motion of liberty, and applied it to the phenomena of tension, he says, "that this motion was unscientifically called by the schools the motion of the *elementary forms*: for it does not only apply to air, water, and flame, but to all the diversities of consistent bodies, as wood, iron, lead, cloth, skins, &c. each body having its own measure of extent or dimension, from whence it is with difficulty stretched to any considerable distance." Bacon's *Works*, vol. ii. p. 725. Aph. 48. § 245.

water. The column formed by this latter fluid was not shortened by the smallest perceptible quantity, even when that of the mercury was 227 centimetres, or about seven feet high, in which case it exerted upon the water an effect triple of that of a column of water 33 feet high."* In this experiment, which must have been carelessly made, the compression ought to have been thrice as great as in the experiments of Canton.

Fluids have also been divided into *perfect* and *imperfect;* but this division is quite arbitrary, as there is no body which possesses the character of perfect fluidity. Boiling water approaches nearer to a state of perfect fluidity than water in any other state. As its temperature diminishes, its viscidity increases, and its fluidity becomes less perfect. In many of the oils, varnishes, and in melted glass, the fluidity is extremely imperfect; whereas it may be considered as nearly perfect in water, alcohol, mercury, &c.

## CHAP. I.

### On the Pressure and Equilibrium of Fluids.

#### FUNDAMENTAL PRINCIPLE.

*When a mass of fluid, in a state of equilibrium, is subjected to the action of any forces, every particle of the fluid mass is pressed equally in every direction, and,* vice versa, *if every particle of the fluid mass is pressed equally in every direction, the whole mass will be in equilibrio.*

This principle, which has been adopted as the foundation of hydrostatics by Euler, D'Alembert, Bossut, and Prony, is a necessary consequence of the definition which we have already given of fluidity; for, since the parts of a fluid yield to the smallest pressure, any particle, which is more pressed in one direction than another, would move to the side where the pressure was least, and consequently the equilibrium would be destroyed. If the particles are equally pressed in every direction, it is equally evident, that the mass of which they are composed must be in equilibrium.

Although the preceding principle is rigorously true only of perfect fluids, yet, in the case of water, alcohol, &c. where the cohesion of the particles is not very great, the inequality of pressure, under which an equilibrium might exist, must be extremely small; and it is accordingly found, that the principle is experimentally true in these fluids. For if, at a given depth below the surface of water in a vessel, an aperture be made, and a piston be applied to the aperture to prevent the water from flowing out, it will be found, that the piston will be pressed outwards with the same force, whether the aperture is horizontal or vertical, or inclined at any angle to the horizon.

*Cor.* If a number of pistons E, F, G, are applied to apertures of different sizes in the sides of a vessel ABCD full of water, the forces with which the pistons are applied will be in equilibrio, if they are proportional to the apertures to which they are applied. Plate CCCXIII. Fig. 1.

Since the pressure of every part of the piston E is transmitted to every part of the piston F, and *vice versa*, it follows, that these pressures will be in equilibrio, if they are equal. But the sum of the pressures propagated by E is proportional to the area of the aperture E, and the sum of the pressures propagated by F proportional to the area of the aperture F; consequently there must be an equilibrium between these opposing pressures, when E : F = area of E : area of F. The same is true of any number of apertures.†

### Sect. I. *On the Pressure and Equilibrium of Fluids of Uniform Density.*

#### Prop. I.

When any fluid, influenced by the force of gravity, is in equilibrio in any vessel, its surface is horizontal, or at right angles to the direction of gravity.

Let the surface of the fluid have the curvilineal form A *p* B, Fig. 2, and let the force of gravity with which any particle *p* is influenced be represented by the vertical line *p o*. This force *p o* may be resolved into the forces *p m*, *p n*, coinciding with the elementary portions of the surface on each side of *p*. Now, the particle *p* being in equilibrium, it is pressed equally in every direction; and, therefore, the equal and opposite forces *m p*, *n p*, exerted against *p* by the neighbouring particles, must be equal to *p m*, *p n*; hence the force *p m* is equal to *p n*, the angle *m p n* must be bisected by *p o*, (See Dynamics, Sect. III.) and the elementary portion of the curve must be perpendicular to *p o*. As the same is true of every other part of the fluid surface, it follows that this surface must be a *horizontal straight line*, if the directions of gravity at different points are considered as parallel, or a portion of a spherical surface, if the directions of gravity meet in one point.

*Cor.* It follows from this proposition, that the surface of a fluid must be perpendicular to the resultant of all the forces which act upon it. Hence the general surface of the ocean will not be perpendicular to the direction of gravity, but to a line which is the resultant of the action of gravity, of the centrifugal force, and of the attraction of the planetary bodies.

The effect of the centrifugal force, combined with gravitation, is such, that the surface of the water assumes a parabolic form, as shewn in Fig. 3. When any number of fluids of different densities are put in the same vessel, and are made to revolve round an axis, or if they are put into a glass globe, and turned by the whirling table, their separating surfaces always assume the form of parabolic conoids, when the axis of rotation is vertical.

#### Scholium.

The depression of the surface of a fluid or D beneath a horizontal straight line for any given length L, may be found from the following simple formula: $D = \frac{2 L^2}{3}$.

#### Prop. II.

If a fluid influenced by the force of gravity is inclosed in a syphon, or in any number of communicating vessels,

* Hauy's *Elementary Treatise on Natural Philosophy*, translated by Dr O Gregory, vol. i. § 174.

† In the two following sections, as well as in other parts of this article, our readers will perceive that we have been under great obligations to the admirable work of the Abbé Bossut, to which we must refer those who wish to obtain a more profound and extensive view of the subject.

the surface of the fluid in each branch will be in the same horizontal plane.

Let ABCD, Plate CCCXIII. Fig. 4, be a syphon with three branches, AB, CB, DB, communicating with each other at B. If water is poured into this vessel till it rises to A in one branch, it will rise to the same height in the other branches, so that ADC is a horizontal line perpendicular to the direction of gravity. Let the syphon be removed, and let the water which it contained form part of the fluid in the vessel *a b c d*, in which it has the horizontal surface *a* ADC *b*, it is easy to suppose that a portion of the water, of the same form and thickness as the syphon, may be converted into ice, without changing its place or its volume. The equilibrium of the water is obviously not affected by such a change; and, therefore, the water will stand at the same height ADC, in a syphon of ice; and, consequently, the same will happen, whatever be the substance of which the syphon is composed. The same conclusion would have been obtained, by supposing all the water frozen, excepting that portion which was at first included in the syphon.

### Scholium.

The arts of levelling and of conducting water are founded upon the preceding proposition. As water will always rise to the same level as the spring from which it flows, it may be conveyed in pipes through the deepest vallies, and over the highest eminences, provided the pipe never rises to a greater height than the source of water. Had the ancients been acquainted with this simple principle, they might have saved the construction of those expensive aqueducts with which their towns were supplied with water.

Levels are sometimes made upon the principle contained in the proposition. Mr Keith's mercurial level is nothing more than a syphon filled with mercury, with a float on each branch, which supports two sights. See *Edinburgh Transactions*, vol. ii. p. 14; and our article Levelling.

### Prop. III.

If a mass of fluid contained in a vessel is in equilibrio, any one particle of the fluid is pressed in every direction, with a force equal to a weight of the column of the fluid, whose base is equal to that particle, and whose height is the depth of the particle below the surface.

Let $p$, Fig. 5, be the particle of fluid whose depth in the vessel of fluid ABCD is $ep$. We may suppose, as formerly, that a portion of the water is frozen, so as to form a tube of ice $ep$, whose diameter is equal to that of the particle $p$, without any change taking place in the pressure sustained by $p$. In this case, the particle $p$ is obviously pressed downwards with the weight of the column $ep$; and, consequently, the measure of this pressure is the absolute weight of the column $ep$. But as the particle is in equilibrio, it must be pressed with this force in every direction.

The proposition is also true of a particle situated at $m$, for drawing the horizontal line $mg$; and supposing a syphon of ice $fghm$ to be formed, it is obvious that the column of fluid in the branch $mh$ is in equilibrio with, or balanced by, the column in $gh$; consequently the particle of water at $m$ is pressed with the same force as the particle at $g$, that is, with a column of water whose height is $fg$.

*Cor.* Hence it follows, that every particle of a vessel containing fluid is pressed with a force equal to a column of fluid, whose base is the particle, and whose height is the depth of the particle below the surface; for, since the particle of fluid adjacent to this particle of the vessel is pressed in every direction with this force, it must exert the same force against that particle of the vessel.

### Prop. IV.

The pressure exerted by a fluid upon any given portion of the vessel which contains it, is equal to a column of the fluid whose base is the area of the given portion, and whose altitude is the depth of the centre of gravity of the portion below the fluid surface.

Let $mn$ be the given portion of the vessel ABCD, Fig. 6. filled with fluid, and let us conceive this portion to be occupied by any number of particles $m, o, p, n$, &c. then the pressure sustained by each of these particles, by Prop. III. will be $\overline{m \times mu} + \overline{o \times ox} + \overline{p \times py} + \overline{n \times nz}$, &c.; but, by the property of the centre of gravity or inertia, (See Mechanics,) the sum of these products is equal to the distance EF of the centre of gravity E, from the surface at F, multiplied into the number of particles $m, n, o, p$; that is, $\overline{m \times mu} + \overline{o \times ox} + \overline{p \times py} + \overline{n \times nz} = \text{EF} \times m, n, o, p$; consequently, since $m, n, o, p$, represents the area, or the number of particles in the given portion $mn$, the pressure upon $mn = \text{EF} \times mn$.

*Cor.* 1. It follows from this proposition, that the pressure sustained by the bottom of the vessel is not the same as the weight of the fluid contained in the vessel. In the cylindrical vessel shewn in Fig. 7, or in any vessel, whatever be its shape, in which the sides are perpendicular to its bottom, the pressure upon the bottom is accurately measured by the weight of the water which it contains; but in vessels of all other shapes, such as Fig. 8, 9, the pressure on the bottom is measured by $mn \times mx$, which in Fig. 8 is much less than the weight of water in the vessel, and in Fig. 9 much greater.

*Cor.* 2. The truth of what is called the Hydrostatic Paradox is easily deduced from the preceding proposition. Let ABCDEFGH, Fig. 10, be a vessel filled with water, then, by the proposition, the pressure upon GF $=$ GF $\times$ GI, however narrow be the column ABCD; that is, *the pressure exerted upon the bottoms of vessels filled with fluid does not depend upon the quantity of the fluid which they contain, but solely upon its altitude.* In like manner, it is obvious from Prop. II. that the water will stand at the same level *a b* AB, Fig. 11, in the two communicating vessels *a b c d*, ABCD, consequently, *any portion of fluid* abcd, *however small, will balance any portion of fluid* ABCD, *however great.*

*Cor.* 3. The pressure exerted upon the sides of a vessel, perpendicular to its base, is equal to the weight of a rectangular prism of the fluid, whose height is equal to that of the fluid, and whose base is a parallelogram, one side of which is equal to the height of the fluid, and the other to half the perimeter of the vessel.

*Cor.* 4. The pressure against one side of a cubical vessel is equal to half the pressure against the bottom; and the pressure against the sides and bottom together, is equal to three-times the pressure against the bottom alone. Hence, by Cor. 1. the pressure against both the sides and bottom together, is equal to three times the weight of fluid in the vessel.

*Cor.* 5. The pressure exerted upon the surface of a hemisphere full of fluid, is equal to the product of that surface multiplied by its radius.

*Cor.* 6. The pressure sustained by different parts of the sides of a vessel are as the squares of their depths below the surface. Hence, these pressures will be represented by the ordinates of a parabola, when the depths are represented by its abscissæ.

DEFINITION.

The *centre of pressure* is that point of a surface exposed to the action of a fluid, to which, if a force equal to the whole pressure upon the surface were applied, the effect would be the same as it is when the pressure is distributed over the whole surface.

PROP. V.

To find the centre of pressure.

Let it be required to find the centre of pressure P, Fig. 11, on the side of a cubical vessel ABCD. Let G be the centre of gravity of the surface, then the pressure exerted against this surface will be $BC \times BC \times GB$, or $\frac{BC^3}{2}$, since in the case of a cube or rectangle, $GB = \frac{BC}{2}$, and since the pressure must be equal to the sum of all the elementary pressures upon the elementary portions $Ff$, we have $\frac{BC^3}{2} \times PB = \int BC \times Ff \times FB \times FB$, or $\frac{BC^2}{2} = \int Ff \times FB^2$. But the sum of the elementary pressures $Ff \times FD^2$ compose a pyramid whose base is $= BC^2$, and whose altitude is BC, consequently, by the property of the centre of inertia (See MECHANICS) $\frac{DC^2 \times PB}{2} = \frac{DC^3}{3}$, and $PB = \frac{2\,DC}{3}$, that is, the centre of pressure is two-thirds of the depth of fluid in the vessel.

COR. The centre of pressure coincides with the centre of percussion, as the centre of percussion is also two-thirds of the height of the body.

SECT. II. *On the Pressure and Equilibrium of Fluids of Variable Density.*

DEFINITION.

THE absolute weights of different bodies that have the same bulk are called their *specific gravities* or *densities*, and any body, that, under the same bulk, is heavier than another, is said to be *specifically heavier.*

PROP. I.

If two fluids of different densities are included in the separate branches of a syphon, they will be in equilibrio, when the altitudes above their common junction are reciprocally proportional to their specific gravities.

Let ABCD, Fig. 12, be the syphon, and AB, CD the heights of the two fluids of different densities, which may be supposed separated from each other by the common junction $m\,n$. Then, if G is the centre of gravity of the surface $m\,n$, the pressure exerted by the fluid in AB is, by Prop. IV. $mn \times Gs$, and that of the fluid in CD, $mn \times GB$; but since their specific gravities S, S′ are, by the hypothesis, reciprocally as their altitudes, that is, $S : S' = Gr : Gs$, we have $S \times Gs = S' \times Gr$; but the pressure of the one column is $mn \times Gs \times S = mn \times Gr \times S$, the pressure of the other, consequently they will be in equilibrio.

If $op$ be the junction of the two fluids, then, by drawing the horizontal line $op\gamma tv$, we may regard the columns $opmn$, $tvnm$ as balancing one another, since they are composed of the same fluid, and then consider the columns $ABpo$, $CDvt$ of different densities, as resting upon the surfaces $op$, $tv$. In this case, $\gamma s \times S' = \gamma r \times S'$, and consequently the pressures $op \times \gamma s \times S = op \times \gamma r \times S'$.

In the case of water and mercury, the values of S, S′ are 1 and 13.58 at a temperature of 60°, consequently $Gs : Gr = 13.58 : 1$; and therefore, to balance 33 feet of water, a column of mercury 29.16 inches will be required.

PROP. II.

The pressure on the bottom of a vessel containing horizontal strata of fluids of different densities, is equal to the area of the bottom multiplied by the sum of the products of the thickness of every stratum and their specific gravities.

Let ABCD, Fig. 13, be the vessel, and $ABfe$, $efhg$, $ghlk$, and $klcD$ strata of different densities, S, S′, S″, S‴. Then since, by the last Prop. any column of fluid is in equilibrio with another, or has the same pressure when their heights are reciprocally as their densities, calling H, H′, H″, &c. the heights of the strata, we have $S : S' = H' : H$, and $H = \frac{S' \times H'}{S}$. We may therefore substitute a column of fluid of the same kind as the lower stratum $k$C, and having an altitude $\frac{S' \times H'}{S}$ instead of the column $gl$, and in like manner, instead of the other columns $eh$, $Af$ we may substitute columns whose heights are $\frac{S'' \times H''}{S}$ $\frac{S''' \times H'''}{S}$, and therefore calling DC the area of the bottom, the whole pressure on the bottom will be $= S \times DC \times H + \left( \times H + \frac{S' \times H'}{S} + \frac{S'' \times H''}{S} + \frac{S''' \times H'''}{S} \right) = DC \times (S \times H + S' \times H' + S'' \times H'' + S''' \times H''')$, which is the truth announced in the proposition.

PROP. III.

If a fluid contained in a vessel consists of an infinite number of strata, whose densities vary according to any law, the fluid will be in equilibrio, when the surfaces of the strata are perpendicular to the direction of gravity.

If the lower stratum of $klc$ D (Fig. 13.) were placed alone in the vessel, its surface $kl$ would be horizontal. Let us now suppose that every point of the surface $kl$ is pressed downwards by equal forces, which it will be, when it is pressed down by the weight of the superior strata with horizontal surfaces, then since there can be no reason why one point should yield more than another to these forces, it follows that the stratum $k$ C will still be in equilibrio. In like manner, it may be shewn, that the stratum $ghlk$ will be in equilibrio, and so on with all those above it, so that we may conclude that the whole fluid in the vessel is in equilibrio.

### Prop. IV.

To find the pressure exerted by a fluid composed of an infinite number of strata of variable density against any part of the vessel which contains it.

Let S, S′, S″, &c. be the specific gravities of the different strata $q\,p$, $p\,o$, $o\,n$, &c. then since the point $q$ sustains the weight of all the columns $q\,p$, $p\,o$, &c. above it, it will be pressed down by a force equal to $S \times q\,p + S' \times p\,o + S'' \times o\,n$, &c. $= S \times \left(\frac{q\,p + S' \times p\,o}{S} + \frac{S'' \times o\,n}{S} \times \text{\&c.} = S' \times \right.$ $\left(p\,o + \frac{S \times q\,p}{S'} + \frac{S'' \times o\,n}{S'} + \text{\&c.} = S'' \times (o\,n + \frac{S \times q\,p}{S''} + \frac{S' \times p\,o}{S''} + \text{\&c.}\right)$ Hence it follows, that we may substitute in place of the fluid of variable density a fluid whose density is uniform through the whole height $q\,m$.

Let us take an infinitely small elementary stratum $e\,n\,f\,\varphi\,\varphi\,\varepsilon$ contained between the horizontal lines $e\,n\,f$, $\varepsilon\,\nu\,\varphi$, then the pressure upon $e\,\nu$ is the absolute weight of the column $m\,\nu$; but making $m\,n = x$, and $\Sigma =$ the specific gravity of the fluid in $n$, the weight of $m\,n$ will be $\int \Sigma\,x$, and therefore the sum of the pressures against A $e$ will be $\int A\,e \times \int \Sigma\,x$. Thus to find the pressure upon the bottom DC, let $q\,m = a$, and $S =$ the specific gravity of the fluid in DC, then $\Sigma = \frac{S\,x}{a}$, and $\int \Sigma \dot{x} = \int \frac{S\,x\,\dot{x}}{a} = \frac{S x^2}{2a}$; and since, in the case of a pressure upon the bottom, $x = a$, we have $\frac{S\,x^2}{2\,a} = \frac{S\,a}{2}$ and the whole pressure upon the bottom $= \frac{S\,a}{a} \times \text{DC}$.

## CHAP. II.

### On Specific Gravities.

### Prop. I.

If any object floats upon a fluid, or is wholly immersed in it without sinking, it is pressed upwards with a force equal to the weight of the fluid displaced.

Let EF (Fig. 14.) be a body floating in the vessel ABCD. Then by Prop. III. Chap. I. any point or particle $n$ is pressed upwards with a force equal to a column of particles whose height is $m\,n$, and as this is true of every part of the surface E $n$ F, then since the part of the solid immersed is made up of these elementary columns, it follows that the sum of all the pressures exerted upon E $n$ F is equal to a quantity of fluid of the same size as the immersed part, which is the same as the quantity of fluid displaced.

When the body EF is wholly immersed, as in Fig. 15, it is obvious, that any part $o$ is pressed downwards with a column of fluid whose height is $m\,o$, while any part $n$ is pressed upwards with a column of fluid whose height is $m\,n$; consequently the point $n$ is pressed upwards with a column $n\,o = m\,n - m\,o$. But the sum of all the elementary columns $n\,o$ make up a quantity of fluid equal to that which is displaced by the body.

*Cor.* When a solid floats on a fluid, the quantity of fluid which it displaces is equal to the weight of the body. Since the whole weight of the solid pressing upon the surface of water E $n$ F is in equilibrio with the fluid mass, it must be equal in weight to the quantity of fluid E $n$ F, which is also in equilibrium with the same fluid mass, but this quantity of fluid is the quantity which is displaced.

### Prop. II.

When a body floats upon a fluid, the centre of gravity of the body and of the fluid displaced are in the same vertical line.

For since the upward pressure which supports the floating body is the same as if it were applied to the centre of gravity of the part immersed, or of the quantity of fluid displaced, then since the whole floating body is in equilibrio, its centre of gravity must be supported by this upward pressure; that is, the centres of gravity of the fluid displaced and of the floating body must be in the same vertical line.

### Prop. III.

The specific gravity of any floating body is to that of the fluid, as the volume of the part immersed is to the whole volume of the body.

Calling S the specific gravity of the fluid, and $s$ that of the solid, we have by Cor. Prop. I. $S \times E\,n\,F = s \times E\,p\,F\,n$, and therefore $s : S = E\,n\,F : E\,p\,F\,n$; that is, as the part immersed is to the whole volume of the body.

### Prop. IV.

If a solid is weighed in a fluid, it will lose as much of its weight as is equal to the quantity of fluid displaced.

It appears from Prop. I. that the body is pressed upwards with a force equal to the weight of the fluid displaced; and as this force acts in opposition to the natural gravity or absolute weight of the body, its absolute weight must be diminished by a quantity equal to the weight of the fluid displaced. The weight which the body in this case loses is not destroyed, but is sustained by an equal and opposite force.

If we call $s$ the specific gravity of the solid, S that of the fluid, B the bulk of the solid, and $m$ B the part of it which is immersed; then since $B \times s$ is the absolute weight of the solid, and $m\,B \times S$ the absolute weight of the quantity of fluid displaced, in order that an equilibrium may take place, we must have $B \times S = m\,B \times S$, and $S : S = m\,B : B$. Hence if $s = S$, we have $m\,B = B$; that is, *if the specific gravity of the solid is equal to that of the fluid, the part immersed is equal to the whole body;* or, in other words, *the solid will be completely immersed, and will remain wherever it is placed.* If $s > S$, then $m\,B > B$; that is, *when the specific gravity of the solid is greater than that of the fluid*, the body will sink to the bottom: and if $S > s$, then $m\,B < B$; that is, *when the specific gravity of the fluid is greater than that of the solid, then the part immersed is less than that of the whole solid*, or the body will float.

### Prop. V.

If a body is held beneath the surface of a fluid, the force with which it will ascend, if it is lighter than the fluid, or with which it will descend if it is heavier, is equal to the difference between its own weight and the weight of an equal quantity of the fluid.

The body held beneath the water obviously descends with its own weight $= B \times s$, while it is pressed upwards with the weight of the quantity of fluid displaced $= B \times S$; consequently the force with which it ascends must be $\overline{B \times S - B \times s}$, and the force with which it descends $= \overline{B \times s} - B \times S$, which are the differences between the weight of the body and the weight of the fluid displaced.

### Scholium.

On the truth contained in this proposition is founded the construction of the Camel for raising sunk vessels, or for lifting ships over high sand banks. (See our article Camel.) A similar effect is exhibited in some of the American rivers, where the ice is formed upon the stones at their bottom. Ice is specifically lighter than water, and therefore, when it accumulates to a certain degree round the stones, the upward pressure upon the stones exceeds their pressure downwards, and they are brought to the surface, having been sometimes torn up with great force. Huge masses of stones appear in many cases to have been floated by the ice adhering to them, and carried to a great distance from the place of their formation.

### Prop. VI.

The specific gravity of a solid is to that of the fluid in which it is weighed, as the absolute weight of the solid is to the loss of weight which it sustains.

In the equation $B \times s = m B \times S$, we have $B = m B$ when the body is weighed in a fluid, and of course wholly immersed; consequently if W be the weight of the body in the fluid, or the weight necessary to keep it in equilibrio with the fluid, then $B \times s = B \times S + W$, (and transposing and multiplying by $s$,) we have $s \times \overline{B \times s - W} = s \times B \times S$, and (Euclid, Book VI. 16.) $s : S = B \times s : B \times s - W$; consequently since $B \times s - W$ is the loss of weight which it sustains, the specific gravity of the solid is to that of the fluid, as the weight of the solid is to its loss of weight.

This Proposition may also be demonstrated, by considering that the weight lost, or $B \times s - W$, is the weight of a bulk of fluid equal to the bulk of the solid, whose weight is $B \times s$; and therefore, as the specific gravities are to one another, by the definition, as the weight of equal bulks, we have $s : S = B \times s : B \times s - W$.

### Prop. VII.

If the same solid body is weighed in two fluids, the specific gravities of the fluids are to one another as the losses of weight which the solids respectively sustain in each.

Making B the bulk of the body as before, S, S′ the specific gravities of the two fluids, and W, $w$ the weights of the solids in each fluid, then the weight of the quantities of fluid displaced will be $B \times S$, $B \times S'$, and since these weights are the weights lost by the body, if we add the weights of the body in the fluid, viz. W, $w$, to these weights, we shall have an expression which will be equal to $B \times s$, the real weight of the body. Thus:

$$B \times S + W = B \times s \text{ and } B \times S' + w = B \times s.$$

Hence we have the two equations,

$$B \times S = B \times s - W \text{ and } B \times S' = B \times s - w; \text{ hence}$$

$S \times B : S' \times B = B \times s - W : B \times S' - w$, consequently, (Eucl. B. V. 16.) $S : S' = B \times s - W : B \times s - w$, that is the specific gravities, or as the losses of weight sustained by the solid, for these losses must always be equal to the difference between the real weights and the weights W, $w$ in the fluid.

*Cor.* Hence, if two solid bodies lose equal parts of their weights in the same fluid, they have equal volumes.

### Prop. VIII.

If a solid body is immersed in two fluids of different specific gravities, so as to be partly in the one and partly in the other, it will be in equilibrio, if the part in the lighter fluid is to the part in the heavier fluid, as the difference between the specific gravities of the solid and the heavier fluid is to the difference of the specific gravities of the solid and the lighter fluid.

Let E F, Fig. 16, be the solid immersed in two fluids, and having the part M in the lighter fluid, whose specific gravity is S, and the part N in the heavier fluid, whose specific gravity is S′, and let $s$ be the specific gravity of the solid. Now the weight of the solid is $s \times \overline{M + N}$, the weight of the heavier fluid displaced by N is $S' \times N$, and the weight of the lighter fluid displaced by M is $S \times M$. But as the solid is, by the hypothesis, suspended in the fluids, the whole of its weight is lost; and consequently the part lost in the lighter fluid, added to the part lost in the heavier fluid, must be equal to its whole weight, that is, $S \times M + S' \times N = s \times \overline{M + N}$; then, by transposition, and Euclid, B. VI. 16, we have $M \times \overline{S - s} = N \times S' - s$ and $M : N = S' - s : S - s$.

*Cor.* 1. Since $M : N = S' - s : S - s$ then, by inversion and composition, Eucl. B. V. prop. B and 18, $M : M + N = S' - s : S' - S$, that is, *the part in the lighter fluid is to the whole solid, as the difference between the specific gravities of the solid and the heavier fluid is to the difference between the specific gravities of the two fluids.*

*Cor.* 2. If the specific gravity S of the lighter fluid is very small when compared to S′, as in the case of air and water, then we may, for ordinary purposes, take the analogy $M : N = S' - s : s$.

### Prop. IX. Prob.

To detect the adulteration of the precious metals.

Let us suppose, as in the case of Hiero's crown, that a mass of pure gold is adulterated by the admixture of silver. If we take a quantity of pure gold of the same weight as the adulterated mass, it will obviously have less bulk, as its specific gravity is greater than that of the mixture, (silver having a less specific gravity than gold) and therefore the quantity of pure gold, when weighed in water, will displace less of the fluid than the adulterated mass. Hence it follows, that we have only to weigh the suspected mass, and a mass of pure gold of the same weight; and if there is any difference in their weight, we must conclude that the mass is adulterated.

If the gold is heavier in water than the suspected mass, it has obviously lost less weight, and has therefore less bulk than the mass; consequently the adulterating mixture has a less specific gravity than gold. If, on the contrary, the gold loses more weight than the mass, it will have a greater bulk, and therefore the adulterating metal must have a higher specific gravity than gold, such as platinum.

### Prop. X.

If two substances of any kind be compounded together, the bulk of the heavier of the two ingredients is to the bulk of the lighter ingredient, as the difference between the specific gravities of the compound and the lighter ingredient is to the difference between the specific gravities of the compound and the heavier ingredient.

Calling S, S′ the specific gravities of the ingredients, B, B′ their bulks and Σ the specific gravity of the compound, then the weight of the compound is $\Sigma \times B + B'$, and as the weight of the compound must be equal to the sum of the weights of its ingredients, we have $\Sigma B + \Sigma B' = B \times S + B' \times S'$, and by transposition, &c. we have $B \times \Sigma - S = B' \times S' - \Sigma$ and (Eucl. VI. 16.) $B : B = S' - \Sigma : \Sigma - S$.

Scholium.

The supposition in the preceding reasoning, that the bulk of the compound is equal to the sum of the bulks of its ingredients, is not physically true. A pint of alcohol or of sulphuric acid, mixed with a pint of water, will not make so much as two pints of the compound fluid; and, on the other hand, a cubical inch of tin, mixed with a cubical inch of lead, will make a compound containing more than two cubical inches of metal. A certain bulk of water is diminished by the addition of $\frac{1}{61}$ of sal ammoniac; and 40 parts of platinum and 5 of iron will make but 39 parts by measure.

Prop. XI. Prob.

To determine accurately the specific gravity of gaseous or aeriform bodies.

As the specific gravities of gaseous bodies are measured in relation to that of air, we must first determine the weight of a given volume of this gas. In order to do this, take a large glass vessel, containing at least five or six litres, and having exhausted it of its air by a good air-pump, weigh it in a delicate balance, and call its weight W. Let the air be now admitted to the glass vessel, and let its weight, as ascertained by the balance, be now called W′. The difference between these weights, or W—W′, will obviously be the weight of the atmospherical air contained in the vessel. Let it now be required to measure the specific gravity of another gas. Weigh the glass vessel when empty as formerly, and also when full of the gas, and let these weights be $w$, $w'$, then $w-w'$ will be the weight of the gas, and $\frac{w-w'}{W-W'}$ will be its specific gravity compared with that of the air, which is taken at 1.000. This specific gravity is that which corresponds with the state of the atmosphere at the time when the experiment was made.

It is obvious, however, that all these measures are affected by a variation in the density, the temperature, and the humidity, of the external atmosphere. The weight, too, of the gases, when they are introduced into the receiver, is affected by the temperature and pressure of the air. The contraction and dilatation of the glass vessel requires also to be computed; and the weight of the gas itself is affected by the temperature and the degree of drying which it has experienced. These various sources of error likewise affect the results, in so far as they affect the external atmospherical air in which both the air itself and the gas must be weighed. Some allowance must also be made for the imperfect exhaustion of the glass vessel, which is always visible by its effect upon the barometer.

It will readily be seen, that it must require no small degree of trouble to calculate the combined influence of these different causes, though, in order to obtain accurate results, such a calculation becomes absolutely necessary. As it would be impracticable in the present article to enter into any lengthened examination of the subject, we must refer such of our readers as wish to study it profoundly, to the 19th, 20th, and 21st chapters of M. Biot's valuable work, entitled *Traité de Physique*, which not only contain the method of deducing the necessary formulæ, but also many excellent remarks and suggestions which could only have been given by one who had investigated the subject both theoretically and practically. The following are his principal formulæ, which are suited to a temperature of 32° of Fahrenheit, or that of melting ice, and to a state of the atmosphere when the barometer stands at 0.76 metres, or 29.94 English inches.

In these formulæ,

$X$ = the absolute weight of atmospheric air contained in the glass vessel at a temperature of 32°, and under a pressure of 29.94 inches of mercury, as calculated from the formulæ.

$Y$ = the absolute weight of any gas under the same circumstances.

$V$ = the interior volume of the glass vessel at the same temperature.

$K$ = the cubical dilatation of glass for every degree of the centigrade thermometer.

At the time when the glass vessel is weighed empty:
- $P$ = the absolute weight of the glass vessel, which never changes.
- $h$ = the atmospherical pressure.
- $t$ = the temperature of the air.
- $p$ = the state of the hygrometer.
- $\theta$ = the tension in the interior of the glass vessel, after a vacuum is made by the air pump.

At the time of the introduction of the gas into the glass vessel:
- $p$ = external pressure exerted upon the gas.
- $t'$ = temperature of the gas.
- $p'$ = its hygrometric state.

At the time when the glass is weighed full of gas:
- $P''$ = the weight of the glass vessel filled with gas.
- $p''$ = the atmospherical pressure.
- $t''$ = the temperature of the external air.
- $h''$ = the state of the hygrometer.

When the glass vessel is weighed empty a second time, after it has been weighed full of gas:
- $P'''$ = the weight of the glass vessel empty observed in air.
- $p'''$ = atmospherical pressure.
- $t'''$ = temperature.

1. *Formulæ suited to the case where the Gases are perfectly dry.*

$$X = \frac{P'' - P\ 0^m.76}{\frac{(1+Kt)p}{1+t.0,00375} + \frac{(1+Kt')p'}{1+t.0,00375} - \frac{(1+Kt'')p''}{1+t''.0,00375}} \qquad \text{(No. 1.)}$$

$$2Y = \frac{(2P'' - P - P''')\ 0^m.76 + \frac{2X(1+Kt'')p''}{1+t''.0,00375} - \frac{X(1+Kt)p}{1+t.0,00375} - \frac{X(1+Kt''')p'''}{1+t'''.0,00375}}{\frac{(1+Kt)p}{1+t'.0,00375}} \qquad \text{(No. 2.)}$$

In the ordinary state of the atmosphere, the barometer and thermometer indicate only very small and progressive changes, so that in the short time which can elapse between the different weighings of the gas, we may safely suppose the atmospherical pressure $p''$, and the temperature $t''$, corresponding to the intermediate weighing of the glass vessel, as arithmetical means between the extreme pressures $p$, $p'''$, and the extreme temperatures $t$, $t'''$. In proportion, therefore, as the variations in these elements have been inconsiderable, we may consider them as compensating themselves in the terms of X: These terms will consequently disappear, and the formula will be reduced to the following simple form:

$$Y = \frac{\left(P'' - \frac{(P+P''')}{2}\right)(1+t'.)0,00375\ .0''',76}{(1+Kt')p'}. \qquad \text{(No. 3.)}$$

This formula will be found sufficiently exact when the gases and the atmospherical air are perfectly dry; but as this is never the case, and as the aqueous vapour has a very considerable influence upon the weight at a temperature above 50° of Fahrenheit, it is necessary to compute its effect.

2. *Formulæ suited to the case where the Gases are perfectly saturated with Water.*

In the following formulæ, X is the weight of a volume of a dry atmospherical air contained in the glass vessel, at the temperature of 32°, and the barometrical pressure of 0.76 metres, or 29.994 English inches.

T = the real tension of aqueous vapour at the weighing of the glass vessel empty.
T′ = the tension at the introduction of the gas.
T″ = the tension at the weighing of the glass vessel full of gas.

$$X = \frac{P'' - P\ .0_m.76}{\frac{(1+Kt)\ (p - \frac{3}{8}T)}{1+t\ .0,00375} + \frac{(1+Kt')\ (p' - \frac{3}{8}T')}{1+t'\ .0,00375} - \frac{(1+Kt'')\ (p'' - \frac{3}{8}T'')}{1+t''\ .0,00375}} \qquad \text{(No. 4.)}$$

$$Y = \frac{(P''-P)_m 0.76 - \frac{5X\ (1+Kt')\ T')}{8(1+t'\ .0.00375)} + \frac{X(1+Kt'')\ (p'' - \frac{3}{8}T''}{1+t''\ .0,00375} - \frac{X(1+Kt)\ (p - \frac{3}{8}T)}{1+t\ .0,00375}}{\frac{(1+Kt')\ (p' - T')}{1+t'\ .0,00375}} \qquad \text{(No. 5.)}$$

These formulæ will answer, when the external air, in which the air and the gas are weighed, are not saturated with moisture. In this case, T′ and T″ will express the tension of the aqueous vapour really suspended in this air.

The preceding results may be rendered independent of the quantity of aqueous vapour contained in the atmosphere at the time of the experiment, by the method employed above, namely, by weighing a second time the glass vessel empty, immediately after it has been weighed full of the gas. Then, if $t'''$ is the temperature at which this is done, $p'''$ the atmospherical pressure, T‴ the tension of the aqueous vapour, and P‴ the weight observed, the resulting formula will be

$$Y = \frac{\left(P'' - \frac{(P+P''')}{2}\right)0^m.76 - \frac{5X\ (1+Kt')\ T'}{8(1+t'\ .0,00375)}}{\frac{(1+Kt')\ (p' - T')}{1+t'.0,00375}} \qquad \text{(No. 6.)}$$

This formula becomes exactly the same as No. 3, when T′ = .0; that is, when the gases are perfectly dry.

3. *Formulæ suited to the Case when the Gases are perfectly dry, but the exhaustion not complete.*

The above formulæ will be sufficiently correct, if the exhaustion of the glass vessel is made with a very fine air pump, but as this is not generally to be met with, let us suppose $\theta$ to be the tension of the little air which remains in the glass vessel, as marked by the gauge. Then

$$Y = \frac{(P'' - P''')\,0^m.76 + \frac{X(1+Kt'')\,(p''-\frac{3}{8}T'')}{1+t''\,.0{,}00375} - \frac{X(1+Kt''')\,(p'''-\frac{3}{8}T''')}{1+t'''\,.0{,}00375}}{\frac{(1+Kt')\,(p'-\theta}{1+t'\,.0{,}00375}} \qquad \text{(No. 7.)}$$

which, by the means formerly described, may be reduced to

$$Y = \frac{\left(P'' - \frac{(P+P''')}{2}\right)(1+t'\,.0{,}00375)\,0^m.76}{(1+Kt')\,(p'-\theta)}.$$

M. Biot has exemplified the use of the formula No. 5. by an experiment which he made on the 3d July 1806, for the purpose of determining the specific gravity of hydrogen gas. In this experiment, the different quantities had the following values.

At the weighing of the empty glass vessel, $P = 662.262$ grammes; $t = 20°\,9$ centigrade; $p = 0.7616$ metres.

At the introduction of the gas into the glass vessel $t' = 21°\,4$ centigrade; $p' = 0.7630$ metres.

At the weighing of the glass vessel when full $P'' = 662.823$ grammes; $t'' = 20°\,6$; $p'' = 0.7622$

The gas was saturated with water, and the hygrometer indicated a state of the atmosphere approaching to extreme humidity.

Weight of the atmospherical air in the glass vessel, as determined by preceding experiments $X = 7.2532$ grammes.

Log. $X = 0.8605315$

Cubical dilatation of glass for one degree of the centigrade thermometer $K = 0.0000262716$

Log. $K = 5.4194865$

Elastic forces of the aqueous vapour at the temperatures $t, t', t''$, calculated from a formula given by Biot, vol. i. p. 27. $T = 0.0185$ metres. $T' = 0.0190$; $T'' = 0.0182$. Consequently $\frac{3}{8}T = 0.0069$. $\frac{3}{8}T'' = 0.0068$. Hence

$$p - \tfrac{3}{8}T = 0.7547 \text{ metres};$$
$$p' - \tfrac{3}{8}T' = 0\,7440;$$
$$p'' - \tfrac{3}{8}T'' = 0.7554;$$

But as the pressures $p, p', p''$, or the altitude of the mercury in the barometer, were observed at different temperatures, they must be reduced to that of 32° of Fahrenheit, by subtracting from each of them the corresponding dilatation of mercury. Hence we shall have

$$p = \frac{0.7547\ .\ 20°.9}{5412} = 0.0029 \text{ metres.}$$
$$p' = \frac{0.7440\ .\ 21°4.}{5412} = 0.0029.$$
$$p'' = \frac{0.7554\ .\ 20°.6}{5412} = 0.0029;$$

so that the barometrical columns thus reduced, will be

$$p - \tfrac{3}{8}T = 0.7518;\ p' - \tfrac{3}{8}T' = 0.7411;\ p'' - \tfrac{3}{8}T'' = 0.7525.$$

We have also . . . . $1 + Kt = 1.000549$; $1 + t\ .0{,}00375 = 1.078375$
$1 + Kt' = 1.000562$; $1 + t'\ .0{,}00375 = 1.080250$
$1 + Kt'' = 1.000541$; $1 + t''\,.0{,}00375 = 1.077250$

With these elements, and with X, which has been found, we have

$$\frac{X\,(1+Kt'')\,(p''-\frac{3}{8}T'')}{1+t''\,.0{,}00375} = 5.088935 \text{ grammes.}$$
$$\frac{X\,(1+Kt)\,(p-\frac{3}{8}T)}{1+t\,0.00375} = 5.078947$$

Difference . . 0.009988

Hence we have the difference of these two terms, or

$$\frac{X(1+Kt'')\,(p''-\frac{3}{8}T'')}{1+t''\,0.00375} - \frac{X(1+Kt)\,(p-\frac{3}{8}T)}{1+Kt\,.0{,}00375} = 0.009988 \text{ grammes.}$$

By adding to this $(P'' - P)$ .0.76 metres . . . . . . . . . . . . $= 0.43016$

we have . . . . . . . . . . . . . . . . . . . . . . . 0.440148

which is the sum of all the positive terms of the numerator.

By subtracting the negative term, or $\frac{5\,X\,(1+Kt')\,T'}{8\,(1+t'\,.0.00375)}$ . . . $= 0.0797783$

The difference is . . . . . . . . . . . . . . . . . . . . 0.360370

which is the value of the numerator of the formula.

$$\text{The denominator, or } \frac{(1+K\,t')\,(p'-T')}{1+t'.0.00375} \quad . \quad . \quad = 0.6891163$$

$$\text{we have } Y = \frac{0.36037}{0.6891163} \quad . \quad . \quad . \quad . \quad . \quad = 0.522945 \text{ grammes,}$$

which is the weight of the volume of hydrogen gas contained in the glass vessel at 32° of Fahrenheit, and 0.76 metres, or 29.994 inches of the barometer. Hence we have the specific gravity of hydrogen gas, or

$$\frac{Y}{X} = \frac{0.522945}{7.25323} = 0.720982.$$

PROP. XII. PROB.

To determine accurately the specific gravity of liquids.

The accurate determination of the specific gravity of liquids is, like that of gaseous bodies, attended with considerable difficulty. As the specific gravities of the gases are referred to that of atmospheric air, so in liquid and solid bodies the specific gravities are referred to that of water, when at the temperature of + 3°.42 of the centigrade scale, or 38°.15 of Fahrenheit, which corresponds to the maximum density of that fluid.

In measuring the specific gravities of liquids, a glass vessel with a narrow neck, after having been accurately weighed when empty, is successively weighed when filled with distilled water, and with the liquid whose specific gravity is required, and the temperature and atmospherical pressure are carefully marked. The volume of water and of fluid may then be obtained by the following formulæ which have been given by M. Biot. In these formulæ,

V = the interior capacity or volume of the glass vessel in cubic centimetres, at the temperature of 32° of Fahrenheit, or that of melting ice.
L = the apparent weight of the liquid when it is weighed.
$\lambda$ = dilatation of the liquid at 32° of Fahrenheit, taking its volume at this temperature for unity.
$\delta'$ = the dilatation of water from its maximum density to the temperature $t'$.
F = the apparent weight of the water at the temperature $t'$.
$t$ = the temperature when the liquid is weighed.
$t''$ = the temperature reckoned from the point of maximum density, or $t'' = t - 3°.42$.
$a$ = the weight of a volume of dry or moist air in the glass vessel at the time the liquid is weighed.
$(a)$ = the weight of a cubic centimetre of dry air, at the temperature of 32°, and the pressure of 0.76 metres, or 29.994 inches.
K = the cubical dilatation of glass for every degree of the centigrade thermometer.
$p$ = the height of the column of mercury when the liquid is weighed.
$p'$ = the height of the column of mercury in the barometer, reduced to the temperature of 32° of Fahrenheit.
$\alpha'$ = the relation of the weight of air to that of water, at the temperature $t'$.
T = the tension of the vapour of water in the air where the liquid is weighed.
$\pi$ = the weight of a cubic centimetre of the liquid at the temperature of 32° of Fahrenheit.

Then we have

$$\delta = 0.00000634750\, t''^2 - 0.00000002708\, t''^3 \quad \text{No. 1.}$$

$$\alpha' = \frac{(a)\, p'\, (1+\delta')}{(1+t'\,.\,0.00375)\, 0^m.76} \quad \text{No. 2.}$$

$$V = E + E\alpha' + \frac{E\,(1+\delta')\,(\alpha' - K\,t' + \alpha'\,K\,t')}{(1-\alpha')\,(1+K\,t')} \quad \text{No. 3.}$$

$$\alpha = \frac{(a)\, V\, (1+K\,t)\,(p - \frac{3}{8}\,T)}{(1+t\,.\,0.00375)\, 0^m.76} \quad \text{No. 4.}$$

$$\pi = \frac{(L+a)\,(1+\lambda)}{V\,(1+K\,t)} \quad \text{No. 5.}$$

The use of these formulæ will be best seen by applying them, as M. Biot has done, to the following experiments on mercury and water by him and M. Arago.

| Liquids. | Apparent weight of air in grammes, or values of L. | Temperature in degrees of the centigrade or values of $t$. | Height of the mercury in the barometer, or values of $p$. |
|---|---|---|---|
| | | | Metres. |
| Exp. 1. Mercury | 1342,989 | 12°.5 | 0.7439 |
| Exp. 2. Mercury | 1340,893 | 20 .6 | 0.7580 |
| Exp. 3. Water | 98,721 | 20 .1 | 0.7600 |
| Exp. 4. Water | 98,716 | 20 .9 | 0.7589 |

In calculating the value of V, from the formula No. 3, we have

$(a) = 0.001299541$ grammes, and Log. $(a) = \bar{3}.1137902$, and by the formula No. 1.

$\delta' = 0.0017017$ for Exp. 3. since $t'' = 20°.1 - 3°.42 = 16°.68$
$\delta' = 0.0018654$ for Exp. 4. $\quad t'' = 20\ .9 - 3\ .42 = 17\ .48$

The height of the mercurial columns, or $p$, being reduced to the temperature of 32° of Fahrenheit, we have

$$p' = 0.760 - 0.0028 = 0.7572 \quad \text{Exp. 3.}$$
$$p' = 0.7589 - 0.0029 = 0.7560 \quad \text{Exp. 4.}$$

With these values, and the temperature $t'$ observed at the time of the weighing, we have by the formula No. 2.

$$\alpha' = 0.001206079$$
$$\alpha' = 0.001192953$$

$$\text{Now } K\,t' = 0.0005281 \quad \text{Exp. 3.}$$
$$K\,t' = 0.0005491 \quad \text{Exp. 4.}$$

$$\text{Hence } \alpha'\,K\,t' = 0.0000006369, \quad \alpha' + \alpha'\,K\,t' - K\,t' = 0.00067861 \quad \text{Exp. 3.}$$
$$\alpha'\,K\,t' = 0.0000006551, \quad \alpha' + \alpha'\,K\,t' - K\,t' = 0.00064451 \quad \text{Exp. 4.}$$

By substituting these values in the formula No 3, we have, in cubic centimetres,

$$V = 98.721 + 0.1679935 + 0.0671518 = 98.9561453 \quad \text{Exp. 3.}$$
$$V = 98.716 + 0.1841449 + 0.0637819 = 98.9639268 \quad \text{Exp. 4.}$$

The arithmetical mean between these results is $V = 98.960036$. The capacity of the glass vessel at the temperature of 32° of Fahrenheit.

The absolute weight of mercury or any other liquid weighed in the same glass vessel, at a given temperature, may now be easily deduced from the formula No. 5. We shall follow M. Biot in applying the formula to Experiments 1. and 2. on mercury.

In order to calculate the value of $a$, we have $(a)$ $V = 0,1286201$ grammes, or the weight of dry air contained in the glass vessel at the standard temperature of 32° of Fahrenheit, and $0^{m}.76$ or 29.994 inches of atmospherical pressure.

Hence we shall have by the formula No. 4.

$a = 0,12004$ Exp. 1. and $a = 0.11872$. Exp. 2. Hence

$$\text{Exp. 1.} \begin{cases} L = 1342,989 \text{ grammes} \\ a = \phantom{134}0,12004 \\ \hline L + a \quad 1343,10904 \end{cases} \qquad \text{Exp. 2.} \begin{cases} L = 1340,93 \text{ grammes} \\ a = \phantom{134}0,11872 \\ \hline L + a \quad 1341,01172 \end{cases}$$

As these weights contain a great number of grammes, it is necessary to calculate the corrections with regard to $K\,t$ and $\lambda$ more exactly than would otherwise have been necessary. We have

$$\frac{L + a}{1 + K\,t} = L + a - \frac{(L + a)\,K\,t}{1 + K\,t}$$

The second of these terms, which is always very small, is the correction sought. Now

$$\frac{L + a}{1 + K\,t} = \overset{\text{grammes.}}{1343,10904} - 0,440919 = 1342,66812 \quad \text{Exp. 1.}$$

$$\frac{L + a}{1 + K\,t} = 1341,01172 - 0,725363 = 1340,286357 \quad \text{Exp. 2.}$$

By adding to each of these results its product by the dilatation $\lambda = \frac{t}{5412}$ in mercury we have

$$\frac{(L + a)\,(1 + \lambda)}{1 + K\,t} = 1342,66812 + 3,10113 = 1345,7692 \quad \text{Exp. 1.}$$

$$\frac{(L + a)\,(1 + \lambda)}{1 + K\,t} = 1340,28636 + 5,10160 = 1345,3880 \quad \text{Exp. 2.}$$

The arithmetical mean between these results is 1345,5786 grammes, which, being divided by V, already found to be 98,960036, we have

$$\pi = \frac{1344,5786}{98,960036} = 13,597190$$

which is the weight of a cubic centimetre of mercury in grammes, at the temperature of melting ice.

If we wish to compare this weight with that of water, we have only to calculate the last for the temperature of melting ice, or for —3°.42 of the centigrade thermometer. But if $\delta$ is the dilatation of water from its maximum density to its freezing point, or for 3°.42, the weight of water required will be $\frac{1}{1+\delta}$, and the relation between the weights of mercury and water at the temperature of melting ice will be $\pi\,(1+\delta)$. But, by substituting —3°.42 in the formula of dilatation, No. 1. we shall have $\delta = 0,0000748$. Hence

$$\pi\,(1+\delta) = 13,597190 + 0,001017 = 13,598207,$$

which is the exact ratio between the weights of equal volumes of mercury and water at the temperature of melting ice.

Prop. XIII. Prob.

To determine accurately the specific gravities of solid bodies.

In determining the specific gravities of solid bodies, we may adopt two methods. 1. We may weigh them successively in air and in some other fluid, which is the ordinary method; and then, if P is the apparent weight of the solid in air, and $p$ the weight of the volume of water which it displaces, we have $\frac{P}{p}$ for the specific gravity of the body, neglecting the necessary reductions; or, 2. After having weighed the solid in air, we may place the solid in a glass vessel, and weigh them conjointly, and then weigh the same glass vessel when filled only with water. If then D is the weight of the solid in air, $p$ the weight of the vessel containing the water and the solid, and $p'$ the weight of the vessel containing water alone; then $p - p'$ is the weight of the quantity of water displaced, and $\frac{P}{P - p + p'}$ will be the specific gravity required.

If the substance is soluble in water, like many of the salts, it is necessary to use alcohol, or some other fluid, such as the essential or fat oils, which are not capable of dissolving it. The specific gravity of the oil being known, that of the salt will be immediately found.

If the solid imbibes water, without either dissolving or decomposing it, it is necessary first to weigh the body when perfectly dry, which weight we may call P, and then weigh it when it has imbibed as much water as possible. Let this weight be P′. We must next find how much water the body displaces, which we may call $a$, then the apparent specific gravity of the body is $\frac{P}{a}$, as it has really displaced the quantity of water $a$. But, in order to know the specific gravity of the solid parts of the body which do not admit water, such as the real fibrous part of sponges, then we must consider, that the quantity of water displaced is not merely $a$, but $a—P'$, and therefore $\frac{P}{a-P'}$ is the real specific gravity, neglecting the necessary reductions.

In order to explain the formulæ given by M. Biot for solid bodies, let us take

$t$ = temperature at which the solid is weighed.
V = the volume of the solid body in cubic centimetres at the temperature $t$.
$(s)$ = the absolute weight of a cubic centimetre of its substance at the temperature of melting ice.
K = the cubical dilatation of the solid for one degree of the centigrade thermometer.
$(e)$ = the weight of a cubical centimetre of water at the temperature of melting ice.
$\delta$ = the dilatation of water from 32° to $t$.
$\alpha$ = the ratio of the weight of air to that of water in the circumstances under which the experiment is made.
$\lambda$ = the dilatation of any other liquid employed instead of water.
$(\pi)$ = the weight of a cubical centimetre of another liquid at the temperature of melting ice.
S = the weight of the solid in air.
S' = the weight of the solid in water.

*Case* 1. When the body is weighed successively in air and water,

$$(s)=\frac{(1+K\,t)\left(\frac{S(\pi)}{1+\lambda}-\frac{S'\,(e)\alpha}{1+\delta}\right)}{S-S'} \quad \text{No. 1.}$$

If the body has been weighed successively in water and in air at the same temperature, then $(\pi)=(e)$ and $\lambda=\delta$, consequently

$$(s)=\frac{(e)\,(1+K\,t)\,(S-S'\,\alpha)}{(1+\delta)\quad(S-S')} \quad \text{No. 2.}$$

*Case* 2. When there are three weighings, 1st of the solid body, 2d of the glass in a vessel filled with a liquid, and 3d of the same vessel containing the solid and the liquid;

$$\text{Then } (s)=\frac{(1+Kt)\left(\frac{S(\pi)}{1+\lambda}-\frac{(P-L)(e)\,\alpha}{1+\delta}\right)}{S-P+L} \quad \text{No. 3.}$$

If the body has been weighed successively in water and in air, then $(\pi)=(e)$ and $\lambda=\delta$, and the formula is reduced to

$$(s)=\frac{(e)\,(1+K\,t)\,[S-(P-L)\alpha]}{(1+\delta)\,(S-P+L)} \quad \text{No. 4.}$$

*Case* 3. When there are only two weighings, 1st of the solid in air, and 2d of the solid in liquid in the same vessel: In this case let M be the weight of the solid and liquid,

$$(s)=\frac{(e)\,(1+K\,t)\,[S-(P-M+S)\alpha]}{(1+\delta)(S-P+M-S)} \quad \text{No. 5.}$$

This formula differs from No. 4. only in the substitution of M — S in place of L.

## CHAP. III.

### On the Theory and Construction of Areometers, or Hydrometers, for measuring Specific Gravities.

### Sect. IV. *On the Construction of different Hydrometers.*

The names *areometer*, *hydrometer*, *gravimeter*, have been indiscriminately applied to those instruments which are employed, when very great accuracy is not required, for determining the specific gravities of spirituous liquors, and other fluids.

Before we enter upon the description of these instruments, we shall first explain the general principles of their construction, as exhibited in the hydrometer of Fahrenheit.

#### 1. *Fahrenheit's Hydrometer.*

This instrument is represented in Plate CCCXIV. Fig. 1. It may be constructed either of glass or metal, and consists of a cylindrical stem AB, Fig. 1. connected with two hollow balls C, D. A small quantity of mercury, or of leaden shot, is introduced into the lower ball D, so as to prevent it from overturning, and to make it float steadily when it is immersed in a fluid. In using this instrument, we may either load it with different weights, or have a scale of equal parts engraven upon its stem. Fahrenheit adopted the first of these methods. He made a mark $w$ upon the stem AB, and having immersed it in the lightest liquor, (Fahrenheit used spirits of wine and spirits of turpentine,) such as ether, he introduced mercury into the ball D, till the surface of the light fluid stood at the mark $w$. The tube AB was then hermetically sealed, and the instrument weighed in a nice pair of scales. This weight will obviously be the weight of the quantity of fluid which it displaces. When the instrument was placed in a denser fluid, such as water, he placed weights in the small box at A, till the hydrometer sunk to the same mark $w$. By again weighing the hydrometer with the additional weights, he obtained the weight of a quantity of the denser fluid which was displaced; but as the part immersed was the same in both cases, the two weights which he had obtained were the absolute weights of equal quantities of two fluids, and were, therefore, the ratios of their specific gravities. Thus if W be the weight of the loaded instrument in distilled water at the temperature of 60° of Fahrenheit, when it has sunk to any mark upon the stem, and $w$ the weight, which must either be taken from the box at A, or added to it, in order to make the instrument sink to the same point in another fluid, and B the volume or bulk of the part immersed, then S, $s$, being the specific gravities, we have $W = S \times B$, and $W \pm w = s \times B$. Hence $B = \frac{W}{S}$ and $B = \frac{W \pm w}{s}$, and $\frac{W \pm w}{s} = \frac{W}{S}$, and by reduction $s = \frac{S \times W \pm w}{W}$; or since $S = 1.00$ in water, $s = \frac{W \pm w}{W}$. In the thermometer of Fahrenheit which we have described, the stem AB is made very short, and is only one-third of the length of a tube which he places between the balls C and D.

The results obtained with this hydrometer, may be reduced to the temperature of 32° of Fahrenheit, and allowance made for the effects of heat, both upon the liquid and the hydrometer itself. The following formula, given by M. Biot, includes these effects.

$$(\pi) = \frac{(P + P')(1 + \lambda)}{(P)(1 + K\,t.)}$$

In this formula, $(\pi)$ is the weight in grammes of a cubic centimetre of the liquid subjected to experiment, $\lambda$ is the dilatation of this liquid from 32° to the temperature $t$, P is the absolute weight of the hydrometer when weighed *in vacuo*, or its weight in air diminished by the weight of the quantity of air which it displaces, and it also expresses, in cubic centimetres, the value of the part immersed in the liquid; (P) is the absolute weight of the part immersed at 32° of Fahrenheit; and K the cubic dilatation of the substance of the areometer.

### 2. *Clarke's Hydrometer.*

The hydrometer invented by Mr Clarke, and described in the Philosophical Transactions by Dr Desaguliers, was made of metal instead of glass. The principal ball was made hollow and of copper, and the brass wire of about $\frac{1}{4}$th of an inch thick, was soldered into it. Upon the stem a mark is made, to which the instrument sinks when it is placed in proof spirits, and another mark is made above and below this, at which it sinks when the spirit is $\frac{1}{10}$th under proof, or $\frac{1}{10}$th above proof. The lower ball could be screwed off, and other balls of different weights screwed on, for liquors that differ more than $\frac{1}{10}$th from proof, so as to give the specific gravities of all the mixtures of spirituous liquors that are used in trials. See the *Phil. Trans.* 1730, No. 413, p. 277.; and Desaguliers' *Course of Experimental Philosophy*, edit. 3d, vol. ii. p. 233.

### 3. *Desaguliers' Hydrometer.*

The object of this instrument was, to ascertain the specific gravities of different kinds of water; and in order to give it a high degree of sensibility, Dr. Desaguliers made the hollow glass ball less than three inches in diameter, while the stem to which it was attached was a long slender wire, whose diameter was only the 40th part of an inch, and whose length was 10 inches. Under the great ball is placed a small ball, about one inch in diameter, to contain shot for floating the instrument in a vertical position. In river or soft spring water, the hydrometer sinks to a fixed point in the middle of its stem. If a single grain weight is added, the stem will descend a whole inch. Now, as the hydrometer weighs 4000 grains, and as one inch of the stem weighs *ten* grains, the part of it immersed must weigh 4000—50=3950 grains, 50 grains corresponding to half the length of the stem. But the quantity of water displaced must weigh 4000 grains, equal to the whole weight of the hydrometer; consequently the instrument will serve to compare together the different bulks of 4000 grains of water; and since one tenth of an inch in the scale corresponds to one tenth of a grain, it will obviously distinguish the strength of a grain in 4000, or the 40,000th part of the whole bulk of water. By altering the quantity of shot in the ballast ball, this hydrometer may be fitted for comparing any other two liquors that have nearly the same specific gravity. See Dr Desaguliers' *Course of Experimental Philosophy*, vol. ii. p. 234.

### 4. *Deparcieux's Hydrometer.*

This instrument, which was intended by its author for measuring the specific gravities of different kinds of water, is represented in Plate CCCXIV. Fig. 2. where AB is a glass phial about seven or eight inches long, and two inches in diameter. It is loaded with shot at the bottom to prevent it from overturning, and its lower part is rounded to prevent the air from lodging below. A brass wire AC, about 30 inches long, and $\frac{1}{12}$ of an inch in diameter, is fixed in the cork of the phial, which is well varnished to prevent the penetration of the water. The length of the wire ought to be such, that, when the phial is loaded and immersed in spring water at a medium temperature, the whole phial, and about an inch of the wire, should be below the scale, while, when it is plunged in very light river water, the wire should be immersed about 20 inches. To the summit of the wire is fixed a cup C, which contains the small weights with which it may be found necessary to load the instrument in order to make it sink to a fixed point in different kinds of water. A tube of white iron DEFG, about 3 feet long, and 3 inches in diameter, is used to hold the water whose specific gravity is to be determined, and there is attached to it a scale EH, divided into inches and parts of an inch, for the purpose of measuring the different depths to which the instrument sinks. This instrument is so sensible, that, if a small quantity of spirits of wine, or a pinch of sugar or salt, are added to the water in the tin tube, the phial will ascend or descend a very sensible quantity. M. Deparcieux made use of a hydrometer which weighed 23 ounces, 2 gros, and 26 grains (French). A weight of 38 grains made it descend through a height of 19 inches, 6 lines, which was equal to $6\frac{3}{19}$ lines for every grain, or the $\frac{1}{17428}$th part of the volume of water displaced. The results given in our general Table of specific gravities, p. 455, for different waters in France, were obtained by means of this instrument. See Prony's *Architecture Hydraulique*, tom. i. § 614—627.

### 5. *Jones's Hydrometer.*

This hydrometer, which was invented by Mr William Jones of Holborn, is constructed so as to apply the correction which is necessary from a change of temperature. This correction had hitherto been applied only in a rough manner; but upon considering that 32 gallons of spirits in winter will expand to nearly 33 gallons in summer, Mr Jones fixed a thermometer to his instrument, and by adjusting the divisions experimentally, he has obtained it pretty correctly. Mr Jones has also taken into account the diminution of bulk which takes place in mixing alcohol and water, which is so great as to produce a loss of four gallons in the 100. Thus, if to 100 gallons of spirit of wine, which are 66 gallons in the 100 over proof, 66 gallons of water are added to reduce it to proof spirit, the compound of water and alcohol will consist only of 162 gallons instead of 166, four gallons having been lost by the mutual penetration of the two fluids.

Mr Jones' hydrometer is represented in Plate CCCXIV. Fig. 3. It consists of a stem AC of the form of a parallelopiped, on the five sides of which the different strength of spirits are marked. One of these sides is shewn in Fig. 3. and the other three separately. This stem is fixed to the oval ball CD, which is made of hard brass, and has its conjugate diameter about one and a half inches. A thermometer DE is attached to the stem DB below the ball, and the whole length AB of the instrument is about 9½ inches. Three weights W, W′, W″ are suited to the three sides of the stem shewn separately. Let us now suppose that the instrument is plunged in a spirituous liquor; then, if it floats, so that the surface of the liquor is somewhere between A and C, the division on the side of the stem marked 0 (viz. the side of the stem attached to the instrument) will indicate the strength of the liquor if it is between 74 gallons in the 100, and 47 in the 100 above proof. But if the surface of the fluid stands below the extremity C of the scale, it must be loaded with any of the weights W, W′, W″, till the surface of the liquor rises above C; then, if the weight W, or No. 1. is required to produce this effect, the side of the stem marked No. 1. will shew the strength of the spirituous liquor from 46 gallons in the 100 to 13 in the 100 above proof. If the weight No 2. is required to raise the surface of the spirits above C, the divisions on the side marked No. 2. will shew the strength from 13 gallons in the 100 above proof to 29 gallons in the 100 under proof; and if the weight No. 3. is required, the division on the side marked No. 3. will shew the strength of the spirits from 29 under proof down to water, which is marked W at the bottom of the scale No. 3. The thermometer DE has four scales engraven upon it, marked No. 1, 2, 3, corresponding with the similarly numbered scales on the stem. Two of these scales only are seen in the figure. The zero or 0 of each scale is at the middle of each column, and corresponds with a temperature of 60° of Fahrenheit; then whatever number of divisions the mercury in the thermometer stands above the zero, so many gallons in the 100 must the liquor be reckoned weaker than the hydrometer indicates; and whatever number of divisions the mercury in the thermometer stands below the zero, so many gallons in the 100 must the spirits be reckoned stronger than the hydrometer indicates.

The diminution of bulk occasioned by the mutual penetration of the two fluids, is marked by the small figures on the different scales of the stem. Thus the figures $2\frac{1}{2}$ at 48, $3\frac{1}{2}$ at 61, and 4 at 66, indicate, that if the spirit be 48 gallons in the 100 over proof, the bulk of the compound will be $2\frac{1}{2}$ gallons less than the sums of the two ingredients, that is, instead of being 148 it will be $145\frac{1}{2}$. This instrument is adjusted, like other hydrometers, to the temperature of 60° of Fahrenheit, and requires only three different weights to determine the strength of spirituous liquors from alcohol to water.

### 6. *Dicas's Hydrometer.*

The hydrometer constructed by Mr Dicas of Liverpool, possesses all the advantages of Jones' hydrometer, but exhibits, with more accuracy, the correction which it is necessary to apply for a change of temperature. It is constructed of metal, with a stem and ball of the ordinary form. It has 36 different weights, which are valued from 0 to 370, including the divisions on the stem; but the chief improvement which distinguishes this hydrometer is its ivory sliding scale, which adjusts it to different temperatures, and indicates the diminution of bulk arising from the mutual penetration of the combined fluids.

### 7. *Quin's Universal Hydrometer.*

The object of this hydrometer is to ascertain with the greatest expedition the strength of any spirit from alcohol to water, the diminution of bulk, and the specific gravity of each different strength, and also the specific gravity of worts. In its general appearance, it is nearly the same as Jones' hydrometer, shewn in Fig. 3. The stem has four sides, one of which indicates the strength of any spirit, from alcohol to water, while the other three shew the specific gravities of worts. The stem has a conical form, in order to make the degrees upon it more equal than they would otherwise have been. A sliding rule, differing very little from that of Mr Dicas, exhibits the variations of density arising from changes of temperature. In using this instrument, place any of the weights, if necessary, upon the top of the part of the stem below the ball; observe the temperature of the spirit with a thermometer, and bring the star of the sliding rule to the degree of heat on the thermometric scale; then the strength of the spirit will be found opposite to the number of the weight and the letter on the stem. See a full account of this hydrometer in the *Transactions of the Society of Arts*, vol. viii. p. 98.

### 8. *Nicholson's Hydrometer.*

The hydrometer invented by the late Mr Nicholson, is superior to the ordinary instruments, both in its general construction, and from its being capable of ascertaining the specific gravities of solids. This instrument, which is shewn in Fig. 4. of Plate CCCXIV. consists of a hollow copper ball CD attached to the dish AB by means of a stem AC, made of hardened steel, and about $\frac{1}{40}$th of an inch in diameter. An iron stirrup E, fixed to the lower extremity of the ball, carries another dish F, sufficiently heavy to keep the instrument in a vertical position. The parts of the instrument are so adjusted, that when 1000 grains are placed in the upper dish AB, the whole will sink in distilled water at the temperature of 60° of Fahrenheit, to the point $m$ in the middle of the stem.

In order to find the specific gravity of a fluid, immerse the instrument in it, and place weights in the dish AB till it sinks to the point $m$; then, since the quantity of fluid displaced is always the same, we shall have $W + 1000 : W \pm w = S : s$; W being the weight of the instrument, $w$ the weight necessary to make it sink to $m$, S the specific gravity of water, and $s$ that of the fluid.

To determine the specific gravities of solids that do not exceed 100 grains in weight, place the instrument in distilled water, and, having put the solid in the dish AB, throw weights into the same dish till the instrument sinks to $m$. The sum of the weights added being subtracted from 1000 grains, will obviously be the weight of the solid, which we may call W. Let the solid be now placed in the lower dish F, and weights added in the upper dish AB till the instrument again sinks to $m$. The weights now added, which we may call $w$, will be the loss of weight which the solid sustains, or the weight of an equal bulk of distilled water, consequently $s : S = W : w$. As the cylindrical stem of this instrument is only $\frac{1}{40}$th of an inch in diameter, the instrument will rise or fall nearly one inch by the subtraction or addition of $\frac{1}{10}$th of a grain. It will therefore indicate changes in weight less than $\frac{1}{20}$th of a grain, or $\frac{1}{620000}$th of the whole; which will give the specific gravities correct to five places of figures. See *Manchester Memoirs*, vol. ii. p. 570; and Nicholson's *Natural Philosophy*, vol. ii. p. 16.

### 9. *Atkins' Hydrometer.*

This instrument, which is of brass, consists of an eliptical bulb and stem, with a small loaded bulb below, for keeping it in a vertical position. The total length is 8 inches, the elliptical bulb is $1\frac{1}{2}$ inches in diameter, and 2 inches long, and the square stem is $\frac{1}{8}$th of an inch wide. One of the faces of the scale is used for liquors that are specifically lighter than water. On this face are engraven the 26 letters of the alphabet, with an 0 or zero at the beginning and end of the letters, thus—0, A, B, C, D, &c. Z, 0.

Opposite to each letter, and between each of them, is a division for marking the point of the stem to which the instrument sinks, so that the total number of divisions is 55. The weight of the hydrometer is 400 grains, and it is furnished with four weights, viz. No. 1, 2, 3, 4, which weigh respectively 20, 40, 61, and 84 grains, which are placed on the instrument, below the elliptical bulb, as occasion requires. These weights are adjusted in such a manner, that when with one of them, such as No. 2, the instrument emerges to the lower division 0, it will, upon changing the weight for the next heavier one, No. 3, sink exactly to the other division 0, at the top of the stem. Hence the stem is virtually extended to five times its real length, and the number of divisions increased to 272; thus, without any weight at all, it will sink exactly to the upper division 0 in a liquor whose specific gravity is .806, and to the lower division 0 in a liquor whose specific gravity is .843, the intermediate specific gravities being indicated by intermediate divisions on the scale. By applying the weight No. 1. we obtain all the specific gravities from .843 to .880; No. 2. gives them from .880 to .918; No. 3. from .918 to .958; and No. 4. from .950 to 1.000. When the last weight is used in water, the instrument sinks to the lower 0 at 55 degrees of Fahrenheit. Each of the divisions on the stem will be found to correspond considerably less than an unit in the third place of the specific gravity, and to indicate a difference of about one-half per cent. or two quarts in a hundred gallons. The correction for temperature is obtained from a sliding rule, by an ingenious application of two scales of equal parts to each other; and the diminution of bulk, or penetration as it is called, is obtained by the same rule. The specific gravities, corresponding to the divisions on the stem, are likewise pointed out by the sliding rule.

Mr Atkins afterwards made considerable changes upon this instrument. Instead of making the weights circular, he made them of different figures, viz. round, square, triangular, and pentagonal, so as to prevent any mistake being committed; and he stamps upon the sliding rule, the figure of the weight opposite to every letter in the series to which it belongs. He has also made the form of the great bulb cylindrical, and rounded off at the upper and lower sides; and instead of the alphabetical scale, he has engraven the real specific gravities on the stem of the instrument. A full account of this instrument will be found in Mr Atkins' pamphlet on the *Relation between the Specific Gravities and the Strength of Spirituous Liquors*, Lond. 1803; and in Nicholson's *Journal*, 8vo. vol. ii. p. 276, and vol. iii. p. 50.

### 10. *Guyton's Gravimeter.*

This instrument, which was invented by the late celebrated chemist M. Guyton Morveau, is made of glass, and carries two basins like the hydrometer of Nicholson. The bulb is cylindrical, and is connected with the upper basin by a slender stem, in the middle of which is the fixed point of immersion. The lower basin, which terminates in a point, contains the ballast, and is attached to the cylinder by two branches. The cylinder is 6.85 inches long, and 0.71 in diameter. The upper basin carries an additional constant weight of 115 grains. To this apparatus, M. Guyton has added another piece, which he calls the *Plongeur*, or plunger, which is a ball of glass loaded with mercury, till its total weight may be equal to the additional weight of 115 grains, added to the weight of the volume of water displaced by the plunger. The plunger is always placed in the lower basin when it is used; and it will readily be seen, that the gravimeter will sink to the same mark on the stem, whether it is loaded with the constant weight of 115 grains in the upper basin, or with the plunger in the lower basin.

The object of this instrument is to ascertain, 1st, The specific gravities of solids, whose absolute weight is less than 115 grains; 2d, Of liquids inferior to water in specific gravity; 3d, Of liquids of greater specific gravity than water; 4th, The absolute weight of bodies below 115 grains; and, 5th, The degree of rarefaction and condensation of water in proportion to its bulk, the purity of the water being previously known.

In order to find the specific gravity of any solid by this instrument, place the solid in the upper basin, and add weights till the instrument sink to the fixed point of immersion. Subtract these weights from the constant weight of 115 grains, and the remainder is the absolute weight of the solid. Multiply this by the specific gravity of the fluid, and reserve the product, place the solid in the lower basin, and add weights in the upper basin till the instrument sinks to a fixed point of immersion; and subtracting these additional weights from the additional weights when the body was in the upper basin, the remainder will be the loss of weight by immersion. Divide the reserved product by this loss of weight, and the quotient will be the specific gravity of the solid with regard to distilled water at the standard temperature and pressure.

In order to find the specific gravity of a fluid, immerse the gravimeter in the fluid, and having observed the weight which is necessary to sink it to the fixed point of immersion, add this weight to that of the gravimeter. To the weight required to sink it in distilled water, add also the weight of the gravimeter. Divide the first sum by the second, and the quotient will be the specific gravity of the fluid. See the *Annales de Chimie*, vol. xxi. p. 3; and Nicholson's *Journal*, 4to, vol. i. p. 110.

### 11. *Speer's Hydrometer.*

This instrument consists of a ball and stem, with a counterpoise underneath. The stem is cut into an octagonal form; and upon each of the eight faces of the octagon is engraved a scale of per centages, by the inspection of which the strength of the spirit may be found. The scale upon each of the faces is suited to the temperatures of 35°, 40°, 45°, 50°, 55°, 60°, 65°, and 70°. When the temperature of the spirits is found by the thermometer, their strength must be sought on that face of the octagon which corresponds with the temperature. As the temperature is indicated only to every five degrees, there is an index which performs the office of a weight, for pointing out the effect for intermediate temperatures. The precision of a single degree of the thermometer may also be obtained by four small pins, which are inserted in the holes in the counterpoise below, where they operate as weights of adjustment, and produce the same effect as a variation of temperature. For a full account of this hydrometer, see Speer's *Enquiry into the Causes of the Errors and Irregularities which take place in ascertaining the Strength of Spirituous Liquors by the Hydrometer.* Lond. 1802; *Philosophical Magazine*, vol. xiv. p. 151; and the *Repository of Arts*, 2d series, vol. iii. p. 81.

### 12. *Mr Adie's Statical Hydrometer.*

This hydrometer, which is one of the neatest and most correct instruments that we have seen, was first constructed about the year 1799 by Mr Adie, optical instrument maker in Edinburgh. It is made entirely of brass, and consists of a lever AB $10\frac{1}{2}$ inches long, resting upon a fulcrum C, so that the shorter arm AC is $2\frac{1}{2}$ inches, and the longer one CB 8 inches long. At the extremity A of the shorter arm is suspended a brass ball, whose solid content is $\frac{1}{100}$ of a gallon. This ball is immersed in the fluid which is held in the cylindrical brass jar FG. Two moveable weights *m*, *n*, slide along each arm of the balance. When the temperature of the spirits is found by the thermometer, the weight *m* is set to the corresponding degree upon the thermometric scale AC. The weight *n* is then moved along the other arm CB, till the ball E is in equilibrium in the fluid, which is indicated by the coincidence of the arm CB with the horizontal index *o*, fixed to the bar *b*. The whole of this instrument is nicely packed into a mahogany box 11 inches long and $2\frac{1}{2}$ square, which serves as a stand for the balance.

### 13. *Mr Adie's Sliding Hydrometer.*

The sliding hydrometer, invented by Mr Adie, differs from all other hydrometers, in requiring no weights whatever for its adjustment. It is a floating hydrometer, of the usual form; but instead of being adjusted by weights, the volume of the instrument is increased by drawing out a tube, while its weight is invariable. If the instrument sinks to the fixed point of immersion in distilled water, before the tube is drawn out, it is obvious that in spirituous liquors, it may be made to sink to the same point, merely by drawing out a tube below the principal bulb; for the same effect is thus produced by increasing the volume of the instrument, as if its weight were diminished.

### 14. *Charles's Thermometrical Hydrometer.*

This instrument, which, we believe, has been described for the first time by M. Biot in his *Traité de Physique*, tom. i. p. 414, was invented by M. Charles, to whom experimental philosophy is under great obligations. It is called a thermometrical hydrometer, from its being employed to measure the densities of water at different temperatures. In order to give a very high degree of sensibility to the instrument, M. Charles makes the ball very large, and the stem very small; the augmentation of the ball rendering the absolute effects of the dilatation more considerable, and the smallness of the stem enabling us to measure these dilatations upon a greater scale. The whole instrument, with the basin for holding the weights, weighed in air 90.303 grammes, or 90.4209 when reduced to a vacuum. An account of the results obtained with this instrument will be found in M. Biot's work.

### 15. *Charles's Balance Areometer.*

This hydrometer, which is intended to measure the specific gravities of solids, does not differ very essentially from the hydrometer of Nicholson. It has a contrivance, however, for inverting the lower basin, when the solid whose specific gravity is required is lighter than water. In this case the basin is inverted, and the solid presses upwards against its bottom, and tends to elevate the hydrometer. See Biot's *Traité de Physique*, tom. i. p. 435.

### 16. *Dr Wilson's Hydrometer with Glass Beads.*

The late Dr Wilson, professor of astronomy in the university of Glasgow, proposed to measure the specific gravities of fluids by a series of small glass beads, or hollow balls, differing from each other in specific gravity. When any of the beads are thrown into the fluid, all those that are heavier than the fluid sink to the bottom, while those that are lighter float upon the surface. By holding the vessel either in the warm hand, or near a fire or candle, the fluid will dilate, and one of the glass beads will sink. Hence it follows, that the specific gravity of this bead, which is marked upon it, was either equal to, or a little less than that of the fluid before the heat was applied. If any of the beads should happen to be broken, the specific gravity of the liquor may be determined by the other beads; for the liquor in which No. 4. sinks will also allow No. 2. to sink by heating it a few degrees, so that No. 3. may be dispensed with. Complete sets of these bubbles, with a small treatise pointing out the method of using them, were made by Mr Brown, an artist in Glasgow, and have been pretty generally used by spirit-dealers. In some of these sets, the numbers upon each bead are the number of gallons of proof spirits contained in 100 gallons of the liquor; while in other sets, the number expresses the gallons of water which will make a liquor of that strength, if added to 14 gallons of alcohol.

### 17. *Lovi's Patent Areometrical Beads.*

The patent areometrical beads have been brought to a very high degree of perfection by Mrs Lovi. They are now used by many of the first distillers and practical chemists, and have been honoured with the highest approbation of some of the principal philosophers and chemists in Scotland. The patent beads are fitted up in boxes, containing different quantities, according to the purposes for which they are wanted, and they are always numbered to every two units in the 3d place of specific gravity; for example, 920, 922, 924, &c. If they are required merely for spirituous liquors, thirty beads will be sufficient; but if they are required for all fluids, from ether to the most concentrated sulphuric acid, three hundred at least will be required. As these beads are marked with their respective specific gravities, we have only to throw a parcel of them into the fluid till we find the one that stands in the middle of the liquid without either rising to the top or sinking to the bottom. The number marked upon this bead will indicate the specific gravity of the fluid. The beads are accompanied by a sliding rule and a thermometer for making the corrections for differences of temperature, and for finding the strength of the spirits, in the language of spirit dealers and excise officers. The superiority of this hydrometer to every other instrument with which we are acquainted, is very great. If the ordinary hydrometer meets with any accident, it is incapable of being repaired; but if any of the areometrical beads are broken, they can easily be replaced, and the specific gravity may be determined with sufficient accuracy, if one or even two beads of the series are destroyed.

The areometrical beads have been applied with great success by Mr Hutton to an improved method of ascertaining the quantity of spirituous liquors by weighing instead of measuring them.

"The weight of a very large quantity," says Mr Hutton, "may be ascertained at one operation, in a short time, and comparatively with little trouble. Now, if the weight of a cask be ascertained when empty, and afterwards when filled with spirits, the difference of these weights will be the weight of the spirits the cask contains; and since the specific gravity of spirits is easily found by means of the patent beads, we can thus obtain with the greatest facility both the weight and specific gravity of the spirits; and from these data, it is easy to calculate the quantity which a cask may contain, in terms of any given measure,

| | C. | Qr. | lb. | oz. |
|---|---|---|---|---|
| Thus, suppose that a cask weighs, when empty, . . . . . . | 1 | 3 | 2 | 2 |
| And when filled with spirits, | 12 | 3 | 0 | 0 |
| The difference or weight of the spirits will be . . . . . | 10 | 3 | 25 | 14 |

And suppose that the spirit is of the specific gravity 920, and that it is required to find the number of wine gallons which the cask contains,

We may proceed in this manner:

Since a cubic foot, or 1728 cubic inches, of spirit of this strength weighs 920 ounces, and a wine gallon contains 231 cubic inches; to ascertain the weight of a wine gallon of such spirits we have this proportion:

$$\overset{\text{In.}}{1728} : \overset{\text{Oz.}}{920} : : \overset{\text{In.}}{231} : \overset{\text{Oz.}}{\frac{920 \times 231}{1728}}$$ the weight of a wine gallon of spirits of the specific gravity 920.

And to ascertain the number of wine gallons or quantities of the weight $\frac{920 \times 231}{1728}$ ounces, contained in 10 C. 3 qrs. 25 lb. 14 oz. or 19,678 ounces, we have this proportion:

$$\overset{\text{Oz.}}{\frac{920 \times 231}{1728}} : \overset{\text{Gall.}}{1} : : \overset{\text{Oz.}}{19{,}678} : \overset{\text{Gall.}}{\frac{19\,678}{\frac{920 \times 231}{172.8}}} = \frac{1728 \times 19678}{920 \times 231} = \overset{\text{Gallons.}}{160.}$$

A quantity of spirits, therefore, of the specific gravity 920, and which weighs 10 C. 3 qrs. 25 lb. 14 oz. will measure exactly 160 wine gallons.

It is easy also, the number of wine gallons and specific gravity being given, to calculate the weight. Thus, in the above example, all the alteration that this state of the question would have occasioned, would have been in the second proportion, which would have stood thus:

$$\overset{\text{Gall.}}{1} : \overset{\text{Oz.}}{\frac{920 \times 231}{1728}} : : \overset{\text{Gall.}}{160} : \overset{\text{Oz.}}{\frac{160 \times 920 \times 231}{1728}} = \overset{\text{C.}}{10} \quad \overset{\text{Qr.}}{3} \quad \overset{\text{lb.}}{25} \quad \overset{\text{oz.}}{14}$$

In this manner Mr Hutton has calculated a series of tables for giving the quantity of spirits by inspection. At the top, in the centre, is the specific gravity of the spirits, commencing at 906, and ending with 934, and embracing the different specific gravities at which spirits are usually met with in commerce. On the right of the number denoting the specific gravity, and on the same line with it, is the approximate weight of one gallon of spirits of that specific gravity, expressed in pounds and ounces. The tables consist of two sets of columns; one contains the number of gallons, and the other their weight: they begin with 30 gallons, being the smallest quantity it is considered necessary to weigh, and increasing by single gallons, they extend to 185 gallons, being the contents of the largest cask used in trade.

### 18. *Dr Brewster's Capillary Hydrometer.*

This instrument is founded upon a principle which was never before employed in hydrometrical measurements. It is well known that alcohol is a much more perfect fluid than water, possessing much less viscidity, in consequence of the small force of cohesion which exists between its particles. Hence it follows, that if a vessel containing alcohol is emptied through a capillary tube, so as to discharge the fluid only by drops, the drops will be much smaller, and consequently much more numerous, than when the same vessel is filled with water and emptied through the same tube. The capillary hydrometer, which is founded on this principle, is represented in Fig. 6. where ABC is a glass vessel three, or four, or five inches long, having a hollow bulb B about half an inch or an inch in diameter. This instrument is filled by suction at the lower end C, and the water is discharged at C till it stands nearly at the point $m$, the zero of the scale. By removing the finger from the lower end C, the water is discharged by drops, and the number of drops which fall till the fluid descends to another fixed point $n$ are accurately counted. This experiment is carefully repeated at different temperatures, so that the number of drops of distilled water contained in the vessel between the points $m$ and $n$ is known for various temperatures. Hence, if N is the number of drops of water whose specific gravity is S, and $n$ the number of drops of alcohol whose specific gravity is $s$, and $d$ the number of drops given by any other mixture of alcohol and water, then $n - \text{N} : \text{S} - s = d - \text{N} : \frac{(d-\text{N})(\text{S}-s)}{n-\text{N}}$, and therefore $\text{S} - \frac{(d-\text{N})(\text{S}-s)}{n-\text{N}}$ will be the specific gravity of the mixture required. The same experiment is made with the purest alcohol, and the number of drops carefully marked. With an instrument of this kind, the number of drops necessary to empty it when filled with water was 724, whereas, when it was filled with ordinary proof spirits, the number of drops amounted to 2117. This experiment, which was performed rudely, for the purpose of obtaining a general idea of the magnitude of the scale, was made nearly at the temperature of 60°. Now as the specific gravity of the spirit was about .920, and that of water 1.000, we have in the present case no less than a scale of 1393 drops for measuring specific gravities between .920 and 1.000: that is, a variation in the fifth figure, or in the fourth place of decimals of the specific gravity, nearly corresponds with a variation of two drops. With another instrument made on a very small scale, the number of drops amounted to 47 with water and 122 with spirit, whose specific gravity was 928. As this instrument was too large, I was obliged to incline it, in order to prevent the fluid from issuing in a continued stream. In the first experiment, N = 724, $n$ = 2117, S = 1.000, $s$ = 920. Hence if $d$ = 1500, we have $\text{S} - \frac{(d-\text{N})\ (\text{S}-s)}{\text{N}-n} =$ $\frac{1.000 - 776 \times 0.080}{1393} = .9555.$

The bulk of a drop of water will be about 2.93 times as large as the bulk of a drop of the spirit used in the first experiment. In the 2d experiment, the drop of water was 2.6 times greater than the drop of the spirit. See Chapter V. p. 473 of this article.

### 19. *Sikes' Hydrometer.*

As this hydrometer is now universally used in the collection of the revenue in both kingdoms, we shall lay before our readers a drawing and description of it, although it does not differ much in principle from the ordinary hydrometers. It is represented in Plate CCCXIV. Fig. 7. where AB is a flat stem 3.4 inches long, which is divided on both sides into 11 equal parts, each of which is subdivided into 2, the scale being numbered from 0 to 11. This stem is soldered into a brass ball 1.6 inch in diameter, into which is fixed a small conical stem CD, 1.13 inch long, at the end of which is a pear-shaped loaded bulb DE, half an inch in diameter. The whole instrument, which is made of brass, is 6.7 inches long. The instrument is accompanied with 8 circular weights, numbered 10, 20, 30, 40, 50, 60, 70, 80, and another weight of the form of a parallelopiped. Each of the circular weights are cut into their centre, so that they can be placed on the conical stem C, and slide down to D; but in consequence of the enlargement of the cone they cannot slip off at D, but must be brought up to C for this purpose. The square weight, of the form of a parallelopiped, has a square notch in one of its sides, by which it can be placed upon the summit A of the stem. In using this instrument, it is immersed in the spirit, and pressed down by the hand to 0, till the whole divided part of the stem be wet. The force of the hand required to sink it will be a guide in selecting the proper weight. Having taken one of the circular weights which is necessary for this purpose, it is slipped on the conical stem at C. The instrument is again immersed and pressed down as before to 0, and is then allowed to rise and settle at any point of the scale. The eye is then brought to the level of the surface of the spirit, and the part of the stem cut by the surface, *as seen from below*, is marked. The number thus indicated by the stem is added to the number of the weight employed, and with this sum at the side, and the temperature of the spirits at the top, the strength per cent. is found in a Table of six quarto pages. "The strength is expressed in numbers denoting the excess or deficiency per cent. of proof spirit in any sample; and the number itself (having its decimal point removed two places to the left) becomes a factor whereby the gauged content of a cask or vessel of such spirit being multiplied, and the product being added to the gauged content if over-proof, or deducted from it if under proof, the result will be the actual quantity of proof spirit contained in such cask or vessel."

The instrument is also accompanied with three sliding rules made of boxwood, which may be used instead of the Table. "The officers of excise are directed to estimate the temperature by the nearest degree *above* the surface of the mercury, when it stands between any two degrees of the thermometer, and the indication or (numbers on the stem) by the nearest division *below* the surface of the sample, when its level cuts the stem of the hydrometer between one division and another; thus giving the difference in favour of the trader in both cases. The square weight or cap shews the difference between the weight of proof spirit and that of water, as described in the first clause of the hydrometer act, and being one-twelfth part of the total weight of the hydrometer and weight 60. If this weight is placed upon the top of the stem at A, and if the hydrometer is loaded with weight No. 6, it will sink in distilled water at the temperature of 51° to the proof Point P, at that temperature, as marked on the narrow edge of the stem."

### 20. *On the Hydrostatic Balance.*

Although the hydrostatic balance can scarcely be called a hydrometer, yet as it is employed for measuring specific gravities when great accuracy is required, we shall give a description of it in this place. The hydrostatic balance, of which we have given a front and a side view in Figs. 8. and 9, of Plate CCCXIV. Figs. 8, 9. is nothing more than a good balance, with some additional apparatus for enabling it to measure specific gravities with accuracy and expedition. The support of the balance is a pillar AB, fixed into a stand or base CD. By a silken string P*pe*, Fig. 9, attached to a screw S, and passing over the pullies P, *p*, is suspended the balance by means of the horizontal arm EF, on which the hook *e* is hung: *af*, *fb*, are the arms of the balance, *ef* its tongue, *c d*, the scales, and *m n* a slender curved rest, which prevents any of the arms from descending too far on either side. By means of the screw S, a vertical ascent or descent of the balance can be obtained; but when it is necessary to raise it much higher or lower, the whole sliding-piece into which the screw S is fixed, may be moved either forward or backward in a groove, or upon a brass rod placed upon the stand CD. A board GH is fixed upon the projecting arm L beneath the two scales, and being moveable up and down in a groove, it can be fixed in any position by a screw. In the middle of the lower surface of each scale is fixed a hook, to which are suspended brass wires *c k*, *d g*, which pass freely through two openings in the board GH. To the wire *c k* is suspended a cylindrical wire K *k*, about 5 inches long, perforated at each end, and covered with paper, containing a scale of equal parts. A brass tube MN is fixed on the corner of the board GH, on which a wire MN is made to move. On the lower part of the wire moves another tube W, carrying an index NO, which can be moved either horizontally by turning round the tube, or vertically by pushing it up or down; so that the index MN can be made to point to any division on the scale K *k*. A weight *k* is suspended to the wire K *k*, to which is fixed the wire *k l*, (of such a size that one inch of it will weigh about 4 grains,) with a small brass ball *l* about ¼ of an inch in diameter. A large glass bubble *h*, is in like manner suspended by a horse hair to the wire *dg*. The length of these wires is such, that the ball *l*, and the bubble *h*, hang about the middle of the cylindrical glass vessels X, Y, in the ordinary position of the balance. Since brass is nearly eight times heavier than water, it is evident, that for every inch that the wire *k l* sinks in the water in the vessel X, it will become half a grain lighter, and for every inch that it rises out of the water it will become half a grain heavier: consequently if it sinks 2 inches below its middle point $x$, or rises two inches above it, the wire will become one grain lighter or heavier. Let the middle point $x$, therefore, be brought to the surface of the water, and the index NO set to the middle of the scale K *k*, and let the distances OK, O *k* be each divided into 100 parts, then if it is required to weigh bodies to the accuracy of the 100th part of a grain, it may be done in the following manner. Let the body to be weighed be placed in the scale *c*, and let its weight be between 52 and 53 grains, as determined by the weights in the opposite scale, then if we move the balance gently up and down by the screw S, till the tongue of the balance *ef* indicates a perfect equilibrium, the distance of the index NO from *k*, as measured upon the scale, will indicate the number of hundredth parts of a grain which the real weight of the body is above 52, or below 53, according as either of these weights is placed in the scale *d*. If 52 be the weight in the scale *d*, then since the weight of the body in the scale *c* exceeds 52, the scale *c* will preponderate, and the balance being let down until the equilibrium is restored by the loss of weight sustained by the immersed wire *k l*, the index NO will rise as it were from the middle part of K *k*. Hence if it points to 12 divisions above the middle of K *k*, the weight of the body will be 52.12 grains. Had the weight 53 been placed in the scale, it would have been necessary to raise the balance, so that the scale *c* might acquire an equilibrium with 53 grains, by an addition to the weight of the wire *k l* in consequence of its ascent from the water. In this case, the index NO would have pointed to division 88 below the middle point of the scale, and the weight of the body would have been $53.00 - 0.88 = 52.12$, as before.

The weight of the body in air being thus obtained with the utmost accuracy, it is next to be suspended to the hook g by means of the horse hair, and weighed when immersed in the water in the jar Y. The difference between these two weights, when they have been corrected by the methods formerly described,* will lead to an accurate determination of the specific gravity of the body. The wire *k l* should always be oiled, and the oil wiped off, so that a thin film may adhere to it, in order to prevent the adhesion of the water.

Sect. II. *On the Table of Specific Gravities.*

The determination of the specific gravities of bodies is of the greatest use, not only in many of the sciences, but also in most of the practical arts of life. Hence it has been the object of philosophers to determine, with all the accuracy in their power, the specific gravities of the various solid and fluid substances which occur in nature. The following Table, which we have collected with great labour from the tables of Brisson and other sources, contains the most important specific gravities that have been determined. All the measures are related to that of water, whose specific gravity is 1.000, excepting the gases or aëriform bodies, whose specific gravities are determined in relation to that of atmospheric air, which is taken at 1.00. The bodies are arranged in an alphabetical order, for the sake of more easy reference.

## *Table of Specific Gravities.*

| | | |
|---|---|---|
| A | | |
| Acacia, inspissated juice of, | | 1.5153 |
| Acid, nitric, | | 1.2715 |
| nitric, highly concentrated, | | 1.583 |
| muriatic, | | 1.1940 |
| red acetous, | | 1.0251 |
| white acetous, | | 1.0135 |
| distilled acetous, | | 1.0095 |
| acetic, | | { 1.007<br>1.0095 |
| sulphuric, | | 1.8409 |
| highly concentrated, | | 2.125 |
| fluoric, | | 1.500 |
| phosphoric, liquid, | | 1.417 |
| solid, | | 2.852 |
| citric, | | 1.0345 |
| arsenic, | | 3.391 |
| of oranges, | | 1.0176 |
| of gooseberries, | | 1.0581 |
| of grapes, | | 1.0241 |
| prince, | | 0.705 |
| boracic, in scales, | | 1.479 |
| do. melted, | | 1.803 |
| molybdic, | | 3.460 |
| benzoic, | | 0.667 |
| formic, | | { 1.102<br>1.113 |
| Actinolite, glassy, | *Kirwan.* | { 2.950<br>3.903 |
| Adularia, See *Felspar.* | | |
| Agalmatolite, | | 2.800 |
| Agate, oriental, | | 0.5901 |
| onyx, | | 2.6375 |
| speckled, | | 2.607 |
| cloudy, | | 2.6253 |
| stained, | | 2.6324 |
| veined, | | 2.6667 |
| Icelandic, | | 2.348 |
| of Havre, | | 2.5881 |
| jasper, | | 2.6356 |
| Mocha, | | 2.5891 |
| iridescent, | | 2.5535 |
| Air, atmospheric, | | |
| Barom. 29.75 } Thermom. 32. } | | 0.00122 |
| Barom. 29.85 } Thermom. 54°.5 } | *Lavoisier.* | 0.0012308 |
| Alabaster of Valencia, | | 2.638 |
| veined, | | 2.691 |
| Alabaster of Piedmont, | | 2.693 |
| of Malta, | | 2.699 |
| yellow, | | 2.699 |
| Spanish saline, | | 2.713 |
| oriental white, | | 2.730 |
| ditto, semi-transparent, | | 2.762 |
| stained brown, | | 2.744 |
| of Malaga, pink, | | 2.8761 |
| of Dalias, | | 2.6110 |
| Alcohol, absolute, | *Lowitz.* | 0.791 |
| highly rectified, | | 0.8293 |
| commercial, | | 0.8371 |
| 15 parts, Water 1 part | | 0.8527 |
| 15 2 | | 0.8674 |
| 13 3 | | 0.8815 |
| 12 4 | | 0.8947 |
| 11 5 | | 0.9075 |
| 10 6 | | 0.9199 |
| 9 7 | | 0.9317 |
| 8 8 | | 0.9427 |
| 7 9 | | 0.9519 |
| 6 10 | | 0.9594 |
| 5 11 | | 0.9674 |
| 4 12 | | 0.9733 |
| 3 13 | | 0.9791 |
| 2 14 | | 0.9852 |
| 1 15 | | 0.9919 |
| Alder-wood, | *Muschenbroek.* | 0.8000 |
| Allanite, | *Bournon.* | { 3.119<br>4.001 |
| | *Thomson.* | 3.533 |
| | *Jardine.* | 3.665 |
| Aloes, hepatic, | | 1.3586 |
| socotrine, | | 1.3795 |
| Alouchi, an odoriferous gum, | | 1.0604 |
| Alumine, sulphate of, | *Muschenbroek.* | 1.7140 |
| saturated solution of, temp. 42°, | *Watson.* | 1.033 |
| Amber, yellow transparent, | | 1.0780 |
| opaque, | | 1.0855 |
| red, | | 1.0834 |
| green, | | 1.0829 |
| Ambergris, | | { 0.7800<br>0.9263 |
| Amethyst, common. See *Rock* crystal. | | 2.750 |
| Amianthus, long, | | 0.9088 |
| penetrated with water, | | 1.5662 |
| short, | | 2.3134 |
| penetrated with water, | | 3.3803 |

* See Prop. XII. and XIII. p. 434, 435.

| | | |
|---|---|---|
| Amianthinite from Raschau, | | 2.584 |
| Bayreuth, | | 2.916 |
| Ammonia, liquid, | | 0.8970 |
| muriate of, | *Muschenbroek.* | 1.4530 |
| saturated solution of temp. 42°, | *Watson.* | 1.072 |
| Amphibole. See *Hornblende* basaltic | | |
| Amphigene. See *Leucite.* | | |
| Analcime, | | 2.0<br>3.0 |
| Andalusite, or hardspar | *Haüy.* | 3.165 |
| Anhydrite, or Muriacite, | | 2.95 |
| Anime, oriental, | | 1.0284 |
| occidental, | | 1.0426 |
| Anthophyllite, | | 3.20 |
| Antimony, glass of, | | 4.9464 |
| in a metallic state, fused, | | 6.624<br>6.860 |
| native, | *Klaproth.* | 6.720 |
| grey, | | 4.3 |
| sulphur of, | | 4.0643 |
| ore, grey and foliated, | *Kirwan.* | 4.368 |
| radiated, | *Kirwan.* | 4.440 |
| red, | *La Metherie.* | 3.750 |
| | *Klaproth.* | 4.090 |
| Apatite. See *Phosphorite.* | | |
| Aplome | | 3.45 |
| Apophyllite. See *Fish Eye Stone.* | | |
| Apple-tree, wood of the, | *Muschenbroek.* | 0.7930 |
| Aquamarine. See *Beryl.* | | |
| Arcanson, | | 1.0857 |
| Areca, inspissated juice of, | | 1,4573 |
| Aretizite, or Wernerite, | *Dandrada.* | 3.606 |
| Argillite, or slate clay, | *Kirwan.* | 2.600<br>2.680 |
| Arnotto, | | 0.5956 |
| Arragonite, | *Haüy.* | 2.946 |
| | *Thenard* and *Boit.* | 2.9267 |
| | *Malus.* | 2.94686 |
| Arsenic bloom, Pharmacolite, | *Klaproth.* | 2.640 |
| fused, | *Bergman.* | 8.310 |
| native, | *Kirwan.* | 5.670 |
| | *La Metherie.* | 5.600 |
| | *Brisson.* | 6.522 |
| glass of, (arsenic of the shops), | | 3.5942 |
| Arsenical pyrites, or Mispickel, | | 6.5 |
| See *Realgar.* | | |
| Asbestinite, | *Kirwan.* | 3.000<br>3.310 |
| Asbestos, mountain cork, | *Bergman.* | 0.6806<br>0.9933 |
| penetrated with water, | | 1.2492<br>1.3492 |
| ripe, | *Brisson.* | 2.5779 |
| penetrated with water, | | 2.6994 |
| starry, | | 3.0733 |
| penetrated with water, | | 3.0808 |
| unripe, | | 2.9958 |
| penetrated with water, | | 3.0343 |
| Ash trunk, | *Muschenbroek.* | 0.8450 |
| dry, | *Turin.* | 0.800 |
| Asphaltum, cohesive, | | 1.450<br>2.060 |
| compact, | | 1.070<br>1.165 |
| Assafœtida, | | 1.3275 |
| Aventurine, semitransparent, | | 2.6667 |
| opaque, | | 2.6426 |
| Augite, or Pyroxene, | *Häuy.* | 3.226 |
| | *Werner.* | 3.471 |
| | *Reuss.* | 3.777 |
| Automalite, Gahnite, or Fahlunite, | | 4.200 |
| Axinite, or Thumerstone, | | 4.690 |
| | *Haüy.* | 3.213<br>3.296 |
| | *Gerard.* | 3.250 |
| Azure stone, or lapis lazuli, | *Brisson.* | 2.7675 |
| | *Kirwan.* | 2.896 |
| oriental, | | 2.7714 |
| of Siberia, | | 2.9454 |

B

| | | |
|---|---|---|
| Barolite, or Witherite. See *Barytes,* Carbonate of. | | |
| Barytes, or Baroselenite, | | 4.400<br>4.865 |
| white, | | 4.4300 |
| grey, | | 4.4909 |
| rhomboidal, | | 4.4434 |
| octahedral, | | 4.4712 |
| in stalactites, | | 4.2984 |
| sulphate of, native, | *Kirwan.* | 4.000<br>4.460 |
| | *Malus.* | 4.48141 |
| carbonate of, native, | | 4.300<br>4.338 |
| Basaltes, | *Kirwan.* | 2.979 |
| | *Bergman.* | 3.000 |
| Basaltes, from the Giant's Causeway, | | 2.864 |
| prismatic from Auvergne, | | 2.4215 |
| of St Tubery, | | 2.7948 |
| Baras, a juice of the pine, | | 1.0441 |
| Bay tree, Spanish, | *Muschenbroek.* | 0.8220 |
| Bdellium, | | 1.1377 |
| Beech-wood, | *Muschenbroek,* | 0.8520 |
| Beer, red, | | 1.0338 |
| white, | | 1.0231 |
| Benzoin, | | 1.0924 |
| Beryl, oriental, | | 3.5491 |
| occidental, | | 2.723 |
| or aquamarine, | *Werner.* | 2.650<br>2.759 |
| schorlous, or shorlite. See *Pycnite.* | | |
| Bezoar oriental, | | 1.666 |
| occidental, | | 2.233 |
| Bismuth, native, | *Kirwan.* | 9.570 |
| sulphuretted, | *Kirwan.* | 6.131 |
| ochre, | *Brisson.* | 4.371 |
| in a metallic state, fused, | | 9.756<br>9.822 |
| Bismuth, | *Brisson.* | 9.070 |
| Bitumen of Judea, | | 1.104 |
| Black-coal, pitch coal, | *Wiedemann* | 1.308 |
| slate coal, English, | *Kirwan.* | 1.250<br>1.370 |
| Bielschowitz, | *Richter.* | 1.321<br>1.382 |
| cannel coal, | *La Metherie.* | 1.270 |
| Blende, yellow, | *Gellert.* | 4.044<br>4.048 |
| brown, foliated, | *Gellert.* | 3.770<br>4.048 |
| black, | *Gellert.* | 3.930 |
| | *Brisson.* | 4.166 |
| auriferous from Nagyag, | *Van Muller.* | 5.393 |
| Blood, human, | *Jurin.* | 1.054 |
| crassamentum of, | *Jurin.* | 1.126 |
| serum of | *Jurin.* | 1.030 |

| | | |
|---|---|---|
| Blood Stone. See *Heliotrope*. | | |
| Boles, | *Kirwan.* | 1.400<br>2.000 |
| Bone of an ox, | | 1.656 |
| Boracite, | *Westrumb.* | 2.566 |
| Borax, | | 1.714 |
| saturated solution of, temp. 42°, | *Watson.* | 1 010 |
| Bournonite, | | 5 576 |
| Boxwood, French | *Muschenbrock.* | 0 9120 |
| Dutch, | *Muschenbroek.* | 1.3280 |
| dry, | *Jurin.* | 1 030 |
| Brass, common cast, | | 7.824 |
| wiredrawn, | | 8.544 |
| cast, not hammered, | *Brisson.* | 8.395 |
| Brazil wood, red, | *Muschenbrock.* | 1.0310 |
| Bronzite, | | 3.20 |
| Brick, | | 2.000 |
| Butter, | | 0.9423 |

C

| | | |
|---|---|---|
| Cacao butter | | 0·8916 |
| Cachibou, gum | | 1.0640 |
| Calamine, | *Brisson.* | 3.525 |
| | *La Metherie.* | 4.100 |
| Calcareous spar. See *Spar.* | | |
| Calculi urinary, | | 1.700<br>1.240<br>1.434 |
| Campeachy wood, or logwood, | *Muschenbroek.* | 0.9130 |
| Camphor,* | | 0.9887 |
| Caoutchouc, elastic gum, or India rubber, | | 0.9335 |
| Caragna, resin of the Mexican tree caragna, | | 1.1244 |
| Carbon of compact earth, | | 1.3292 |
| Carnelian, stalactite, | | 2.5977 |
| speckled, | | 2.6137 |
| veined, | | 2.6234 |
| onyx, | | 2.6227 |
| pale, | | 2.6301 |
| pointed, | | 2 6120 |
| arborized, | | 2 6133 |
| Cat's eye, | *Klaproth.* | 2 600<br>2.625 |
| grey, | | 2.5675 |
| yellow, | | 2.6573 |
| blackish, | | 3.2593 |
| Catchew, juice of an Indian tree, | | 1.3980 |
| Caustic ammoniac, solution of, or fluid volatile alkali, | | 0.897 |
| Ceder tree, American, | *Muschenbroek.* | 0.5608 |
| wild, | *Muschenbroek.* | 0.5608 |
| Palestine, | *Muschenbroek.* | 0 5960 |
| Indian, | *Muschenbroek.* | 1.3150 |
| Celestine. See *Strontian*, sulphate of. | | |
| Cerite, | | 4.500 |
| Ceylanite, or Pleonaste, | *Hauy.* | 3 765<br>3.793 |
| Chabasie, | | 2.718 |
| Chalcedony, bluish, | | 2.5867 |
| onyx, | | 2 6151 |
| veined, | | 2 6059 |
| transparent, | | 2.6640 |
| reddish, | | 2 6645 |
| common, | *Kirwan.* | 2.600<br>2.655 |
| Chalk, | *Muschenbroek.* | 2.252 |
| | *Watson.* | 2.657 |
| Chiastolite. See *Macle.* | | |
| Cherry-tree, | *Muschenbroek.* | 0.7150 |
| Chrysoberyl. See *Cymophane.* | | |
| Chrysolite of the jewellers, | *Brisson.* | 2.782 |
| of Brasil, | | 2.692 |
| | *Werner.* | 3.340<br>3.410 |
| Chrysoprase, a variety of Chalcedony, | | 2.489<br>3.250 |
| Chrystal. See *Rock Crystal.* | | |
| Chrystalline lens, | | 1.100 |
| Cimolite, | | 2.0 |
| Cinnabar, dark red, from Deux-Ponts, | *Kirwan.* | 7.786 |
| from Almaden, | *Brisson.* | 6.902 |
| crystallized, | *Brisson.* | 10.218 |
| hepatic, | | 7.1 |
| Cinnamon, volatile oil of, | | 1.044 |
| Cinnamon-stone, | | 2.6 |
| Citron-tree, | *Muschenbroek.* | 0.7263 |
| Clinkstone, | *Klaproth.* | 2.575<br>2.620 |
| Cloves, volatile oil of, | | 1 036 |
| Cobalt, in a metallic state, fused, | | 7.645<br>7.811 |
| ore, grey, | *Hauy.* | 5 511<br>7 721 |
| | *Kirwan.* | 5.309 |
| earthy, black, indurated, | *Gellert.* | 2.019<br>2 425 |
| vitreous oxide of, | | 2 4405 |
| Cocoa wood, | *Muschenbroek.* | 1.0403 |
| Coccolite, | *Dandrada.* | 3.316 |
| Columbium, | *Hatchet.* | 5.918 |
| Copal, opaque, | | 1 1398 |
| transparent, | | 1.0452 |
| Madagascar, | | 1.0600 |
| Chinese, | | 1.0628 |
| Copper, native, | *Kirwan.* | 7.600<br>7 800 |
| from Siberia, | *Hauy.* | 8 5084 |
| Hungary, | *Gellert.* | 7.728 |
| ore, compact vitreous, | *Kirwan.* | 4 129 |
| Cornish, | *Kirwan.* | 5 452 |
| purple, from Bannat, | *Kirwan.* | 4.956 |
| from Lorraine, | *La Metherie.* | 4.300 |
| | *Kirwan.* | 4 983 |
| | *Wiedemann.* | 5.467 |
| glance, | | 5 6 |
| pyrites, | *Kirwan.* | 5.080 |
| | *Brisson.* | 4.344 |
| ore, white, | *La Metherie.* | 4.500 |
| grey, | *Hauy.* | 4.865<br>4 5 |
| yellow, | | 4 3 |
| blue, | | 3.2<br>3.4 |
| foliated, florid, red, | *Wiedemann.* | 3.950 |
| azure, radiated. | *Wiedemann.* | 3.231 |
| | *Brisson.* | 3.608 |
| emerald, | *La Metherie.* | 2 850 |
| | *Hauy.* | 3.300 |
| muriate of, | | 4.4 |
| arseniate of, hexahedral, | | 2.549 |
| octahedral, | | 2.88 |
| trihedral | | 4.2 |
| prismatic, | | 4.2 |

* M. Venturi found, that when camphor was deprived of the air which adhered to it, by placing it under the receiver of an air-pump, it was heavier than water deprived of its air by the same air-pump. See *Memoires presentés a l'Institut.* tom. p. 125, Paris, 1805.

| | | |
|---|---|---|
| Copper ore, partial arseniate, | | 3.4 |
| sulphate of, saturated solution of, temp. 42°, | *Watson.* | 1.150 |
| drawn into wire, | | 8.878 |
| fused, | | 7.788 |
| | *Hatchet.* | 8.895 |
| Copper sand, muriate of copper, | *La Metherie.* | 3.750 |
| | *Herrgen.* | 4.431 |
| Cork, | *Muschenbroek.* | 0.2400 |
| Corundum of India, | *Klaproth.* | 3.710 |
| | *Bournon.* | 3.875 |
| of China. | | 2.981 |
| Cross stone. See *Harmotome.* | | |
| Cryolite, | *Karsten.* | 2.957 |
| Cube iron ore, | *Bournon.* | 3.000 |
| spar, | *Hauy.* | 2.964 |
| Cubizite. See *Analcime.* | | |
| Cyanite, Sappare, or Disthene, | *Saussure, jun.* | 3.517 |
| | *Hermann.* | 3.622 |
| Cyder, | | 1.0181 |
| Cymophane, or Chrysoberyl, | *Werner.* | 3.600<br>3.720 |
| | *Hauy.* | 3.796 |
| Cypress wood, Spanish, | *Muschenbroek.* | 0.6440 |
| **D.** | | |
| Datolite, | | 2.98 |
| Dipyre, | | 2.63<br>2.84 |
| Diallage. See *Smaragdite.* | | |
| Diamond, oriental, colourless. | | 3.5212 |
| rose-coloured, | | 3.5310 |
| Diamond, oriental, orange-coloured, | | 3.5500 |
| green-coloured, | | 3.5238 |
| blue-coloured, | | 3.5254 |
| Diamond, Brazilian, | | 3.4444 |
| yellow, | | 3.5185 |
| orange, | *Hauy.* | 3.55 |
| Dichroite. See *Iolite.* | | |
| Disthene. See *Cyanite.* | | |
| Dolomite | | 2.800 |
| Dragons blood, | | 1.2045 |
| Ether, sulphuric, | from<br>to | 0.716<br>0.745 |
| nitric, | | 0.9088 |
| muriatic, | | 0.7296 |
| acetic, | | 0.8664 |
| Ebony, Indian, | *Muschenbroek.* | 1.2090 |
| American, | *Muschenbroek.* | 1.3310 |
| Elder tree, | *Muschenbroek.* | 0.6950 |
| Elemi, | | 1.0182 |
| Elm trunk, | *Muschenbroek.* | 0.6710 |
| Emerald, | *Gahn and Berzelius.* | 2.673<br>2.683 |
| | *Werner.* | 2.600 |
| | *Hauy.* | 2.723 |
| of Brasil, | | 3.1555 |
| pseudo, | *Gahn and Berzelius.* | 2.701 |
| Epidote. See *Zoisite.* | | |
| Euclase, | *Hauy.* | 3.0625 |
| Euphorbium, gum | | 1.1244 |
| **F.** | | |
| Fahlunite. See *Automalite.* | | |
| Fat of beef, | | 0.9232 |
| Fat of veal, | | 0.9342 |
| mutton, | | 0.9235 |
| hogs, | | 0.9368 |
| Felspar, fresh, | *Hauy.* | 2.438 |
| Adularia, | *Struve.* | 2.500<br>2.600 |
| Labrador stone, | *Brisson.* | 2.697<br>2.704 |
| glassy, | | 2.518<br>2.589 |
| Fettstein, | *Borkowski.* | 2.563 |
| | *Hauy.* | 2.614 |
| Filbert tree, | *Muschenbroek.* | 0.6000 |
| Fir, male, | *Muschenbroek.* | 0.5500 |
| female, | *Muschenbroek.* | 0.4980 |
| Fish eye stone, Ichthyophthalmite, or Apophyllite, | | 2.5782 |
| | *Hauy.* | 2.467 |
| Flint, | *Blumenbach.* | 2.594 |
| olive, | | 2.6057 |
| spotted, | | 2.5867 |
| onyx, | | 2.6644 |
| of Rennes, | | 2.6538 |
| of England, | | 2.6087 |
| variegated of Limosin, | | 2.2431 |
| veined, | | 2.6122 |
| Egyptian, | | 2.5648 |
| black, | | 2.582 |
| Fluor spar. See *Spar.* | | |
| **G.** | | |
| Gabbronite, | | 2.94 |
| Gadolinite, | | 4.00<br>4.20 |
| Gahnite. See *Automalite.* | | |
| Galbanum, | | 1.2120 |
| Galena. See *Lead glance.* | | |
| Galipot, a juice of the pine, | | 1.0819 |
| Gamboge, | | 1.2220 |
| Garnet, precious, of Bohemia, | *Klaproth.* | 4.085 |
| | | 4.188 |
| | *Werner.* | 4.230 |
| | *Kastner.* | 4.352 |
| volcanic, | | 2.468 |
| 24 faces. | | |
| of Syria, | | 4.000 |
| in dodecahedral crystals, | | 4.0637 |
| common, | *Werner.* | 3.576 |
| | *Kastner.* | 3.688 |
| Gas, atmospheric,* or common air, | | 1.000 |
| phosgene, or chloro carbonic gas, | *J. Davy.* | 3.3888 |
| nitrous acid gas, calculated, | *Gay Lussac.* | 3.176 |
| | *Sir H. Davy.* | 2.427 |
| vapour of sulphuret of carbon, | *Gay Lussac.* | 2.6447 |
| sulphuric ether, | *Gay Lussac.* | 2.5860 |
| iodine, calculated, | *Gay Lussac.* | 8.6195 |
| hydriodic ether, | *Gay Lussac.* | 5.4749 |
| oil of turpentine, | *Gay Lussac.* | 5.0130 |
| hydriodic acid gas, | *Gay Lussac.* | 4.4430 |
| fluosilicic acid gas, | *John Davy.* | 3.5737 |
| chlorine, | *Gay Lussac and Thenard.* | 2.470 |
| euchlorine, | *Sir H Davy.* | 2.409 |
| | *Gay Lussac.* | 2.3144 |
| fluoboracic gas, | *J. Davy.* | 2.3709 |

* The specific gravities of the gases are taken from Biot's *Traité de Physique*, tom. i. p. 383; from Gay Lussac's Table in the *Annales de Chimie et de Physique*, vol. i. p. 218; and from Thomson's *Annals of Philosophy*, vol. i. p. 118. The measures for the gases, taken by M. M. Biot and Arago, are calculated from Biot's formulæ, which we have given in p. 432, 433 of this article. They are given in relation to atmospheric air which is supposed to be unity. Their relation to water is easily computed.

| | | |
|---|---|---|
| Gas, vapour of muriatic ether, | *Thenard.* | 2.219 |
| chloro cyanic vapour, | *Gay Lussac.* | 2.111 |
| sulphurous acid, | *Sir H. Davy.* | 2.193 |
| | *Gay Lussac* and *Thenard*, | 2.1204 |
| vapour of alcohol, | *Dalton.* | 2.1 |
| absolute alcohol, | *Gay Lussac.* | 1.613 |
| cyanogen, | *Gay Lussac.* | 1.806 |
| nitrous oxide, or prolixite of azote, | *Sir H. Davy.* | 1.614 |
| | *Colin.* | 1.5204 |
| carbonic acid, | *Saussure.* | 1.518 |
| | *Allan* and *Pepys.* | 1.524 |
| | *Biot* and *Arago.* | 1.51961 |
| muriatic acid, or hydro chloric gas, | *Sir H. Davy.* | 1.278 |
| | *Biot and Arago.* | 1.2474 |
| sulphuretted hydrogen, | *Gay Lussac* and *Thenard.* | 1.1912 |
| | *Sir H. Davy.* | 1.777 |
| oxygen, mean, | | 1.104 |
| | *Saussure.* | 1.114 |
| | *Kirwan* and *Lavoisier.* | 1.103 |
| | *Biot* and *Arago.* | 1.0359 |
| | *Allan* and *Pepys.* | 1.127 |
| nitrous gas, or deutoxide of azote, | *Berard.* | 1.0388 |
| | *Sir H. Davy.* | 1.094 |
| olefiant gas, | *Theodore Saussure.* | 0.97804 |
| azote, | *Biot* and *Arago.* | 0.96913 |
| carbonic oxide, | *Cruickshank.* | 0.9569 |
| hydrocyanic vapour, | *Gay Lussac.* | 0.9476 |
| phosphuretted hydrogen, | *Sir H. Davy.* | 0.870 |
| steam, | *Tralles.* | 0.6896 |
| | *Gay Lussac.* | 0.62349 |
| ammoniacal, | *Sir H. Davy.* | 0.590 |
| | *Biot* and *Arago.* | 0.59669 |
| carburetted hydrogen, | *Thomson.* | 0.555 |
| | *Sir H. Davy.* | 0.491 |
| | *Cruickshank.* | 0.678 |
| | *Dalton.* | 0.600 |
| arsenical hydrogen, | *Trommsdorf*, *Dalton.* | 0.529 |
| phosphuretted hydrogen, | *Haüy.* | 0.852 |
| | *Sir H. Davy.* | 0.435 |
| hydrogen, | *Thomson.* | 0.073 |
| | *Sir H. Davy.* | 0.074 |
| | *Biot* and *Arago.* | 0.072098 |
| Gehlenite, | *Fuchs.* | 2.78 |
| Girasol, | *Brisson.* | 4.000 |
| Glance coal, slaty, | *Metherie.* | 1.300 |
| | *Klaproth.* | 1.530 |
| Glass, crown of St. Louis, | *Cauchoix, Biot.* | 2.487 |
| flint of M. Dartigues, | *Cauchoix, Biot.* | 3.20 |
| flint used by Mr. Tully for his achromatic telescopes, | | 3.192<br>3.334<br>3.354<br>3.437 |
| white flint, | | 3.00 |
| crown, | | 2.520 |
| common plate, | | 2.760 |
| yellow plate, | | 2.520 |
| white or French crystal, | | 2.8922 |
| St. Gobins, | | 2.4882 |
| gall, | | 2.8548 |
| bottle, | | 2.7325 |
| Leith crystal, | | 3.189 |
| green, | | 2.6423 |
| borax, | | 2.6070 |
| fluid, | | 3.329 |
| of Bohemia, | | 2.3959 |
| of Cherbourg, | | 2.5596 |
| Glass, of St. Cloud, | | 3.2549 |
| animal, | | 2.5647 |
| mineral, | | 2.2694 |
| tears, or Rupert's drops of flint glass, | | |
| Glauberite, | | 2.700 |
| Gold, native, | | 17.00<br>19.00 |
| pure, of 24 carats, fine, fused, but not hammered, | *Haüy.* | 19.2587 |
| the same hammered, | | 19.342 |
| English standard, 22 carats, fine, fused, but not hammered, | | 18.888 |
| guinea of George II. | | 17.150 |
| guinea of George III. | | 17.629 |
| Parisian standard, 22 carats, not hammered, | | 17.486 |
| the same hammered, | | 17.589 |
| Spanish gold coin, | | 17.655 |
| Holland ducats, | | 19.352 |
| trinket standard, 20 carats, not hammered, | | 15.709 |
| the same hammered, | | 15.775 |
| Portuguese coin, | | 17.9664 |
| French money $21\frac{2}{3}$ carats fused, | | 17.4022 |
| coined, | | 17.6474 |
| French, in the reign of Louis XIII. | | 17.5531 |
| Granite, red Egyptian, | | 2.6541 |
| grey Egyptian, | | 2.7279 |
| beautiful red, | | 2.7609 |
| of Girardmor, | | 2.7163 |
| violet of Gyromagny, | | 2.6852 |
| red of Dauphiny, | | 2.6431 |
| green, ——— | | 2.6836 |
| radiated, of Dauphiny, | | 2.6678 |
| red of Semur, | | 2.6384 |
| grey of Bretagne, | | 2.7378 |
| yellowish, | | 2.6186 |
| of Carinthia, blue, | *Kirwan.* | 2.9564 |
| Granitelle, | | 3.0626 |
| of Dauphiny, | | 2.8465 |
| Graphic ore, | *Muller.* | 5.723 |
| Graphite. See *Plumbago.* | | |
| Grenatite. See *Staurotide.* | | |
| Gum Arabic, | | 1.4523 |
| tragacanth. | | 1.3161 |
| seraphic, | | 1.201 |
| cherry tree, | | 1.4817 |
| Bassora, | | 1.4346 |
| Acajou, | | 1.4456 |
| Monbain, | | 1.4206 |
| Gutte, | | 1.2216 |
| ammoniac, | | 1.2071 |
| Gayac, | | 1.2289 |
| liquid, from Botany Bay, | *Thomson.* | 1.196 |
| lac, | | 1.1390 |
| animè, Eastern | | 1.0284 |
| Western | | 1.0426 |
| Gunpowder in a loose heap, | | 0.836 |
| shaken, | | 0.932 |
| solid, | | 1.745 |
| Gypsum, opaque, | | 2.1679 |
| compact, specimen in the Leskean collection, | | 2.939 |
| compact, | | 1.872<br>2.288 |
| impure, | | 2.473 |
| foliated, mixed with granular limestone, | *Kirwan.* | 2.725 |
| semitransparent, | | 2.3062 |
| fine ditto. | | 2.2741 |
| opaque, | | 2.2642 |

| | | |
|---|---|---|
| Gypsum, rhomboidal, | | 2.3114 |
| ditto, 10 faces, | | 2.3117 |
| cuniform, chrystallised, | | 2.3060 |
| striated of France, | | 2.3057 |
| of China. | | 2.3088 |
| flowered, | | 2.3059 |
| sparry opaque, | | 2.2746 |
| semitransparent, | | 3.3108 |
| granularly foliated, in the Leskean collection, | *Kirwan.* | 2.900 |
| mixed with marl, of a slaty form, | | 2.473 |
| **H.** | | |
| Harmotome, or Cross Stone, | | 2.3333 |
| Hazel, | *Muschenbroek.* | 0.606 |
| Hauyne, or Latialite, | | 3.20 |
| Heavyspar. See *Barytes*, sulphate of. | | |
| Heliotrope, or Blood Stone, | *Kirwan.* | 2.629<br>2.700 |
| | *Blumenbach.* | 2.633 |
| Hematites. See *Ironstone.* | | |
| Hollow spar, Chiastolite, | | 2.944 |
| Hone, razor, white, | | 2.8763 |
| penetrated with water, | | 2.8839 |
| razor, white and black, | | 3.1271 |
| Honey, | | 1.4500 |
| Honeystone, or Mellite, | *Haüy.*<br>*Abich.* | 1.586<br>1.666 |
| Hornblende, common, | *Kirwan.* | 3.600<br>3.830 |
| resplendent, Labrador, | *Kirwan.* | 3.350<br>3.434 |
| Schiller spar, | *Kirwan.* | 2.882 |
| Hornblende, schistose, | *Kirwan.* | 2.909<br>3.155 |
| basaltic, | *Reus.* | 3.150<br>3.220 |
| | *Kirwan.* | 3.333 |
| Hornstone, or petrosilex, | | 2.530<br>2.643 |
| ferruginous, | | 2.813 |
| veined, | | 2.747 |
| grey, | | 2.654 |
| blackish grey, | | 2.744 |
| yellowish white, | | 2.563 |
| bluish, and partly yellowish grey, | | 2.626 |
| dark purplish red iron shot, | | 2.638 |
| greenish white, with reddish spots, from Lorraine, | | 2.532 |
| iron shot, brownish red, outside bluish, grey inside | | 2.813 |
| Hyalite, | *Kirwan.* | 2.110 |
| Hyacinth, | *Karsten.* | 4.000 |
| | *Klaproth.* | 4.545<br>4.620 |
| Hydrargillite. See *Wavellite.* | | |
| Hyperstene. See *Hornblende, Labrador.* | | |
| Hypocist, | | 1.5263 |

I

| | | |
|---|---|---|
| Jade, or Nephite, white, | | 2.9592 |
| green, | | 2.9660 |
| olive, | | 2.9829 |
| from the East Indies, | *Kirwan.* | 2.977 |
| of Switzerland, | *Brisson.* | 3.310<br>3.389 |
| combined with the boracic acid and boracited calx, | | 2.566 |

| | | |
|---|---|---|
| Jasmin, Spanish, | *Muschenbroek.* | 0.7700 |
| Jasper, veined, | | 2.6955 |
| red, | | 2.6612 |
| brown, | | 2.6911 |
| yellow, | | 2.7101 |
| violet, | | 2.7111 |
| grey, | | 2.7640 |
| cloudy | | 2.7354 |
| green, | | 2.6274 |
| bright green, | | 2.3587 |
| deep green, | | 2.6258 |
| brownish green, | | 2.6814 |
| blackish, | | 2.6719 |
| blood coloured, | | 2.6277 |
| onyx, | | 2.8160 |
| flowered, red and white, | | 2.6228 |
| red and yellow, | | 2.7500 |
| green and yellow, | | 2.6839 |
| red, green, and grey, | | 2.7323 |
| red, green, and yellow | | 2.7492 |
| universal, | | 2.5630 |
| agate, | | 2.6608 |
| Idocrase. See *Vesuvian.* | | |
| Jenite, | | 3.80<br>4.00 |
| Jet, a bituminous substance, | | 1.2590 |
| Indigo, | | 0.7690 |
| penetrated with water, | | 1.0095 |
| Inspissated juice of liquorice, | | 1.7228 |
| Iolite, or Dichroite, | | 2.56 |
| Iridium, ore of, discovered by Mr Tennant, | *Wollaston.* | 19.500 |
| Iron, native, meteoric, | | 6.48 |
| chromate of, from the department of Var, | | 4.0326 |
| chromate of, from the Uralian mountains, in Siberia, | *Lauguier.* | 4.0579 |
| sulphate of, saturated solution, temp. 42. | *Watson.* | 1.157 |
| arseniate of, | | 3.000 |
| fused, but not hammered, | | 7,200 |
| forged into bars, | | 7.600<br>7.788 |
| pyrites, dodecahedral, | *Hatchet.* | 4.830 |
| from Freyberg, | *Gellert.* | 4.682 |
| Cornwall, | *Kirwan.* | 4.789 |
| cubic, | *Brisson.* | 4.702 |
| radiated, | *Hatchet.* | 4.698<br>4.775 |
| magnetic, | *Hauy.* | 4.518 |
| white, | | 4. |
| sand, magnetic sand, from Virginia, | *Bergman.* | 4.600<br>7.800 |
| magnetic, | | 4.200<br>4.900 |
| ore specular, | *Kirwan.* | 4.793<br>5.139 |
| ore specular, | *Brisson.* | 4.939<br>5.218 |
| micaceous, | *Kirwan.* | 4.728<br>5.070 |
| Ironstone, red, ochry, | *Wiedemann.* | 2.952 |
| compact, | *Kirwan.* | 3.423 |
| from Siberia, | *Kirwan.* | 3.760 |
| Lancashire, | *Brisson,*<br>*Wiedemann.* | 3.573<br>3.863 |
| compact, brown, from Bayreuth, | *Kirwan.* | 3.551 |

| | | |
|---|---|---|
| Ironstone, from Tyrol, | *Kirwan.* | 3.753 |
| cubic, | *Brisson.* | 3.503 |
| | | 3.477 |
| red hematites, | *Kirwan.* | 5.005 |
| | *Gellert* | 4.6[illegible]0 |
| brown hematites, | *Kirwan.* | 3.951 |
| | *Gellert.* | 3.789 |
| | *Wiedemann.* | 4.029 |
| sparry, or calcareous, | *Kirwan.* | 3.640 |
| | | 3.810 |
| | *Brisson.* | 3.672 |
| decomposed, | *Kirwan.* | 3.300 |
| | | 3.600 |
| black, compact, | *Wiedemann.* | 4.076 |
| clay reddle, | *Brisson.* | 3.139 |
| | *Blumenbach.* | 3.931 |
| clay, lenticular, | *Kirwan.* | 2.673 |
| clay, common, from Cathina at Raschau, | *Kirwan.* | 2.936 |
| from Roscommon in Ireland, | *Rotheram.* | 3.471 |
| Carron in Scotland, | *Rotheram.* | 3.205 |
| | | 3.357 |
| clay, reniform iron ore, | *Wiedemann.* | 2.574 |
| clay, pea ore, | *Molinghof.* | 5.207 |
| Iron, native, (Heleachen mass) | *Monheim.* | 6.723 |
| ore, lowland, from Sprottau, | *Kirwan.* | 2.944 |
| Iserine, an oxide of titanium from the Iser in Bohemia, | | 4.500 |
| Juniper tree, | *Muschenbroek.* | 7.5560 |
| Ivory, dry, | | 1.8250 |
| Ivy gum, from the hedera terrestris, | | 1.2948 |
| **K** | | |
| Keffekil, or Meerschaum, | *Klaproth.* | 1.6000 |
| Kinkina, | *Muschenbroek.* | 0.7840 |
| Kyanite. See *Cyanite.* | | |
| **L** | | |
| Labdanum, resin, | | 1.1862 |
| *in tortis,* | | 2.4933 |
| Lapis nephriticus, | | 2.894 |
| hæmatites, | | 4.360 |
| judaicus, | | 2.500 |
| manatis, | | 2.270 |
| hepaticus, | | 2.666 |
| lazuli. See *Azure stone.* | | |
| Laumonite, | | 2.20 |
| Lard, | | 0.9478 |
| Latialite. See *Hauyne.* | | |
| Lazulite. See *Azure stone.* | | |
| Lead glance, or galena, common, | *Gellert.* | 7.290 |
| from Derbyshire, | *Watson.* | 6.565 |
| | | 7.786 |
| compact, | *Gellert.* | 6.886 |
| | | 7.444 |
| | *Kirwan.* | 4.319 |
| | | 5.052 |
| crystallised, | *Brisson.* | 7.587 |
| radiated, | *La Metherie.* | 5.500 |
| from the Hartz, | *Kirwan.* | 7.448 |
| Kautenbach, | *Vauquelin.* | 6.140 |
| Kirschwalder, | *Vauquelin.* | 5.820 |
| ore, corneous, | *Chenevix.* | 6.065 |
| reniform, | *Bindheim.* | 3.920 |
| of black lead, | | 6.745 |
| blue, | *Gellert.* | 5.461 |
| brown, | *Wiedemann.* | 6.974 |
| from Huguelgoet, | *Klaproth.* | 6.600 |
| | *Haüy.* | 6.909 |

| | | |
|---|---|---|
| Lead ore, black, | *Gellert.* | 5.770 |
| white, from Leadhills, | *Chenevix.* | 7.236 |
| | *Haüy.* | 6.559 |
| phosphorated, from Wanlockhead, | *Klaproth.* | 6.560 |
| Zschoppau, | *Klaproth.* | 6.270 |
| Brisgaw, | *Haüy.* | 6.941 |
| red, or red lead spar, | *Bindheim.* | 5.750 |
| | *Brisson.* | 6.027 |
| yellow, molybdenated, | | 5.092 |
| Lead, | *Fischer, Wollaston.* | 11.352 |
| | *Gellert.* | 11.445 |
| arseniate of, | | 5.00 |
| | | 6.40 |
| carbonate of, | | 6.00 |
| | | 7.20 |
| muriate of, | | 6.00 |
| sulphate of, | | 6.3 |
| chromate of, | | 6.00 |
| acetate of, | *Muschenbroek.* | 2.3953 |
| vitriol, from Anglesea, | *Klaproth.* | 6.300 |
| Lemon tree, | *Muschenbroek.* | 0.7033 |
| Lenticular ore (arseniate of copper) | *Bournon.* | 2.882 |
| Lepidolite, lilalite, | *Klaproth.* | 2.816 |
| | *Haüy.* | 2.854 |
| Leucolite. See *Dypyre.* | | |
| Leucite, or Amphigene, | *Klaproth.* | 2.455 |
| | | 2.490 |
| Lignum vitæ, | *Muschenbroek.* | 1.3330 |
| Limestone, compact, | | 1.3864 |
| | | 2.7200 |
| foliated, | | 2.710 |
| | | 2.837 |
| granular, | | 2.700 |
| | | 2.800 |
| green, | | 3.182 |
| arenaceous | | 2.742 |
| white fluor. See *Calcareous spar.* | | |
| Linden, wood, | *Muschenbroek.* | 0.604 |
| Lithomarge, | | 2.50 |
| Logwood, or campeachy wood, | *Muschenbroek.* | 0.9130 |
| **M** | | |
| Macle, | | 2.9444 |
| Madder root, | *Müschenbroek.* | 0.7650 |
| Mahogany, | | 1.0630 |
| Magnesia, sulphate of, saturated solution, temp. 42°, | *Watson.* | 1.232 |
| native, hydrate of, | | 2.330 |
| Magnesite, or carbonate of magnesia, | | 2.200 |
| a new species, from Baumgarten in Silesia, | *Haussmann.* | 2.95 |
| Magnetic pyrites. See *Iron.* | | |
| Malachite, | *Brisson.* | 3.572 |
| compact, | *Brisson.* | 3.641 |
| | *Muschenbroek.* | 3.994 |
| Manganese, | *Bergman.* | 6.850 |
| | *Hielm.* | 7.000 |
| grey ore of, striated, | *Brisson.* | 4.249 |
| | | 4.756 |
| | *Rinmann.* | 4.181 |
| grey foliated, | *Hagen.* | 3.742 |
| red from Kapnick, | *Kirwan.* | 3.233 |
| black, | *Dolomieu.* | 2.0000 |
| | | 3.0000 |
| | *Brisson.* | 3.7076 |
| penetrated with water, | | 3.9039 |
| scaly, | | 4.1165 |

| | | |
|---|---|---|
| Manganese sulphuret of | | 3.95 |
| white | | 2.8 |
| phosphate of | | 2.6 |
| Maple wood, | *Muschenbroek.* | 0.7550 |
| Marble Carrara, | *Brisson.* | 2.716 |
| Pyrenean, | | 2.726 |
| black Biscayan, | | 2.695 |
| Brocatelle, | | 2.650 |
| Castilian, | | 2.700 |
| Valencian, | | 2.710 |
| Granadian white, | | 2.705 |
| Siennian, | | 2.678 |
| Roman, violet, | | 2.755 |
| African, | | 2.708 |
| Italian, violet, | | 2 858 |
| Norwegian, | | 2.728 |
| Siberian, | | 2.728 |
| French, | | 2.649 |
| Switzerland, | | 2.714 |
| Egyptian, green, | | 2.668 |
| yellow of Florence, | | 2.516 |
| Mastic, | | 1.0742 |
| tree, | *Muschenbroek.* | 0.8490 |
| Medlar tree, | *Muschenbroek.* | 0.9440 |
| Meerschaum. See *Kessekil.* | | |
| Meionite, | | 3.10 |
| Melanite, or black garnet, | *Karsten.* | 3.691 |
| | *Werner.* | 3.800 |
| Mellite. See *Honeystone.* | | |
| Menachanite, | *Lampadius.* | 4.270 |
| | *Gregor.* | 4.427 |
| Mercurial hepatic ore, compact, | *Kirwan.* | 7.186<br>7 352 |
| | *Gellert.* | 7.937 |
| Mercury at 32° of heat, | | 13.619 |
| at 60° | | 13.580 |
| at 212° | | 13.375 |
| at 3°.42, centigrade, | *Fischer.* | 13.58597 |
| in a solid state, 40° below 0 Fahr. | *Biddle.* | 15.612 |
| in a fluid state, 47° above 0, | *Biddle.* | 13.545 |
| native, | *Haüy.* | 13.5681 |
| corrosive muriate of, saturated solution, temp. 42° | *Watson.* | 1.037 |
| natural calx of, | | 9.230 |
| precipitate *per se* | | 10.871 |
| red | | 8.399 |
| mineralized by sulphur, native Ethiops. See also Cinnabar, | *Hahn.* | 2.233 |
| Mesotype, | | 2.0833 |
| Mica, or glimmer, | *Brisson.* | 2.791 |
| | *Haüy.* | 2.6546<br>2.9342 |
| Milk, woman's | | 1.0203 |
| mare's, | | 1.0346 |
| ass's, | | 1.0355 |
| goat's, | | 1.0341 |
| ewe's, | | 1.0409 |
| cow's, | | 1.0324 |
| Mineral pitch, elastic, or asphaltum, | *Hatchet.* | 0.905<br>1.233 |
| | *La Metherie.* | 0.930 |
| tallow, | | 0.770 |
| Molybdena in a metallic state, saturated with water, | | 7.500 |
| native, | *Kirwan.* | 4.048 |
| | *Shumacker.* | 4 667 |
| | *Brisson.* | 4.7385 |
| Mountain crystal. See *Rock Crystal.* | | |
| Mulberry tree, Spanish, | *Muschenbroek.* | 0.8970 |
| Muriacite. See *Anhydrite.* | | |
| Muricalcite, crystallized, or rhomb spar, | | 2.480 |
| Myrrh, | | 1.3600 |

N

| | | |
|---|---|---|
| Natrolite Swedish, | *Thomson.* | 2 779<br>2.790 |
| Naphtha, | | 0.8475 |
| Nepheline, or Sommite | *Haüy.* | 3.2741 |
| Nephrite. See *Jade.* | | |
| Nickel in a metallic state, | | 7.421<br>8 500 |
| | *Bergman.* | 9.3333 |
| copper, | *Brisson.* | 6.6086<br>6 6481 |
| | *Gellert.* | 7.560 |
| Nickel, ore of, called arsenical nickel, or Kupfer-nickel of Saxony, | | 6.648 |
| Kupfernickel of Bohemia, | | 6.607 |
| sulphuretted, | | 6.620 |
| Nickeline, a metal discovered by Richter, cast, | *Richter.* | 8.55 |
| forged, | *Richter.* | 8.69 |
| Nigrine, or calcareo-siliceous titanic ore, | *Vauquelin.* | 3.700 |
| | *Klaproth.* | 4.445 |
| | *Lowitz.* | 4.673 |
| Nitre, | *Muschenbroek.* | 1.9000 |
| quadrangular, | *Muschenbroek.* | 2.2460 |
| saturated solution of, temperature 42°, | *Watson.* | 1.095 |
| Novaculite, or Turkey hone. See *Slate Whet.* | | |

O

| | | |
|---|---|---|
| Oak, 60 years old, heart of, | *Muschenbroek.* | 1.1700 |
| Obsidian, | | 2.348 |
| Octohedrite, | *Haüy.* | 3.857 |
| Oil of filberts, | | 0.916 |
| walnut, | | 0.92 |
| hemp-seed, | | 0.9258 |
| poppies, | | 0.9238 |
| rape-seed, | | 0.9193 |
| lint-seed, | | 0.9403 |
| poppy-seed, | | 0 929 |
| whale, | | 0.9233 |
| ben, a tree in Arabia, | | 0.9119 |
| beechmast, | | 0.9176 |
| codfish, | | 0.9233 |
| olives, | | 0.9153 |
| almonds, sweet, | | 0.9170 |
| volatile of mint, common, | | 0.8982 |
| volatile of sage, | | 0.9016 |
| thyme, | | 0.9023 |
| rosemary, | | 0 9057 |
| calamint, | | 0.9116 |
| cochlearia, | | 0.9427 |
| wormwood, | | 0.9073 |
| tansy, | | 0.9328 |
| Stragan, | | 0.9949 |
| Roman camomile, | | 0 8943 |
| sabine, | | 0.9294 |
| fennel, | | 0.9294 |
| fennel-seed, | | 1.0083 |
| coriander-seed, | | 0 8655 |
| caraway-seed, | | 0.9049 |
| dill-seed, | | 0.9128 |
| anise-seed, | | 0.9867 |

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|---|---|---|
| Oil volatile of juniper-seed, | | 0.8577 |
| cloves, | | 1.0363 |
| cinnamon, | | 1.0439 |
| turpentine, | | 0.8697 |
| amber, | | 0.8865 |
| the flowers of orange, | | 0.8798 |
| lavender, | | 0.8938 |
| hyssop, | | 0.8892 |
| Olibanum, gum, | | 1.1732 |
| Olive tree, | *Muschenbroek.* | 0 9270 |
| copper ore foliated, | *Bournon.* | 4.281 |
| fibrous, | *Bournon.* | 4.281 |
| Olivine. See *Peridot.* | | |
| Opal, precious, | *Blumenbach.* | 2.114 |
| common, | *Klaproth.* | { 1.958 / 2 015 } |
| | *Kirwan.* | 2.144 |
| semiopal, reddish, from Telkobanya. | *Klaproth.* | 2.540 |
| ligniform, or wood, | | 2.600 |
| Opium, | | 1.3365 |
| Ophites. See *Porphyry Hornblende.* | | |
| Opoponax, | | 1.6226 |
| Orange tree, | *Muschenbroek.* | 0 7059 |
| Orpiment, | *Kirwan.* | { 3 048 / 3.435 } |
| Orpiment, red. See *Realgar.* | | |
| Osmium and Iridium, alloy of, | | 19.5 |
| **P** | | |
| Palladium, | | 11.8 |
| Paranthine. See *Scapolite.* | | |
| Pear tree, | *Muschenbroek.* | 0.6610 |
| Pearl stone, | | 2.34 |
| Pearls, oriental, | | 2.683 |
| Peat, hard, | | 1.329 |
| Edinburgh, | *Thomson.* | 0.600 |
| Peridot, or Olivine, | | 3.428 |
| | *Werner.* | 3.225 |
| Peruvian bark, | | 0.7849 |
| Petrol, | | 0.8783 |
| Petrosilex. See *Hornstone.* | | |
| Pharmacolite, or arseniate of lime, | | 2.6 |
| Phosphorite, or Spargel stone, whitish, from Spain, before absorbing water, | | 2.8249 |
| after absorbing water, | | 2.8648 |
| greenish, from Spain, | | 3.098 |
| Saxon, | | 3.218 |
| Phosphorus, | | 1.714 |
| Pierre de volvic, | | 2.320 |
| Pinite, | *Kirwan.* | 2.980 |
| Pitch ore, or sulphuretted uranite, | *Guyton.* | 6.378 |
| | *Haüy.* | 6.530 |
| | *Klaproth.* | 7.500 |
| Pitch-stone, black, | *Brisson.* | 2.0499 |
| yellow, | *Brisson.* | 2.0860 |
| red, | *Brisson.* | 2.6695 |
| brick red, from Misnia, | *Kirwan.* | 2.720 |
| leek green, inclining to olive, | *Kirwan.* | 2.298 |
| pearl grey, | *Kirwan.* | 1.970 |
| blackish, | *Brisson.* | 2.3191 |
| olive. | *Brisson.* | 2.3145 |
| dark green, | *Brisson.* | 2.3149 |
| Pitchy, iron ore, | | 3.956 |
| Plasma, | | 2.04 |
| Platina, | *Klaproth.* | 20.722 |

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|---|---|---|
| Platina, drawn into wire, | | 21.0417 |
| a wedge of, sent by Admiral Gravina to Mr Kirwan, | | 20.663 |
| a bar of, sent by the king of Spain to the king of Poland, | | 20.722 |
| in grains purified by boiling in nitrous acid, | | { 17.500 / 18.500 } |
| native, | | { 15 601 / 17.200 } |
| fused, | | 14 626 |
| purified and forged, | | 20.336 |
| milled and purified, | *Haüy.* | 20.98 |
| compressed by a flatting mill, | | 22.069 |
| Pleonaste. See *Ceylanite.* | | |
| Plum tree, | *Muschenbroek.* | 0.7850 |
| Plumbago, or graphite, | *Kirwan.* | { 1.987 / 2.267 } |
| Pomegranate tree, | *Muschenbroek.* | 1.3540 |
| Poplar wood, | *Muschenbroek.* | 0.3830 |
| white Spanish, | *Muschenbroek.* | 0.5294 |
| Porcelain from China, | | 2.3847 |
| Seves, hard, | | 2.1457 |
| tender, | | 2 1654 |
| Saxony, modern, | | 2 4932 |
| Limoges, | | 2.341 |
| of Vienna, | | 2.5121 |
| Saxony, called *Petite Jaune,* | | 2.5450 |
| Porcellanite, | | 2 30 |
| Porphyry, green, | | 2.6766 |
| red, | | 2.7651 |
| red of Dauphiny, | | 2.7933 |
| red from Cordova, | | 2 7542 |
| green from ditto, | | 2.7278 |
| hornblende, or orphites, | | 2.9722 |
| pitch-stone, | | 2.452 |
| mullen, | | { 2.600 / 2 728 } |
| sand-stone, | | 2 564 |
| Potash, carbonate of, | | 1.4594 |
| muriate of, | *Muschenbroek.* | 1.8365 |
| tartrite of, acidulous, | *Muschenbroek.* | 1.9000 |
| antimonial, | | 2.2460 |
| sulphate of, | | 2.2980 |
| Potassium at 15° centigrade, | *Gay Lussac,* and *Thenard,* | 0.97223 |
| Potstone, | | { 2 80 / 3.00 } |
| Prasium, | | 2.5805 |
| Prehnite of the Cape, | *Haüy.* | 2.697 |
| | *Brisson.* | 2.9423 |
| of France, | *Haüy.* | 2.610 |
| Proof spirit, according to the English excise laws, | | 0.916 |
| Pumice stone, | | 0.9145 |
| Pycnite, or shorlous beryl, | *Haüy,* | 3.5145 |
| Pyrites. See *Copper* and *Iron.* | | |
| Pyrope. | *Klaproth.* | 3.718 |
| | *Werner.* | 3 941 |
| Pyrophysalite, | | 3.450 |
| Pyroxene. See *Augite.* | | |
| **Q** | | |
| Quartz crystallized, brown, red, | | 2.6468 |
| brittle, | | 2.6404 |
| crystallized, | | 2 6546 |
| milky, | | 2.652 |
| elastic, | *Gerhard.* | 3 750 |
| | *Kirwan.* | 2.6240 |

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|---|---|---|
| Quicksilver. See *Mercury*. | | |
| Quince tree, | *Muschenbroek.* | 0.7050 |
| **R** | | |
| Realgar, or red orpiment, | *Bergman.* | 3 225 |
| | *Brisson.* | 2 338 |
| Resin, or Guiacum, | | 1.2289 |
| of jalap, | | 1.2185 |
| Rock crystal, from Madagascar, | | 2 6530 |
| clove brown, | *Karsten.* | 2.605 |
| snow white from Marmerosch, | *Karsten.* | 2.888 |
| crystal, European, pure, gelatinous, | | 2.6548 |
| | *Malus.* | 2 63717 |
| of Brasil, | | 2.6526 |
| iridescent, | | 2.6497 |
| rose-coloured, | | 2 6701 |
| yellow Bohemian, | | 2.6542 |
| blue, | | 2.5818 |
| violet, or amethyst, | | 2.6535 |
| violet purple, or Carthaginian amethyst, | | 2.6570 |
| pale violet, white amethyst, | | 2.6513 |
| brown, | | 2.6534 |
| black, | | 2.6536 |
| Roucou, | | 0 5956 |
| penetrated with water, | | 1.1450 |
| Ruby oriental, | | 4.2833 |
| Brazilian, or occidental, | | 5.5311 |
| spinelle, | | 3.7600 |
| | *Klaproth.* | 3 5700 |
| ballas, | | 3.6458 |
| Rutile. See *Titanite*, | *Haüy.* | 4.102 |
| | *La Metherie.* | 4.246 |
| Rutilite or Sphene, | | { 3.1<br>{ 3.5 |
| **S** | | |
| Sahlite, | *Dandrada.* | 3.234 |
| Sal gem, | | 2.143 |
| Salt of vitriol, | | 1.9000 |
| sedative of Homberg, | | 1.4797 |
| polychrest, | | 2.1410 |
| *de Prunelle*, | | 2.1480 |
| volatile of hartshorn, | | 1.4760 |
| Sandarac, | | 1.0920 |
| Santal, white, | *Muschenbroek.* | 1.0410 |
| yellow, | *Muschenbroek.* | 0.8090 |
| red, | *Muschenbroek.* | 1.1280 |
| Sapagenum, | | 1.2008 |
| Sappare. See *Cyanite*. | | |
| Sapphire, oriental, white, | | 3.991 |
| of Puys, | | 4 076 |
| oriental, | | 3.994 |
| Brazilian, or occidental, | | 3.1307 |
| | *Haüy.* | { 3.994<br>{ 4.283 |
| | *Hatchet.* | { 4.000 |
| | *Greville.* | { 4.083 |
| Sarcocolla, | | 1.2684 |
| Sardonyx, pure, | *Brisson.* | 2.6025 |
| pale, | *Brisson.* | 2 6[illegible]60 |
| pointed, | *Brisson.* | 2 6215 |
| veined, | *Brisson.* | 2 5951 |
| onyx | *Brisson.* | 2 5949 |
| arborescent, | *Brisson.* | 2.5988 |
| blackish, | *Brisson.* | 2 6284 |
| Sassafras, | *Muschenbroek.* | 0.4820 |

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|---|---|---|
| Saussurite, | | 3.260 |
| Scammony, of Aleppo, | | 1.2354 |
| Smyrna, | | 1.2743 |
| Scapolite, or paranthine, | *Dandrada.* | { 3.6800<br>{ 3.7000 |
| Schistus. See *Slate, Hone, Stone*. | | |
| Schmelstein. See *Dipyre*. | | |
| Schorl, black, prismatic, hexahedral, | | 3.3636 |
| octahedral, | | 3.2265 |
| enneahedral, | | 3.0926 |
| black, sparry, | | 3.3852 |
| amorphous, or ancient basaltes, | | 2.9225 |
| cruciform, | | 3.2861 |
| violet of Dauphiny, | | 3.2966 |
| green, | | 3.4529 |
| common, | *Brisson.* | 3.092 |
| | *Gerhard.* | 3 150 |
| | *Kirwan.* | 3.2[illegible]2 |
| Selenite, or broad foliated gypsum, | | 2.322 |
| Serpentine, opaque, green, Italian, | | 2.4295 |
| penetrated with water, | | 2.4729 |
| ditto, red and black veined, | | 2.6273 |
| ditto, veined, black and olive, | | 2.5939 |
| semitransparent, grained, | | 2.5859 |
| ditto, fibrous, | | 2.9997 |
| ditto, from Dauphiny, | | 2.6693 |
| opaque, spotted black and white, | | 2.3767 |
| spotted black and grey, | | 2 2645 |
| spotted red and yellow, | | 2.6835 |
| green from Grenada, | | 2.6849 |
| deep green from Grenada, | | 2.7[illegible]97 |
| black, from Dauphiny, or variolite, | | 2 9339 |
| green from Dauphiny, | | 2.9883 |
| green, | | 2.8960 |
| yellow, | | 2 7305 |
| violet, | | 2 6424 |
| of Dauphiny, | | 2 7913 |
| Shale, | | 2.6 |
| Siderocalcite, or brown spar, | | 2.837 |
| Silver sulphuretted, or silver glance, | *Brisson.* | 6 910 |
| | *La Metherie.* | 7.200 |
| brittle, | *Gellert.* | 7.208 |
| white, | | 5.3 |
| red, or ruby, | *Brisson.* | 5.564 |
| light red, | *Brisson.* | 5.5886 |
| | *Gellert.* | 5.443 |
| sooty, | *Vauquelin.* | 5.592 |
| native, common, | *Gellert.* | 10.000 |
| | *Selb.* | 10.333 |
| antimonial, | *Hauy.* | 9.4406 |
| | *Selb.* | 10 000 |
| auriferous, | *Kirwan.* | 10.600 |
| ore, dark red, | *Gellert.* | 5 684 |
| | *Brisson.* | 5 5637 |
| arseniated, ferruginous, | | 2.178 |
| penetrated with water, | | 2.340 |
| ore, corneous, or horn ore, | *Brisson.* | 4 7488 |
| | *Gellert.* | 4.804 |
| virgin, 12 deniers, fine, not hammered, | | 10 474 |
| 12 deniers hammered, | | 10.510 |
| Paris standard, 11 deniers, 10 grains, fused, | | 10.175 |
| hammered, | | 10 376 |
| | *Klaproth.* | 10.784 |
| shilling of George II. | | 10 0[illegible]0 |
| George III. | | 10.534 |
| French money, 10 deniers, 21 grains fused, | | 10.046 |

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|---|---|---|
| Silver, French money, 10 deniers, 21 grains, coined, | | 10.408 |
| Sinople, coarse jasper, | | 2.6913 |
| Slate clay. See *Argillite*. | | |
| common, | | 2.6718 |
| or schistus, common | | 2.6718 |
| penetrated with water, | | 2.6905 |
| whet, or novaculite, | *Kirwan.* | 0.722 / 2.609 |
| Isabella, yellow, | *Kirwan.* | 2 955 |
| stone, | | 2.1861 |
| fresh polished, | | 2.7664 |
| adhesive, | *Klaproth.* | 2.080 |
| new | | 2 8535 |
| siliceous, | *Kirwan* | 2.596 / 2 641 |
| horn, or shistose porphyry, | *Kirwan.* | 2.512 / 2.700 |
| Smalt, or blue glass of cobalt, | | 2.440 |
| Smaragdite, | | 3.00 |
| Soda, sulphate of, | *Muschenbroek.* | 2.2460 |
| muriate of | *Muschenbroek.* | 2.1250 |
| saturated solution, temperature 42°, | *Watson.* | 1.198 |
| tartrite of, saturated solution of, | *Watson.* | 1.114 |
| fossil | | 2.1430 |
| saturated solution of, temperature 42°, | *Watson.* | 2.054 |
| Sodalite, | *Thomson.* | 2.378 |
| Sodium, at 15° centigrade, | *Gay Lussac* and *Thenard.* | 0.86507 |
| Sommite. See *Nepheline*. | | |
| Spar, brown. See *Sidero-Calcite*. | | |
| white sparkling, | | 2.5946 |
| red ditto, | | 2.4378 |
| green ditto, | | 2.7045 |
| blue ditto, | | 2.6925 |
| green and white ditto, | | 3.1051 |
| transparent ditto, | | 2.5644 |
| adamantine. See *Corundum*. | | 3.873 |
| schiller. See *Horn-blende Labrador*. | | |
| fluor, white, | | 3.1555 |
| Spar, fluor, red, or false ruby, | | 3.1911 |
| octahedral, | | 3.1815 |
| yellow, or false topaz, | | 3.0967 |
| green, or false emerald, | | 3.1817 |
| octahedral, | | 3.1838 |
| blue, or false sapphire, | | 3.1688 |
| greenish blue, or false aquamarine, | | 3.1820 |
| violet, or false amethyst, | | 3.1757 |
| violet purple, | | 3.1857 |
| English, | | 3.1796 |
| of Auvergne, | | 3.0943 |
| in stalactites, | | 3.1668 |
| pearl, or bitter, (carb. of lime and magnesia,) | | 2.8378 |
| calcareous rhomboidal, | | 2.7151 |
| in tubes, | | 2.71409 |
| of France, | | 2.7146 |
| prismatic, | | 2.7182 |
| and pyramidal, | | 2.7115 |
| pyramidal, | | 2.7141 |
| (puant gris,) | | 2.7121 |
| (puant noir,) | | 2.6207 |
| or flos ferri, | | 2.6747 |
| Spargel stone. See *Phosphorite*. | | |
| Spermaceti, | | 0.9433 |
| Spinelle. See *Ruby*. | | |
| Sphene. See *Rutilite*. | | |

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|---|---|---|
| Spirit of wine. See *Alcohol*. | | |
| Spodumene, or triphane, | *Hauy.* | 3.1923 |
| | *Dandrada.* | 3.218 |
| Stalactite transparent, | | 2.3239 |
| opaque, | | 2.4783 |
| penetrated with water, | | 2.5462 |
| Staurotide, staurolite, or grenatite, | *Hauy.* | 3 286 |
| Steatites of Bareight, | | 2.6149 |
| penetrated with water, | | 2.6657 |
| indurated, | | 2.5834 |
| penetrated with water, | | 2.6322 |
| Steel, | *Muschenbroek.* | 7.767 |
| soft, | | 7.8331 |
| hammered, | | 7.8404 |
| hardened in water, | | 7.8163 |
| hammered, and then hardened in water, | | 7.8180 |
| Stilbite, | | 2.50 |
| St John's wort, inspissated juice of, | | 1.5263 |
| Strontian, sulphate of, | *Hauy.* | 3.583 / 3.958 |
| carbonate of, | *Hauy.* | 3 658 / 3.675 |
| Stone, sand, paving, | | 2.4158 |
| grinding, | | 2.1429 |
| cutlers, | | 2.1113 |
| Fountainbleau, glittering, | | 2.5616 |
| crystallized, | | 2.6111 |
| scythe of Auvergne, mean grained, | | 2.5638 |
| fine grained, | | 2.6090 |
| coarse grained, | | 2.5686 |
| Lorraine, | | 2.5298 |
| Liege, | | 2.6356 |
| mill, | | 2.4835 |
| Bristol, | | 2.510 |
| Burford, | | 2.049 |
| Portland, | | 2.496 |
| rag, | | 2.470 |
| rotten, | | 1.981 |
| St Cloud, | | 2.201 |
| St Maur, | | 2.034 |
| Notre Dame, | | 2.378 |
| Clicard, from Brachet, | | 2.357 |
| rock of Chatillon, | | 2.122 |
| hard paving, | | 2.450 |
| Siberian blue, | | 2.945 |
| touch, | | 2.415 |
| prismatic basaltes, | | 2.722 |
| of the quarry of Bourè, | | 1.3864 |
| of Cherence, | | 2.4682 |
| Storax, | | 1.1098 |
| Sugar, white, | *Muschenbroek.* | 1.6060 |
| Sulphur, native, | *Hauy.* | 2.0332 |
| fused, | | 1.9907 |
| Sulphuric, or vitriolic acid, | | 1.841 |
| Sulphuret, triple, of lead, antimony, and copper, | *Hatchet.* | 5.766 |
| Sylvanite, or tellurite, in a metallic state, twice fused, | | 6.343 |
| Sylvan, native, | *Jacquin, jun.* | 4.107 |
| | *Muller.* | 5.723 |
| | *Klaproth.* | 6.115 |
| ore, yellow, | *Muller.* | 10.678 |
| black, | *Jacquin, jun.* | 6.157 |
| | *Muller.* | 8.919 |
| Syringa, | *Muschenbroek.* | 1.0989 |

T

| | | |
|---|---|---|
| Tacamahaca, resin, | | 1.0463 |

| | | |
|---|---|---|
| Tacamahaca, resin, | *Haüy.* | 2.8534 |
| | | 2.8729 |
| Talc, black crayon, | | 2.080 |
| ditto, German, | | 2.246 |
| yellow, | | 2.655 |
| white, | | 2.704 |
| of mercury, | | 2.7917 |
| black, | | 2.9004 |
| earthy, | | 2.6325 |
| slaty, | *Gahn* and *Berzelius.* | 2.718 |
| common Venetian, | | 2.700 |
| | | 2.800 |
| indurated, | | 2.90 |
| Tallow, | | 0.9419 |
| Tantalite, | *Ekeberg.* | 7.953 |
| Tantalium metal, | *Berzelius.* | 5.61 |
| in large masses, | *Gahn* and *Berzelius.* | 6.291 |
| in small pieces, | | 6.208 |
| Tartar | *Muschenbroek.* | 1.8490 |
| Telesie. See *Sapphire.* | | |
| Terra Japonica, | | 1.3980 |
| Tellurium, native, | | 5.700 |
| | | 6.10 |
| graphic, | | 5.7 |
| yellow, | | 10.6 |
| black, | | 8.9 |
| Thumerstone. See *Axinite.* | | |
| Tin, pure, from Cornwall, fused, | *Watson.* | 7.170 |
| | | 7.291 |
| fused and hammered, | | 7.291 |
| of Malacca, fused | | 7.296 |
| fused and hammered, | | 7.306 |
| of Gallicia, | *Gellert.* | 7.063 |
| of Ehrenfriedensdorf in Saxony, | *Gellert.* | 7.271 |
| of pyrites, | *Klaproth.* | 4.350 |
| | *La Metherie.* | 4.785 |
| stone, | *Gellert.* | 6.300 |
| | | 6.989 |
| | *Brunich.* | 6.750 |
| black | *Brisson.* | 6.901 |
| red, | *Brisson.* | 6.9348 |
| | *Klaproth.* | 5.845 |
| | | 6.970 |
| fibrous, | *Werner.* | 7.000 |
| | *Brunich.* | 5.800 |
| | *Blumenbach.* | 6.450 |
| new, fused, | | 7.3013 |
| fused and hammered, | | 7.3115 |
| fine, fused, | | 7.4789 |
| fused and hammered, | | 7.5194 |
| common, | | 7.9200 |
| called *Claire-etoffe*, | | 8.4869 |
| ore, Cornish, | *Brunich.* | 5.800 |
| | *Klaproth.* | 6.450 |
| from Fahlun, | *Gahn* and *Berzelius.* | 6.55 |
| stone, white, | | 6.008 |
| Titanite, Rutilite, or Sphene, | *Haüy.* | 4.102 |
| | *Lametherie.* | 4.246 |
| Topaz, oriental, | | 4.0106 |
| Brazilian, | | 3.5365 |
| from Saxony, | | 4.5640 |
| oriental pistachio, | | 4.0615 |
| Saxony white, | | 3.5535 |
| greenish blue, | *Hauy.* | 3.5489 |
| red, | *Hauy.* | 3.5311 |
| Tourmaline, | *Brisson.* | 3.086 |
| green, | *Hauy.* | 3.362 |
| blue, | *Werner.* | 3.155 |

| | | |
|---|---|---|
| Tremolite, | | 2.9 |
| | | 3.2 |
| Triphane. See *Spodumene.* | | |
| Tungsten, | *Leysser.* | 4.355 |
| | *Kirwan.* | 5.800 |
| | | 6.028 |
| | *Brisson.* | 6.066 |
| | | 6.015 |
| | *Klaproth.* | 5.570 |
| Turbeth mineral, | | 8.235 |
| Turpentine, spirits of, | | 0.870 |
| liquid, | | 0.991 |
| Turquoise, ivory tinged by the blue calx of copper, | | 2.500 |
| | | 2.908 |
| **U** | | |
| Ultramarine, | *Desormes* and *Clement.* | 2.360 |
| Uran glimmer or Uranite, | | 2.19 |
| Uranite in a metallic state, | *Klaproth.* | 6.440 |
| sulphuretted. See *Pitch ore.* | | |
| Uranitic ochre indurated, | *La Metherie.* | 3.150 |
| | *Hauy.* | 3.2438 |
| Uranium, | | 7.500 |
| Urine, human, | | 1.015 |
| | | 1.026 |
| diabetic, | *Henry.* | 1.028 |
| | | 1.040 |
| **V** | | |
| Vermeille, a kind of oriental ruby, | | 4.2299 |
| Vesuvian, | *Wiedemann.* | 3.575 |
| | *Klaproth.* | 3.420 |
| of Siberia, | *Klaproth.* | 3.365 |
| | | 3.339 |
| | *Hauy.* | 3.407 |
| Vine, | *Muschenbroek.* | 1.2370 |
| Vinegar, red, | *Muschenbroek.* | 1.0251 |
| white, | | 1.0135 |
| radical, | | 1.080 |
| Vitriol, Dantzic | | 1.715 |
| **W** | | |
| Walnut-tree of France, | *Muschenbroek.* | 0.6710 |
| Water distilled at 32° of Fahr. | | 1.0000 |
| sea, | | 1.0263 |
| of Dead sea, | | 1.2403 |
| wells, | | 1.0017 |
| of Bareges, | | 1.00037 |
| of the Seine filtered, | | 1.00015 |
| of Spa, | | 1.0009 |
| of Armeil, | | 1.00046 |
| Avray, | | 1.00043 |
| Seltzer, | | 1.0035 |
| Wavellite, or hydrargillite, | *Davy.* | 2.7000 |
| Wax, bees, | | 0.9648 |
| white, | | 0.9686 |
| shoemaker's, | | 0.897 |
| Whey, cows, | | 1.019 |
| Willow, | *Muschenbroek.* | 0.5850 |
| Witherite. See *Barolite.* | | |
| Wine of Torrins, red, | | 0.9930 |
| white, | | 0.9876 |
| Champagne, white, | | 0.9979 |
| Pakaret, | | 0.9997 |
| Xeret, | | 0.9924 |

| | | |
|---|---|---|
| Wine of Malmsey Madeira, | | 1.0382 |
| Burgundy, | | 0.9915 |
| Jurancon, | | 0.9932 |
| Bourdeaux, | | 0.9939 |
| Malaga, | | 1.0221 |
| Constance, | | 1.0819 |
| Tokay, | | 1.0538 |
| Canary, | | 1.033 |
| Port, | | 0.997 |
| Wolfram, | *Gmelin.* | 5.705 |
| | *Elhuyar.* | 6.835 |
| | *Leonhardi.* | 7.000 |
| | *Hatchet.* | 6.955 |
| | *Hauy.* | 7.333 |
| Wolf's eye (name of a mineral) | | 2.3507 |
| Woodstone, | | { 2.045 / 2.675 |

Y

| | | |
|---|---|---|
| Yenite. See *Jenite.* | | |
| Yew tree, Dutch, | *Muschenbroek.* | 0.7880 |
| Spanish, | *Muschenbroek.* | 0.8070 |
| Yttrotantalite, | *Ekeberg.* | 5.130 |
| Yttrocerite, | *Ghan* and *Berzelius.* | 3.447 |

Z

| | | |
|---|---|---|
| Zeolite from Edelfors, red, scintillant, | | 2.4868 |
| white scintillant, | | 2.0739 |
| compact, | | 3.1344 |
| cubic. See *Chabasie.* | | |
| siliceous, | | 2.515 |
| Zinc, pure and compressed, | | 7.1908 |
| in its usual state, | *Bergman.* | 6.862 |
| formed by sublimation and full of cavities. | *Kirwan.* | 5.918 |
| sulphate of, | *Muschenbroek.* | 1.9000 |
| saturated solution of temp. 42°, | *Watson.* | 1.386 |
| See *Blende.* | | |
| Zircon, or Jargon, | *Klaproth.* | 4.615 |
| | *Karsten.* | 4.666 |
| | *Wiedemann.* | 4.700 |
| | *Hauy.* | { 4.3858 / 4.4161 |
| Zirconite, | | 4.24 |
| Zoisite. | *Klaproth.* | { 3.26 / 3.31 |

## CHAP. IV.

### On the Equilibrium and Stability of Floating Bodies.

We have already seen, (Chap. II. Prop. I. p. 429,) that when a body is in equilibrium in a fluid, its weight is always equal to that of the fluid displaced; and that the centre of gravity of the floating body when homogeneous, must be situated in the same vertical line with the centre of gravity of the part submersed, or of the fluid displaced, Prop. II. p. 430. From the equality between the weight of the body and that of the displaced fluid, the upward pressure of the fluid is exactly capable of balancing the downward tendency of the body; but unless these two forces are directly opposed to each other by passing through the same point, the solid body will have a rotatory motion, instead of a position of perfect equilibrium. In order, therefore, to determine the positions in which a body will float permanently on the surface of a fluid, we have only, after the specific gravity of the body has been ascertained, to discover in what positions the solid can be placed, in order that the centre of gravity of the solid and of the part immersed may be in the same vertical line. The solid, however, will not float permanently in every case, when these centres of gravity are situated in the same vertical line; for there are examples, in which the body cannot remain in this position of equilibrium, but will actually assume another, in which it will continue to float permanently. Mr Atwood has illustrated this by the case of a cylinder, whose specific gravity is to that of the fluid on which it floats as 3 to 4, and whose axis is to the diameter of its base as 2 to 1. When the cylinder which we suppose to be 2 feet long, and its base 1 foot in diameter, is held in the fluid, with its axis in a vertical line, it will sink to a depth of $1\frac{1}{2}$ feet: but as soon as it ceases to be supported, it instantly oversets, and remains floating with its axis horizontal. If the cylinder, instead of being 2 feet long is only 6 inches, or one-half the diameter of its base, it will sink to the depth of $\frac{3}{8}$ths of its diameter, or $4\frac{1}{2}$ inches, and will float permanently in that position. In this last case, if the axis of the cylinder is not exactly in a vertical line, but a little inclined to it, the cylinder will still settle permanently with its axis in a vertical line.

Hence it is obvious, that there are different kinds of equilibrium.

1st, The *equilibrium of stability*, or that which is exhibited in the short cylinder 6 inches long, which floats permanently in a given position.

2d, The *equilibrium of instability*, or that which is exhibited in the cylinder 2 feet long, which oversets, although the centre of gravity of the solid and that of the part immersed are in the same vertical line. In this case the equilibrium is as perfect as in the first case; for while the centres of gravity are in the same vertical line, the solid must continue erect; but the slightest deviation of the centres of gravity from that line creates a rotatory motion, from which the solid necessarily oversets.

3d, The *equilibrium of indifference*, or the insensible equilibrium in which the solid floats indifferent to motion, and without any tendency to recover its position when inclined from it, or to incline itself farther. The equilibrium of indifference takes place, when the proportion between the axis of the cylinder and the diameter of its base is greater than 1 to 2, and less than 2 to 1. This kind of equilibrium is exhibited in a homogeneous sphere, or in a homogeneous cylinder, floating with its axis horizontal.

If a solid floats permanently on a fluid surface, and if it is moved from its position of equilibrium by any external force, the resistance which the solid opposes to this inclination is called the *stability of floating*; and the horizontal line round which it moves is called the *axis of motion*.

It would be impossible in a work like this, to enter at great length into a subject so difficult and profound as the present. We shall, therefore, content ourselves with stating the general principles relative to the stability of floating bodies, and with investigating the different positions of stability and instability which they assume; and in doing this shall freely avail ourselves of the labours of Mr Atwood, whose papers on the stability of floating bodies are remarkable for their perspicuity. In arranging, abridging, and sometimes simplifying his demonstrations, we trust we shall do an important service to the reader.

### Prop. I.

To determine the stability of bodies floating on a fluid at any angle of inclination from a given position of equilibrium.

Let EDHF be a vertical section through the centre of gravity G, of a homogeneous solid, whose figure is symmetrical with regard to the axis of motion, and let it float on the surface HABL of the fluid, O being the centre of gravity of the part immersed. Plate CCCXV. Fig. 1. The line GOC will therefore be perpendicular to AB. If by an external force the solid is inclined through an angle KGS, the solid will take the position IRLMN, and the part immersed will now be WRMNP. Hence, as the part XWI is raised out of the water, and the corresponding and equal part XNP immersed, the centre of gravity which would otherwise have been at E (taken so that GO = GE) will now be transfered to some other point Q. Having drawn QS parallel to GO, and EY and ZG$z$ perpendicular to SQ, it is obvious that the upward pressure of the fluid will be exerted in the line QS, with a force equal to the weight of the body, or that of the fluid displaced, and this force will have the same tendency to turn the body round its axis of motion, as if it were applied at the point Z. In determining, therefore, the position which bodies assume on a fluid surface, and the stability with which they float, it is necessary only to find the perpendicular distances GZ, between the two vertical lines which pass through the centre of gravity of the solid and the part immersed.

Since the weight of the body continues the same, the portion IXW, elevated from the fluid in consequence of the inclination, must always be equal to the portion PXN which is immersed. Hence, supposing $a$ to be the centre of gravity of IXW, and $f$ that of NXP, then the centre of gravity Q will be at a distance from E, corresponding to the change produced, by removing the fluid IWX to the position NXP. In order to determine, by a geometrical construction, the line, GZ, let fall the perpendiculars $a\,b$, $f\,c$, and in the line EY drawn parallel to AB, take ET, so that ET : $b\,c$ = volume IWX : volume WRMP. Through T draw FTS parallel to GO, then the centre of gravity required will be somewhere in FS, and because ER : EG = sin. KGS : rad. the line GO = EG being supposed given, the line ER will be determined, and being taken from ET already found, will leave RT or GZ the perpendicular distance required.

Now, when one body of a system is removed from its place, the corresponding motion of the common centre of gravity, estimated in any given direction, is to the motion of the body moved and estimated in the same direction as the weight of that body is to the weight of the whole system. Hence, considering IRMN as a system of bodies whose common centre of gravity is E, and that the body IWX, whose centre of gravity is $a$, has moved, or been transferred to NXP, whose centre of gravity is $f$, we shall have volume WRMP or ADHB : volume IWX or WXP = $b\,c$ : ET, the motion of one body, the motion of the centre of gravity of the system. Calling, therefore,

- V = volume of the part of the floating body immersed,
- A = the volume NXP, or the part immersed in consequence of the inclination,
- $h$ = GO the distance between the centre of gravity of the whole solid and that of the part immersed,
- $s$ = sine of the angle of inclination KGS,
- $b$ = $b\,c$ the space through which A has been transferred.

Then, by the proposition $b : \mathrm{ET} = \mathrm{V} : \mathrm{A}$, and $\mathrm{ET} = \frac{b \times \mathrm{A}}{\mathrm{V}}$. But ER : EG or GO = $s$ : 1, we have ER = $h\,s$; consequently, RT=ET—ER, or $\mathrm{GZ} = \frac{b\,\mathrm{A}}{\mathrm{V}} - h\,s$.

If the floating solid should be of an irregular form, the same demonstration will hold good; but we must, in this case, consider that the volume or space immersed by the inclination will no longer be WXP, but a space which must be obtained by calculation from the shape and dimensions of that volume. The centres of gravity of the volumes PXN, IXW, will in that case be no longer $a$ and $f$ the centres of gravity of the areas, but must be found by the usual rules. This proposition is applicable either to homogeneous or heterogeneous bodies, and enables us to determine the stability of vessels or other bodies, at any angle of inclination from a given position of equilibrium; for the stability is measured by a force equal to the upward pressure of the fluid, or the weight of the loaded vessel applied perpendicularly at the end of the lever GZ moving round the axis of motion.

### Prop. II.

To ascertain the different positions of equilibrium in which a body will float permanently on the surface of a fluid, and to discover in which of these positions the equilibrium is permanent or stable, and in which of them it is momentary or instable.

In order to do this, we must attend to the species of equilibrium in which the solid is placed previous to its being inclined from it. Assuming that the body is in a state of stable equilibrium, let it be inclined through an angle till it is again placed in a position of equilibrium. Then since during this inclination the upward pressure of the fluid acts with a force proportional to GZ to diminish the angular distance from the primitive position of equilibrium, it follows that the same force must act on the solid, so as to increase the inclination or angular distance from the second position of equilibrium to which the body arrives after revolving through the angle A, or any part of it. Hence it is obvious, that the second position of equilibrium must be that of instability, and, in general, that when a floating body is caused by an external force to revolve round its axis of motion, and pass through different positions of equilibrium, the positions of stability and instability must alternate, and no position of either species can follow a position of the same species.

In determining, therefore, the position which a solid will assume, after it has been overset from any situation of instable equilibrium, we must ascertain the angle of inclination through which the solid must revolve, so that the distance GZ may become evanescent, and we must also determine whether any position of equilibrium originally given is stable or instable. This may easily be done from the value of GZ already given; for if we take any point $t$ in the line ER, and through $t$ draw $q\,t\,z$ parallel to GO, then it is obvious,

1. That while $\frac{b\,\mathrm{A}}{\mathrm{V}} = \mathrm{ET}$ is *greater* than $h\,s$ = ER, the part Z and the line of support QZ, will be between the axis and the parts of the solid immersed in consequence of the inclination, which gives a *stable equilibrium*.

2. That while $\frac{b\,\mathrm{A}}{\mathrm{V}} = \mathrm{ET}$ is *less* than $h\,s$ = ER, the part $q$ and the line of support $q\,z$ will be on the opposite

side of the axis, and will give an *instable equilibrium.* Hence we can always determine, from the value of GZ, what is the particular kind of equilibrium with which the body will float when the angle of inclination, and consequently its sine, are assumed to be evanescent.

### Prop. III.

To find an expression for the stability or instability of floating, when the floating solid is not of an uniform figure and dimensions with respect to its axis of motion.

Let us suppose in Fig. 1. that another section of the solid is drawn parallel to ADHB, and very near it. A small portion of the solid will be comprehended between these planes; now, since the sine $s$ of the angle KGS is evanescent, and since WXP=IXW, and the angle NXP=the angle IXW, the point X will bisect the line AB, and the points P, B, N will be coincident. Hence, the evanescent area $NXP = \frac{XB^2 \times s}{2} = \frac{AB^2 \times s}{8}$; and if we represent by $z$ a line drawn through the middle of the solid, on a level with the surface of the fluid, and parallel to the larger axis, the evanescent portion of the solid comprehended between the adjacent vertical planes ADHB, and the one supposed extremely near it, will be $\frac{AB^2 \times s}{8} \times dz$; the perpendicular distance of the centre of gravity of this evanescent solid from the point X is $\frac{AB}{3}$. In order to find the distance from X of the centre of gravity of the whole volume immersed by the inclination, or the common centre of gravity of the elementary solids $\frac{AB^2 \times sdz}{8}$ corresponding to the length $z$, we must multiply each elementary solid by the distance of its centre of gravity from the horizontal line passing through X, and divide the sum of these products by the sum of the elementary solids. Hence, in the present case, since the distance from X of the centre of gravity of the elementary solid is $\frac{AB}{3}$, the product arising from multiplying the distance by the solid itself will be $\frac{AB^3 \times sdz}{24}$, and the sum of the products corresponding to the whole line $z$ will be fluent of $\frac{AB^3 \times sdz}{24}$; and since A represents the volume of the part immersed by inclination, and also of the part elevated by inclination, the distance of the centre of gravity of the immersed part or $c$ X, also of the part elevated, or $b$ X, will be fluent of $\frac{AB^3 \times sdz}{24A}$, and the distance between the two centres of gravity in the line $b\,c$ will be twice this quantity, or fluent of $\frac{AB^3 \times sdz}{12A}$. Substituting this value for $b$ in the general equation, we have $GZ =$ fluent of $\frac{AB^3 \times s\,d\,z}{12\,V} - h\,s$, which is the general expression required.

Now it follows, 1. That if the first member of this equation, viz. fluent of $\frac{AB^3 \times s\,d\,z}{12\,V}$, is greater than the second $h\,s$, the line of support QZ will be between the axis of motion and the part immersed by inclination, and the solid will float permanently; and, 2. That if the first member is less than the second, the line of support $q\,z$ will be on the contrary side of the axis, and the body will overset. Hence it is obvious, that between these limits, we must have the equilibrium of indifference which takes place when fluent of $\frac{AB^3 \times s\,d\,z}{12\,V} = h\,s$.

If the solid has an uniform figure and dimensions, then putting D for the area of any of the sections immersed under the fluid, the solid contents of the volume immersed will be D$z$, hence V=D$z$; and since AB is now a constant quantity, we have fluent of $\frac{AB^3 \times sdz}{12Dz} = \frac{AB^3 \times s\,z}{12Dz} = \frac{AB^3 \times s}{12\,D}$, consequently $GZ = \frac{AB^3 \times s}{12\,D} - h\,s$.

### Prop. IV. Prob.

To determine the limits of stability and instability in a parallelopiped depending on the dimensions and specific gravity of the solid.

In applying the preceding expressions to a parallelopiped, let EFDC be its vertical section, with its flat surface EF upwards, and IK the surface of the fluid. Through its centre of gravity G draw SGL parallel to CE, and let us take

$c =$ CE

$a =$ CD

$n =$ specific gravity of the solid, or $n : 1 =$ SN : SL. Fig. 2. Then if O be the centre of gravity of the part immersed, and since $n : 1 =$ SN : SL, or CL, we have SN$=$ $nc$; $GO = \frac{c}{2} - \frac{n\,c}{2}$, and ABCD $= a\,c\,n$. Substituting these values in the general expression already found, we have $GZ = \frac{a^3\,s}{12\,acn} - \frac{s \times \overline{c - nc}}{2}$; and since the equilibrium is one of indifference, when the first member of the expression is equal to the second, or when $\frac{a^3\,s}{12\,acn} = \frac{s \times \overline{c - n\,c}}{2}$, we have, by the resolution of this quadratic equation, $n^2 - n = -\frac{a^2\,s}{6\,c^2}$, and

$$n = \tfrac{1}{2} \pm \sqrt{\tfrac{1}{1} - \frac{a^2}{6\,c^2}}.$$

*Cor.* 1. From this proposition, we may infer, that whenever $\frac{a^2}{6\,c^2}$ is less than $\frac{1}{4}$, or when the height $c$ of the solid has a greater proportion to the base than that of $\sqrt{2}$ to $\sqrt{3}$, two values may be assigned to the specific gravity of the solid, which will cause it to float in the equilibrium of indifference. If, for example, $c=a$, we have $n = \frac{1}{2} \pm \sqrt{\frac{1}{4} - \frac{1}{6}}$, which gives

$$n = \tfrac{1}{2} + 0.28868 = 0.78868$$
$$n = \tfrac{1}{2} - 0.28868 = 0.21132.$$

*Cor.* 2. If the specific gravity of the solid is very small compared with that of the fluid, the term $\frac{a^3\,s}{12\,a\,c\,n}$ must be greater than $\frac{s \times \overline{c - c\,n}}{2}$, and the solid will float permanently with the line EF parallel to the horizon.

*Cor.* 3. If the specific gravity of the solid is increased beyond .21132, then, since this is the limit at which it ceases to float with stability, if it is placed with its flat surface upward, its equilibrium will be instable, and it will therefore assume a position of permanent equilibrium. By increasing the specific gravity from .21132 to .78868, the instability increases at first, and reaches its maximum, when $n = \frac{1}{\sqrt{6}}$; it then diminishes and vanishes at the second limit, when $n = .78868$. When $n$ is between .78868 and 1, the body will float permanently with its flat surface EF horizontal. The maximum of instability is found by putting the least increment of the quantity $\frac{a^3 s}{12\,acn} - \frac{s \times \overline{c - c\,n}}{2} = 0$, considering $n$ as variable, and making $a = c$.

*Cor.* 4. If the height SL of the parallelopiped is in a less proportion to its base CD than that of $\sqrt{2}$ to $\sqrt{3}$, there is no value of $n$ at which the stability will vanish; for in this case the quantity $\sqrt{\tfrac{1}{4} - \frac{a2}{6\,c2}}$ become impossible. The solid will therefore always float permanently with its surface EF horizontal.

PROP. V.

To determine the limits of stability and instability of a square parallelopiped, when one of its diagonals is in a vertical position.

Let EDCF be a vertical section of the parallelopiped floating on the surface AB of the fluid, and let G, as formerly, be the centre of gravity of the solid O, that of the part immersed, and $n$ the specific gravity of the solid. Fig. 3. Then if DC $= a$, we shall have GC $= \frac{a}{\sqrt{2}}$. But since HB=HC, we have ABC=HB$^2$; and since ABC : DEFC $= n : 1$, we have ABC $= a^2 n$, HB$^2$ $= a^2 n$, HC $= a \times \sqrt{n}$; AB$=2a\sqrt{n}$; OC $= \frac{2a\sqrt{n}}{3}$

and GO $= \frac{a}{\sqrt{2}} - \frac{2a\sqrt{n}}{3} = \frac{a \times 3 - \sqrt{8n}}{\sqrt{2} \times 3}$

If we now apply the general expression GZ $= \frac{\text{AB}^3 \times s}{12\,\text{D}} - h\,s$ to the present case, we shall obtain AB$^3 =$ $8\,a^3\,n^{\frac{3}{2}}$; D $= a^2\,n$; $h = \frac{a \times 3 - \sqrt{8\,n}}{\sqrt{2} \times 3}$, and consequently

GZ $= \frac{8\,a^3\,n^{\frac{3}{2}}\,s}{12\,a^2\,n} - \frac{a \times 3 - \sqrt{8\,n}}{\sqrt{2} \times 3}$. In order, therefore, to obtain the limit between the stability and instability of floating, we must make $\frac{\text{AB}^3 \times s}{12\,\text{D}} = h\,s$, as in Prop. IV. or making $\frac{8\,a^3\,n^{\frac{3}{2}}}{12\,a^2\,n} = \frac{a \times 3 - \sqrt{8\,n}}{\sqrt{2} \times 3}$, we shall have $\tfrac{2}{3}\sqrt{n} = \frac{3 - \sqrt{8\,n}}{\sqrt{2} \times 3}$ or $n = \tfrac{9}{32} = .28125$, the specific gravity at which the equilibrium of indifference begins, or the limit between the specific gravities at which the solid will float with stability and instability.

*Cor.* 1. It follows from the value of GZ given above, that when $n$ is evanescent, or extremely small, the solid will overset when placed on the fluid with the angle uppermost; for the first term of the value of GZ must necessarily be less than the second.

*Cor.* 2. If $n : 1 = 9 : 32$ the solid will float with the equilibrium of indifference; and therefore if $n : 1$ in a less ratio than that of 9 to 32, the solid will overset; but if $n$ exceeds that limit, then the solid will float permanently, with the angle E uppermost.

PROP. VI.

To determine the limit of stability and instability in a square parallelopiped with one of its angles upwards, when its specific gravity is greater than one half of the specific gravity of the fluid.

Let EDCF, Plate CCCXV. Fig. 5. be the square parallelopiped, which having a greater specific gravity than $\frac{1}{2}$, that of the fluid will sink so that the diagonal FD is below the surface of the water IK. Using the same symbols as in the last proposition, we have the area ABDCFA $= a^2\,n$, and the area EAB $=$ EH$^2$ $= a^2 - a^2\,n$, and consequently EH $= a\sqrt{1-n}$, and AB $= 2$ EH $= 2\,a\sqrt{1-n}$, and GH $= a \times \overline{\frac{1}{\sqrt{2}} - \sqrt{1-n}}$. Now if P be the centre of gravity of the area AEB, then from the property of the centre of gravity we have GH $\times$ area EDCF $=$ area ABDCFA $\times$ OH $-$ area AEB $\times$ HP, or $a^3 \times \overline{\frac{1}{\sqrt{2}} - \sqrt{1-n}} = a^2\,n \times \text{OH} - a^3 \times \frac{\overline{1-n}^{\frac{3}{2}}}{3}$, and by reduction

$$\text{HO} = \frac{a \times 3 - \sqrt{18} \times \sqrt{1-n} + a \times \sqrt{2} \times \overline{1-n}^{\frac{3}{2}}}{\sqrt{18} \times n}$$

Subtracting from this expression the value of HG $= a \times \overline{\frac{1}{\sqrt{2}} - \sqrt{1-n}} = \frac{3n - \sqrt{18\,n^2} \times \sqrt{1-n}}{\sqrt{18} \times n}$, we shall have the line

$$\text{GO} = \frac{a \times 3 - 3n\ \sqrt{18} \times \overline{1-n}^{\frac{3}{2}} \times \sqrt{2} \times \overline{1-n}^{\frac{3}{2}}}{\sqrt{18} \times n}$$

By inserting these values in the general formula GZ $= \frac{\text{AB}^3 s}{12\,\text{D}} - h\,s$, we have AB$^3$ $= 8\,a^3 \times \overline{1-n}^{\frac{3}{2}}$; D $= a^2\,n$, and since GO $= d$ we obtain GZ $= \frac{8\,a^3 \times \overline{1-n}^{\frac{3}{2}}}{12\,a^2\,n} - \frac{a \times 3 - 3n - \sqrt{18} \times \overline{1-n}^{\frac{3}{2}} + \sqrt{2} \times \overline{1-n}^{\frac{3}{2}}}{\sqrt{18} \times n}$. This value of GZ being put $= 0$ to obtain the limit, and the whole being multiplied by $\frac{3\,n \times \sqrt{2}}{\overline{1-n} \times a}$ we shall have

$$2\sqrt{2} \times \sqrt{1-n} = 3 - 3\sqrt{2} \times \sqrt{1-n} \times \sqrt{2} \times \sqrt{1-n}$$

or $\sqrt{1-n} = \frac{3}{4\sqrt{2}}$, and $1 - n = \frac{9}{32}$ and $n = \frac{23}{32}$ the limit required.

*Cor.* Hence from this, and the preceding propositions, we have the four limiting values of the specific gravities, viz. $\frac{1}{2} - \sqrt{\frac{1}{4} - \frac{1}{6}}$; $\frac{9}{32}$; $\frac{23}{32}$ and $\frac{1}{2} + \sqrt{\frac{1}{4} - \frac{1}{6}}$, or .211, .281, .718, and .789; that is, if the specific gravity is less than 211, the parallelopiped, with its flat surface upward and horizontal, will float permanently in that position, but will overset if the specific gravity is greater than .211 and less than .789. If the parallelopiped has one of its angles upward, when the specific gravity is less than .281, it will overset; if greater than .281, and less than .718, it will float permanently with an angle upward; but if the specific gravity exceeds .718, it will overset when placed in the fluid with an angle upward.

### Prop. VII.

If the parallelopiped is placed in the fluid in a position of instable equilibrium, so as to overset or change its position, it is required to ascertain the position which it will assume when it continues to float permanently; or to ascertain through what angle the solid will revolve, till its centre of gravity and the centre of gravity of the part immersed are again in the same vertical line.

Let EFDC, Fig. 5. be the vertical section of the parallelopiped when in its position of instable equilibrium; IK the surface of the water; G its centre of gravity; O the centre of gravity of the part immersed. Let the solid, after oversetting, have revolved through an angle UGS into the position YWVH, the part immersed will now be ZHVR, and QXR will be the part now immersed in consequence of the inclination. Bisect PZ and RQ in $m$ and $n$, join $m$ X, $n$ X, and taking X $a = \frac{2}{3}$ X $m$, and X $f = \frac{2}{3}$ X $n$, $a$ and $f$ will be the centres of gravity of the triangles PXZ, and QXK. Let fall the perpendiculars $a\,b$, $f\,c$ upon the line AB. In applying the general equation $GZ = \frac{b\,a}{V} - f\,s$ to the present case, we have QXR = A; ZHVR or ACDB = V; $b\,c = b$; OG $= f$; sine of UGO $= s$. Make $t$ equal the tangent of the angle UGO. Then from the similarity of triangles QX = XP; ZP = QR; ZX = XR. Making SL $= c$, and VU or XQ $= a$: then QR $= a\,t$; and Q $n = \frac{a\,t}{2}$; X $n = \sqrt{a^2 + \frac{t^2 a^2}{a}} = \frac{a}{2}\sqrt{4 + t^2}$. Now, since R $n$ or Q $n$ : X $n$ = sin. $n$ XR$n$, we have $\frac{t\,a}{2} : \frac{a}{2} \times \sqrt{4 + t^2} =$ sin. $n$ XR : sin. XR $n$, consequently sin. $n$ XR $= \frac{\text{Sin.}\,n\,\text{RX} \times t}{\sqrt{4 + t^2}}$ and substituting in place of sin. $n$ RX its value $\frac{1}{\sqrt{1 + t^2}}$, we obtain sin. $n$ XR $= \frac{t}{\sqrt{4 + t^2} \times \sqrt{1 + t^2}}$, and cos. $n$ XR $= \frac{2 + t^2}{\sqrt{4 + t^2} \times \sqrt{1 + t^2}}$ and since X $d = \frac{2\,\text{X}\,n}{3} = \frac{a \times \sqrt{4 + t^2}}{3}$, we have X $c = \frac{a \times \sqrt{4 + t^2} \times \overline{2 + t^2}}{3n\sqrt{4 + t^2} \times \sqrt{1 + t^2}} = \frac{a}{3} \times \frac{2 + t^2}{\sqrt{1 + t^2}}$. But X $b$ = X $c$ by similar triangles, and therefore $b\,c = 2\,\text{X}\,c = \frac{2a \times \overline{2 + t^2}}{3 \times \sqrt{1 + t^2}} = b$. Now the immersed part ACDB $= 2\,a\,c\,n =$ V, and the volume QXR $= \frac{a^2\,t}{2} =$ A. Substituting, therefore, these values in the equation $GZ = \frac{b\,A}{V} - h\,s$, we have $GZ = \frac{2a \times \overline{2 + t^2}}{3 \times \sqrt{1 + t^2}} \times \frac{a^2\,t}{4\,a\,c\,n} - h\,s = \frac{a^2\,t \times \overline{2 + t^2}}{6\,c\,n \times \overline{1 + t^2}} - h\,s$; but since $h = \frac{c - c\,n}{2}$; $GZ = \frac{a^2\,t \times \overline{2 + t^2}}{6\,c\,n\sqrt{1 + t^2}} - \frac{\overline{c - c\,n} \times s}{2}$. By substituting for $t^2$ its equal $\frac{s^2}{1 - s^2}$, the formula becomes $GZ = \frac{a^2\,s \times \overline{2 - s^2}}{6\,c\,n \times \overline{1 - s^2}} - \frac{\overline{c - c\,n} \times s}{2}$. As it may be more convenient to make $a$ express the whole breadth AB or PQ, instead of the half breadth, the equation will, by this change, become $GZ = \frac{a^2\,s \times \overline{2 - s^2}}{24\,c\,n \times \overline{1 - s^2}} - \frac{\overline{c - c\,n} \times s}{2}$. By making this value $= 0$, we obtain $s^2 = \frac{2\,a^2 - 12\,c^2\,n + 12\,c^2\,n^2}{12\,c^2\,n^2 - 12\,c^2\,n + a^2}$, or $s^2 = \frac{12\,c^2\,n - 12\,c^2\,n^2 - 2\,a^2}{12\,c^2\,n - 12\,c^2\,n^2 - a^2}$.

In the case of a square parallelopiped, we have $a = c$, and therefore $s^2 = \frac{12\,n - 12\,n^2 - 2}{12\,n - 12\,n^2 - 1}$. In order, therefore, to ascertain from this equation the angle through which the solid revolves, let us take $n = .24$, which being between .211 and .789, will place the solid with a flat surface upward and horizontal, and in an instable equilibrium, consequently $s^2 = \frac{.1888}{1.1888}$, and $s = \sqrt{\frac{.1888}{1.1888}} =$ the sine of 23° 29′, the angle of revolution, after which the solid will settle in a position of stable equilibrium.

The preceding equation determines also the specific gravity $n$, which will make the solid float at the angle $s$; for, by resolving that equation, we obtain $n = \frac{1}{2} \pm \sqrt{\frac{1 - 2\,s^2}{12 - 12\,s^2}}$, and applying this to the particular angle of 23° 29′, we have $n = 0.5 \pm 0.26 = 0.76$ and 0.24, the two specific gravities, which will cause it to float in stable equilibrium at the angle of 23° 29′.

### Prop. VIII.

To ascertain the position of equilibrium, &c. as in Prop. VII. when the surface of the fluid passes through one of the extremities of the base of the floating solid.

The preceding proposition is applicable only to the case where the surface of the water intersects the parallel sides YH, WV. In order to obtain the angle of inclination from a position of equilibrium, with the flat surface horizontal, and the specific gravity of the solid, when the fluid surface passes through one extremity of the base, let AECD, Fig. 6, be a vertical section of the square parallelopiped, and let the water line IK pass through D. Then putting CD $= a$, and $t =$ tangent of KDC, the angle required, we have KC $= a\,t$, and area KCD $= \frac{a^2\,t}{2}$; but area KCD : area AECD $= n$ : 1, we have $n = \frac{t}{2}$. Substituting this value of $n$ in the formula, or value of $s^2$ in the preceding proposition, we obtain $s^2 = \frac{6\,t - 3\,t^2 - 2}{6\,t - 3\,t^2 - 1}$, but $s^2 = \frac{t^2}{1 + t^2}$, consequently $\frac{t^2}{1+t^2} = \frac{6t-3t^2-2}{6t-3t^2-1}$, or $6t^3-3t^4-t^2 = 6t-3t^2-2+6t^3-3t^4-2t^2$, or $4t^2 = 6t-2$, which gives $t = \frac{3}{4} \pm \frac{1}{4}$, that is $t = \frac{1}{2}$, and $t = 1$. The first of these values corresponds to an angle of 26° 33′ 51″, and the second to an angle of 45°, as shewn in Fig. 7. In the first of these cases, KCD : ABCD, $= 1:4$, and therefore $n = \frac{1}{4}$, and the equilibrium is that of stability; in the second case $n = \frac{1}{2}$, and the position of equilibrium is also one of stability.

### Prop. IX.

To find the position of equilibrium as in Prop. VIII. when the fluid surface intersects one of the extremities of the upper side, as shewn in Fig. 8.

Putting ABK $= t$, we have areas ABK $= \frac{a^2 t}{2}$, and KCDB $= \frac{2a^2 - a^2 t}{2}$, consequently $n = \frac{2-t}{2}$, which, being substituted for $n$ in the equation of Prop. VIII. gives $\frac{t^2}{1+t^2} = \frac{6t-3t^2-2}{6t-3t^2-1}$, the same as formerly. Hence since $t = \frac{3}{4} \pm \frac{1}{4}$, we have $n = \frac{2-t}{2} = \frac{3}{4}$, or $n = \frac{1}{2}$.

### Prop. X.

To determine the position in which the parallelopiped will float permanently with a plane angle obliquely upward, when the specific gravity is between $\frac{8}{32}$ and $\frac{9}{32}$, or betwen $\frac{23}{32}$ and $\frac{24}{32}$.

It follows from Prop. VI. that when $n$ is between $\frac{8}{32}$ and $\frac{9}{32}$, or between $\frac{23}{32}$ and $\frac{24}{32}$, the solid will float permanently with the diagonal inclined to a vertical line. In order to find the angle, let IVCF, Fig. 9. represent the square parallelopiped floating with its angle I placed obliquely, and let its inclination to a vertical line be OGT. Let DE be the surface of the fluid, and taking CB a mean proportional between EC and CD, draw BA parallel to FV, and cutting IC in H, CH will be the depth to which the solid sinks when IV is vertical, and therefore area BXE = area XDA. Make CO $= \frac{2}{3}$ CH, and O will be the centre of gravity of the volume ABC. Bisect EB in K and AD in R, and draw KX, RX, and take XM $= \frac{2}{3}$ XR and XL $= \frac{2}{3}$ XK, and M, L will respectively be the centres of gravity of the triangles XAD, BXE. Let fall the perpendiculars MP, QL upon the horizontal line DE, then making PQ $= b$, sin. BXE $= s$; tang. BEX $= t$, and EC $= a$, we have CD $= ta$; CB $= \sqrt{ta^2}$; CH $= \sqrt{\frac{ta^2}{2}}$; CO $= \frac{2}{3}$ CH $= \sqrt{\frac{2ta^2}{9}}$; area ABC $=$ CH² $= \frac{ta^2}{2}$. Putting area BXE $= u$, we have area CDE or ABC : area BXE = PQ : OT or $\frac{ta^2}{2} : u = b :$ OT $= \frac{2bu}{ta^2}$, and OG $= \frac{2bu}{ta^2 s}$. Adding CO to CG, we obtain CG $= \frac{2bu}{ta^2 s} + \sqrt{\frac{2ta^2}{9}}$, and since GC : CV $= 1 : \sqrt{2}$, we have CV $=$ GC $\times \sqrt{2}$ and CV $= \frac{\sqrt{8} \times bu}{ta^2 s} + \sqrt{\frac{4ta^2}{9}} = \frac{\sqrt{72} \times bu + \sqrt{4t^3 a^6 s^2}}{3ta^2 s}$. But since $1 : n =$ area CAHB : IFCV, or as CH² : CV², we have $\sqrt{n} = \frac{\text{CH}}{\text{CV}}$ and $\sqrt{n} = \sqrt{\frac{ta^2}{2}} \times \frac{3ta^2 s}{\sqrt{72} \times bu + \sqrt{4t^3 a^6 s^2}} = \frac{3t^{\frac{3}{2}} a^3 s}{12bu + 2\sqrt{2}t^{\frac{3}{2}} a^3 s}$.

If we assume the angle OGT or BXE $= 15°$, and take CE $= 1$, we shall find BXE $= u = .039395$, and PQ $= b = 0.73089$, which being substituted in the above value of $n$, gives $\sqrt{n} = \frac{.34063}{.34552 + .32114} = 0.51094$ and $n = 0.261$, the specific gravity with which the solid will float in stable equilibrium, when its diagonal is inclined 15° to a vertical line.

The preceding solution is applicable to all cases in which $n$ is between $\frac{8}{32}$ and $\frac{9}{32}$; and by a similar process we may obtain an equation for the case when the specific gravity is between $\frac{23}{32}$ and $\frac{24}{32}$. In this case, the solid will float permanently with the line IC upward, but inclined to the vertical at some angle between 0° and 18° 26′ 9″.

Mr Atwood has collected into the following abstract, the various positions which the square parallelopiped assumes as depending upon its specific gravity.

1. If $n$ is between 0 and $\frac{1}{2} - \sqrt{\frac{1}{4} - \frac{1}{6}}$, (as shewn in Figs. 10, 11, and 12,) or between 0 and 0.211, the solid will float permanently with a flat surface upwards, and parallel to the horizon.
2. If $n$ is between .211 and 25, (as shewn in Figs. 12, 13, 14), it will float permanently with a flat surface upward, but inclined to the horizon at different angles from 0° corresponding to .211 to 26° 34′ corresponding to .25.
3. If $n$ is between .25 or $\frac{8}{32}$ and .281 or $\frac{9}{32}$, (as shewn in Figs. 14, 15, 16), the solid will float with only one angle immersed, the diagonal being inclined to the vertical at various angles from 18° 26′, corresponding to .25 or $\frac{8}{32}$, and 0° corresponding to .281 or $\frac{9}{32}$.
4. If $n$ is above .281 or $\frac{9}{32}$, (as in Figs. 16, 17,) the solid will float permanently with its diagonal vertical, till the specific gravity becomes .718 or $\frac{23}{32}$.
5. If $n$ is below .718 or $\frac{23}{32}$ and .75 or $\frac{24}{32}$, (as in Figs. 17, 18,) the solid will float with the diagonal inclined to the vertical at angles varying from 0° corresponding to .718 to 18° 26′ corresponding to .75, three angles of the solid being immersed.
6. If $n$ is between .718 or $\frac{24}{32}$ and .789 (as in Figs. 19, 20, 21,) the solid will float with a flat surface upward, and inclined to the horizon at various angles between 26° 34′ corresponding to .75 and 0° corresponding to .789.
7. If $n$ is between .789 and 1.000, the solid will float permanently with a flat surface parallel to the horizon.
8. When the solid revolves round its larger axis, or axis of motion, so as to complete an entire revolution of 360°, it will pass either through 16 or 18 positions of equilibrium. If $n$ is between .211 and .281, or between .719 and .789, the positions of equilibrium will be *sixteen*, eight of which will be positions of stable and the other eight of instable equilibrium, alternating with each other. If $n$ is not within these limits, the solid in the course of its revolution will pass only through *eight* positions, four of which are positions of stable, and the other four of instable, equilibrium.

In the preceding propositions, the solid is supposed to have a uniform figure in respect to the axis of motion, so that all its vertical sections are equal. But when the solid has such a form that the sections are unequal, a different process of investigation, though depending on the same principles, must be employed for determining its positions of equilibrium. We shall content ourselves with giving Mr Atwood's application of the preceding principles to a cylinder.

PROP. XI.

To determine the positions of stable and instable equilibrium, in a cylinder placed on the surface of a fluid, with its axis in a vertical position.

Let EFCD represent the cylinder with its axis NP, Fig. 22. vertical, and let it sink to the depth QP. Make $QA = r$, the distance between the centres of gravity G and O, viz. $GO = h$, and let AIBHSKA represent the circular section of the cylinder formed by the surface of the fluid. Draw any diameter IS, and another diameter AB, perpendicular to IS, and let IS be the direction of the axis round which the cylinder is moveable. Through any point W draw the double ordinate KH, and make $QW = z$, $NP = l$, and $\pi = 3.14159$, the ratio of the circumference to the diameter of a circle. Now, from Prop. III. it follows, that the solid will float permanently with the axis vertical, when fluent of $\frac{\overline{KH}^3 \times dz}{12\,V}$ is greater than $h$, and that the equilibrium will be instable if $h$ is the greater of the two, and therefore, when these two quantities are equal, the equilibrium will be the limit between stability and instability. To apply this to the present case, we must find the fluent of $\frac{KH^3 \times dz}{12\,V}$. Now since $QS = r$, $QW = z$, we have, by Euclid, B. III. Prop. 35. $WH = \sqrt{r^2 - z^2}$, $KH = 2 \times \sqrt{r^2 - z^2}$, and $KH^3\,dz = 8 \times \overline{r^2 - z^2}^{\frac{3}{2}} \times dz$, the fluent of which quantity, when $z$ increases from 0 to $r$, is $8 \times \overline{\frac{\pi r^4}{4} - \frac{\pi r^4}{16}} = \frac{8 \times 3\,\pi r^4}{16}$, and for both semicircles fluent of $\overline{KH}^3 \times dz = 3\,\pi r^4$; and since $PQ = l\,n$, and the area of the circle $AIBS = \pi r^2$, we have $V = \pi r^2\,l\,n$. But $GP = \frac{l}{2}$, and $OP = \frac{l\,n}{2}$, consequently $GO = \frac{l - l\,n}{2} = h$; and since $\frac{\text{fluent } KH^3 \times dz}{12\,V} = \frac{3\,\pi r^4}{12\,\pi r^2\,l\,n}$, by making $\frac{\text{fluent } \overline{KH}^3 \times dz}{12\,V} = h$, we shall obtain the limits between the stable and instable equilibriums. Thus $\frac{3\,\pi r^2}{12\,\pi r^2\,l\,n} = \frac{l - l\,n}{2}$, or $n^2 - n = -\frac{r^2}{2\,l^2}$. But since $2\,r = b$, or the diameter of the base, we have $n^2 - n = \frac{-b^2}{8\,l^2}$, and $n = \frac{1}{2} \pm \sqrt{\frac{1}{4} - \frac{b^3}{8\,l^2}}$.

Hence, if the diameter of the base bears a greater proportion to the length of the axis than that of $\sqrt{2}$ to 1, there is no value of the specific gravity $n$, which will cause the solid to float in the equilibrium of indifference: It follows, therefore, from the preceding investigations, that in this case it will always float permanently with its axis in a vertical line.

If the diameter of the base bears a less proportion to the length of the axis than $\sqrt{2}$ to 1, then there are always two values of $n$, which will be the limits of stability and instability. In order to determine the ratio between the length and diameter of the cylinder which limits the case of stability and instability when the specific gravity is given, we obtain from the equation $n - n^2 = \frac{b^2}{8\,l^2}$, the equation $\frac{b}{l} = \sqrt{8\,n - 8\,n^2}$, from which it follows, that since $n$ is given, the diameter of the base should be to the length of the axis of the cylinder in a greater proportion than that of $\sqrt{8\,n - 8\,n^2}$ to 1, in order that the solid may float permanently with its axis upwards; but if the diameter of the base should be to the length of the axis in a less proportion to that, the solid will overset. For example, if $n = \frac{3}{4}$, then $\sqrt{8\,n - 8\,n^2} = \sqrt{\frac{3}{2}} = 1.2247$; that is, the diameter of the base should be in a greater proportion to the length of the axis than 1.2247 to 1, in order that it may float permanently. If the proportion is less than this, it will overset.

We shall now conclude this Section, by following Mr Atwood in his application of the preceding principles to the stability of ships. We have already seen that the force of stability of a ship or any other body is represented by $W \times GZ$, W being the weight of the vessel and its lading. When the angle of inclination is so small as to be considered evanescent, we have seen that $GZ = \frac{\text{fluent of } AB^3 \times dz \times s}{12\,V} - h\,s$; but since the first member of this equation is equal to ET, and since $h = OG = EG$, it follows that $\frac{\text{fluent } AB^3\,dz}{12\,V} = ES$, and $\frac{\text{fluent } AB^3\,dz}{12\,V} - h = GS$, which is an invariable quantity, whatever be the inclination of the floating body, provided it is very small; that is, the point S is immoveable with respect to G. This point S is called the *Metacentre*, or centre of equilibrium; for if the centre of gravity G coincides with the point S, the stability, or $GZ \times W = W \times SG \times s$, will be $= 0$, or the solid will float in all positions alike, without any effort to restore itself if it is inclined, or to incline itself farther. If the centre of gravity G is situated beneath the metacentre S, the solid will always float with stability, as the measure of that stability $W \times SG \times s$ tends always to turn the body in a direction contrary to that in which it is inclined. If the centre of gravity is placed above the metacentre, the force $W \times SG \times s$ having passed through 0, tends to turn the vessel in the same direction as that in which it is inclined, and it will therefore float with an instable equilibrium.

When the angles of inclination, however, are large, the stability of the vessel will, as has already been shewn, be measured by $W \times GZ = \frac{\overline{b\,A}}{V} - d\,s \times W$. In the application of this formula to practice, $b\,A$ is the only quantity which requires to be determined; for all the other values can be easily ascertained from the nature of the case. In order to find $bA$, the following observations must be attended to. If a line parallel to the horizon passes from the head to the stern of the vessel when the ship floats uprightly, this line is called the *longer axis*, to distinguish it from the *shorter axis*, which passes through the same centre, but in a direction perpendicular to the former. If we conceive a vertical plane to pass through the longer axis when the ship floats uprightly, it will divide the vessel into two parts perfectly similar and equal. A ship in equilibrium may also be conceived to be divided into two parts by the horizontal plane which passes through the surface of the water, and this section is called the *principal section of the water*, represented in section by AB, Fig. 1, which will be transferred to IN when the vessel is made to heel or revolve through the angle SGK. The real section of the water will now be AB, which may be called the *secondary section of the water*. These two planes inclined at the angle of heeling SGK, intersect each other in X, and this line of intersection will obviously be parallel to the longer axis.

The position of the point X clearly depends on the shape of the sides of the vessel. In a parallelopiped, with two plane angles immersed, as in Fig. 5, the point X bisects the lines ZR, PQ, corresponding to AB, IN, in Fig. 1; but, when the same solid floats with only one plane angle immersed, as in Fig. 10, the point X no longer bisects these lines, but is removed towards the parts immersed by the inclination. As the breadth of vessels, therefore, has no regular proportion from the head to the stern, the position of X, which is necessary to the determination of $bA$, must obviously be determined practically by approximation. We must therefore conceive the equal volumes NXP, LXW, Fig. 1 and 25, one of which is immersed, and the other raised by the heeling of the ship, to be divided into segments by vertical lines, perpendicular to the longer axis, and at distances of two or three feet. These segments will therefore have the form of wedges, as shewn in Fig. 25, NXP being the inclination of the planes on the faces of the wedges.

The solid contents of the immersed wedges NXD must now be found by approximation; and making $XI = AB - NX$, and $XW = AB - PX$, the solid contents of all the wedges, IXW raised by heeling, must also be obtained. If the size of the immersed wedges is not equal to the size of the elevated wedges, the position of the point X must be altered, till this equality is obtained. To find $bA$, therefore, let the area PXNTP, and its centre of gravity $f$, be determined by approximation. Draw $dc$ perpendicular to PX, and $Xc$ will be the distance of the centre of gravity from the point X, estimated in the horizontal direction PX; and $ex$ being found in a similar manner, $\frac{Xc + ex}{2}$ will be the mean distance of the centre of gravity of the solid segment XPN $xpn$ from the line $Xx$, estimated in the horizontal direction XP. By finding similar distances of the centre of gravity of all the other wedges or segments, from $Xx$, estimated in the same direction, the sum of all these products will be the value of $bA$ required. Hence the measure of the vessel's stability $W \times \overline{\frac{bA}{V} - ds}$ for an angle whose sine is $s$, is obtained.

Such of our readers as wish to prosecute this subject farther, are referred to the following works: Archimedes *De iis quæ vehuntur in humido*. P. Paul Hoste, *Theorie de la Construction des Vaisseaux*, Lyon. 1696. Parent, *Mem. Acad. Par.* 1700. Pitot, *Theorie de la Manauvre des Vaisseaux*, *Mem. Acad. Par.* 1731. D. Bernoulli, *Comment. Petropol.* 1739, vol. x. p. 147; xi. p. 100. D'Alembert's *Essai sur la resistance des Fluides*, and his *Opuscules Mathematiques*, tom. I. Bouguer's *Traité de la Manœuvre des Vaisseaux*. Id. *Mem. Acad. Par.* 1754, p. 312; 1755, p. 481; 1757, Hist. p. 165. Clairaut, *Mem. Acad. Par.* 1760, p. 171. Juan. *Examen Maritimo*, Madr. 1771. Euler. *Theorie Complete de la Construction et Manœuvre des Vaisseaux*. This work was translated into English, and published in 1790. Chapman, *Traité de la Construction des Vaisseaux*. Clairbois, *Architecture Naval*, part ii. Romme, *L'Art de la Marine*, Paris, 1787. Bossut, *Traité d'Hydrodynamique*, tom. i. chap. xii. xiii. xiv. Atwood, *Phil. Transactions*, 1796, p. 46; and 1798, p. 201. English *Phil. Mag.* vol. i. p. 371, 393.

## CHAP. V.

### On Capillary Attraction, and the Cohesion of Fluids.

In our articles on Adhesion and Capillary Attraction, we have already given an account of the principal facts relative to the cohesion of fluids, and the ascent of water in capillary tubes. In the present chapter we propose to resume the subject, and after tracing the progress of discovery in this interesting branch of physics, to lay before our readers an account of additional experiments which have either been made since the publication of these articles, or which appear to us necessary for completing the view of the subject which might be expected in the present work.

The earliest experiments on the ascent of water in capillary tubes, appear to have been first made at Florence,* but we are not acquainted with the name of the philosopher who made them, or with the results which he obtained. The editor of the posthumous tracts of Pascal informs us, that capillary attraction was not known in France when Pascal wrote his posthumous treatise *Sur l'Equilibre des Liqueurs*, which could not have been composed more than a few years before his death in 1662; and he mentions it as if it were a fact well known, that the ascent of water in narrow tubes was first discovered by M. Rohault, a celebrated Cartesian philosopher, who taught mathematics and natural philosophy at Paris. In 1671, Rohault published in 4to his *Traité de Physique*, which was translated into Latin by Dr Clark. This work contains an account of the ordinary experiments on capillary attraction, which Rohault ascribes to the unequal pressure of the air within and without the tube. He states distinctly, that water rises between all bodies which are capable of being wetted with it, whereas it is depressed between substances that are not capable of being wetted. He observed the ascent of water between two plates of glass, and the spherical concavity of the upper surface in capillary spaces; but he no where gives the least hint, that he was the discoverer of these phenomena.†

In the year 1660, our celebrated countryman, Robert Boyle, published at Oxford his *New Experiments Physico-Mechanical touching the Spring of the Air*, &c. in which he has treated of the ascent of water in capillary tubes. He ascribes the discovery to some men of science in France,

* This is stated on the authority of Fabri.

† See Rohaultii *Physica*, edit. 1710, § 69, 70, 71, 80, 81, &c.

on the authority of a celebrated mathematician from whom he received it; and he repeated the experiment with a tube of very small bore, drawn out by means of the blow-pipe. In this tube, the water is said to have sprung instantaneously to the height of *five* inches, to the great surprise of several mathematicians that were present. When the tube was inclined, the water occupied a greater part of it, and it always rose higher in the tube when the inside of it was wetted beforehand. These experiments succeeded equally well, when the tubes were placed in an exhausted receiver. Mr Boyle observed also the concavity of the upper surface of the water, the convexity of the surface of mercury, and its depression in capillary tubes. See the above work, p. 262.

Dr Hooke seems to have been one of those who was present at the exhibition of this experiment; and he *is said* to have explained the phenomenon by affinity. In a tract published in 1660, and entitled "An attempt for the explication of the Phenomena observable in an experiment published by the Right Hon. Robert Boyle, in the 35th experiment of his Epistolical Discourse touching the Air, in confirmation of a former conjecture made by R. H."* Dr Hooke† accounts for the ascent of water in capillary tubes, by the unequal pressure of the atmosphere on the column of fluid within and without the tube. He supposes that there is a greater incongruity between air and glass than between water and glass, and that, on this account, the air is admitted with more difficulty into the tube than the water, the difficulty always increasing as the diameter of the tube diminishes. This hypothesis Dr Hooke endeavours to support, by the fact which he has determined experimentally, that a much greater force is necessary to force a bubble of water into a narrow tube than into a wide one; and he has illustrated it at great length, in the VIth Observation of his *Micrographia*, which appeared in 1667. This observation is entitled, *On Small Glass Canes*, and contains his most mature opinions on the subject. He states, that the water, when it enters small capillary tubes, rises rapidly to the height of 6 or 7 inches; that when the tube is extremely fine, it ascends slowly to a much greater height: and that he had never patience to wait till it rose higher than 21 inches, which must have been in a pipe, whose internal diameter was about the $\frac{1}{1428}$th part of an inch. He defines the term *Congruity*, which may be considered the same as affinity, as that "property of a fluid body, whereby any part of it is readily united with any other part, either of itself, or of any other similar fluid or solid body; and *Incongruity*, to be that property of a fluid, by which it is hindered from uniting with any dissimilar fluid or solid body." Dr Robison, and some other authors, are therefore mistaken in claiming for Dr Hooke the merit of explaining the phenomena of capillary attraction by affinity, by which they meant the affinity of water to glass. Dr Hooke, indeed, employs a term the same as this in his explanation of these phenomena; but it is employed for a quite different purpose; for he supposes that the water rises in the tube, not because it is attracted by the glass, but because there is a greater affinity between water and glass than between air and glass, in consequence of which, the column of air within the tube is not capable of balancing the corresponding atmospherical column without. "For since the pressure" says he, "of the air every way is found to be equal, that is, as much as is able to press up and sustain a cylinder of quicksilver of $2\frac{1}{2}$ feet high or thereabouts; and since of the pressure so many more degrees are required, to force the air into a smaller than into a greater hole that is full of a more congruous fluid; and, lastly, since these degrees that are requisite to press it in are thereby taken off from the air within, and the air within left with so many degrees of pressure less than the air without; it will follow, that the air in the less tube or pipe will have less pressure against the superficies of the water therein, than the air in the bigger. The conclusion, therefore, will necessarily follow, viz. that this unequal pressure of the air, caused by its ingress into unequal holes, is a cause sufficient to produce the effect, without the effect of any other concurrent; and therefore is probably the principal (if not the only) cause of these phenomena. This, therefore, being thus explained, there will be divers phenomena explicable thereby: as, the rising of liquors in a filtre; the rising of spirit of wine, oil, melted tallow, &c. in the wick of a lamp, though made of small wire, threads of asbestos, strings of glass, or the like; and the rising of liquors in a sponge, pieces of bread, sand, &c.; perhaps also the ascending of the sap in trees and plants, through their small and some of them imperceptible pores, at least the passing of it out of the earth into their roots." ‡This hypothesis of Dr Hooke's, which was received at the time with great applause, was afterwards shewn to be unsatisfactory and inconsistent with experiments by Roger Cotes.¶

In the year 1666, the learned Isaac Vossius published at the Hague his work, entitled *De Nili et Aliorum Fluminum Origine*, in the second chapter of which he describes the phenomena of capillary attraction, and endeavours to account for them by a theory which approaches more nearly than any other which had been given to the true theory of the action of capillary tubes. Since water, says he, is by its very nature viscid, it adheres to every thing which it touches, so that it adheres to glass, and is sustained by the glass. But since the water is sustained by the action of the glass, it does not press upon the water below it, as the same weight cannot press in two places, and as no body can be heavier than itself. The portion of water, therefore, which enters the tube, loads the glass tube to the sides of which it adheres, and is destitute of weight in respect of the subjacent water. Hence it follows, that if capillary tubes are immersed in water, and then taken out of it, the water which has entered them will not all flow out of the tube, but as much will remain as the surface of the tube can sustain. From this hypothesis Vossius concludes, that water will rise higher in narrow than in wide tubes, because the narrow tubes, in proportion to their capacity, present more points of contact of adherence to the water, and that mercury being destitute of viscidity, will not adhere to glass, and will therefore sink below its natural level in capillary tubes.

The first person in France who repeated these experiments, and attempted to investigate their cause, was M. Honoré Fabri, a learned Jesuit, who was born at Bellay near Lyons, in the year 1607. In the year 1669, he published a work, entitled *Dialogi Physici*, the fourth chapter of which is entitled, *De humoris elevatione per Canaliculum.* In this chapter, he observes that water, whether hot or

* In 1662, this work was translated into Latin, and published at Amsterdam, by M. Bohem, entitled *Conatus ad explicanda Phenomena notabilia in Experimenta publicata ab Honorabili Viro Roberto Boyle.*

† "In the year 1660," says Dr Hooke in his *Micrographia*, "I printed a little tract, entitled *An Attempt*, &c. and being unwilling then to publish this theory, as supposing it might be prejudicial to my design of watches, which I was then procuring a patent for, I only hinted the principle which I supposed to be the cause of these phenomena of springs, in the 31st page thereof in the English edition, and in 38th of the Latin edition, Amst. 1662; but referred the further explication thereof till some other opportunity."—Hooke *on Springs*, 4to, 1678.

‡ Hooke's *Micrographia*, p. 21.

¶ See Cotes' *Hydrostatical Lectures*, Lect. XI. Lond. 1738.

cold, ascends above the level of the water in the vessel; that it rises to a greater height in narrow than in wide capillary tubes; and that the water ascends highest in tubes of the same diameter when the tubes extend farthest above the surface of the water; that the water raised by capillary attraction will never flow out of the top of the tubes, however short; that the water will rise higher in a wet tube than in a dry one; that the water will not rise in a tube, if the finger is placed upon the upper end of its bore previous to immersion; and that in two concentric tubes, the water will rise sometimes higher and sometimes lower in the widest of the two tubes, according as the difference of their diameters is less or greater than the diameter of the inner tube. In explaining these phenomena, he maintains, that the external air, acting as a compressed body, has free access to press upon the surface of the water exterior to the tube, whereas it does not act so freely upon the surface of the water in the tube, and therefore the fluid will rise with a force proportional to the difference of these pressures. The cause of this unequal pressure of the air Fabri supposes to be, that only an inverted cone of air touching the fluid in the tube with its vertex, and having the upper orifice of the tube for its base, can press upon the surface contiguous to its vertex.

The celebrated Alphonso Borelli has attempted to explain the phenomena of capillary attraction in his Treatise *De Motionibus a Gravitate naturali pendente*, which was published at Lyons in 1670. He seems, like Vossius, to ascribe the elevation of water to its adhesion to the sides of the tube, and he considers the attractive force of the tube as extending to the particles of water placed in its axis. "In cavitatibus," says he, "subtilium fistularum internus aquæ contactus grandis est et amplus, respectu illius aquæ moleculæ ibidem existentis: ergo subito ac infimum fistulæ orificium attingit aquam, efficitur, in ejus interna et cava perimetro efficacissimus contactus a cujus adhesione fulciri sustinerique potest majus pondus, quam habet pusilla aquæ particula insinuata, et ideo gradus prædictæ virtutis suspensivæ et adhæsionis exercetur in aqua subjecta, et proinde ea reddetur aliquo pacto levis, seu minus ponderosa, quam sit aqua collateralis libere premens. Et, quia minimæ aquæ particulæ porositatibus et asperitatibus internis fistulæ innixæ efficiuntur operanturque ut totidem *vectes*, quæ flecti possunt et interne rotari, necesse est, ut partes aquæ, collaterales magis compressæ, a totali energia sui, ponderis vim faciant, impellendo sursum particulas aquæ, quæ minus comprimuntur a vectibus supra dictis; et ideo rotando excurrere possunt inferius efformando tumorem, vel monticulum aqueum, qui excurrendo lateraliter altioribus fistulæ porositatibus insinuabitur adhærebitque et ideo denuo imminuetur ejus vis compressiva, renovabiturque causa ulterioris suspensionis et proinde altius aqua intra fistulam impelletur, et sic de novo eminentioribus lateribus adhærendo successive altius impelletur quousque ad supremam et maximum illam altitudinem aqua perducta, in qua equilibrium, cum aqua collaterali libere premente efficiatúr: tunc quidem quies ejus subsequetur nec altius elevari poterit;" and in another place, prop. clxxxviii. p. 243, he accounts for the elevation of water to a greater height in small tubes: "Quia adhærentia et connexio aquæ parietibus internis canalium majorem proportionem ad molem aquæ insinuatæ *extensive* et *intensive* in canaliculis subtilissimis habet quam in amplis et capacioribus. *Extensive*, quia vis adhæsionis mensuratur a contactibus, et ideo a superficie interna canaliculorum; e contra resistentia iisdem canaliculis; estque proportio cylindrorum aquearum ejusdem altitudinis duplicata ejus rationis quam habent eorum perimetri internæ, &c. *Intensive*, quoniam facultas et energia adhæsionis minus efficax est quanto magis a parietibus removetur."

Similar experiments made by our countryman Sinclair, are described in his work, entitled *Ars Nova et Magna Gravitatis et Levitatis*, which was published at Rotterdam in 1669; and the experiments were repeated by Johannes Christopher Sturmius, who adopts the hypothesis of Fabri, and gives a full account of the opinions of Hooke, Boyle, Fabri, and Vossius, in the first part of his *Collegium Experimentale sive Curiosum*, which was published at Nuremberg in 1676.

The suspension of mercury in Toricellian tubes, far above the height of 28 inches, had been observed by several philosophers, and which was owing to the attraction of cohesion, and Huygens and Wallis attempted in vain to explain it. The former of these philosophers ascribes it to the pressure of a matter more subtle than air, which penetrates glass, water, quicksilver, and all other bodies, and which, added to the pressure of the air, enables it to sustain 75 inches of mercury. Wallis is equally unsuccessful in his explanation of the phenomena, which he ascribes to a particular spring of the air, which does not exist in the quicksilver.

The celebrated James Bernoulli appears to have paid some attention to the subject of capillary attraction. In his *Dissertatio de Gravitate Etheris*, which was published in 1683, he has endeavoured to explain the ascent of water, upon the supposition that the particles of air have a greater magnitude than those of water. In order to do this, he employs the diagram in Fig. 1. where ABCD is a capillary tube plunged in the vessel MN, and EFGH what he calls a similar atmospherical cylinder. He then supposes that the diameter of each tube will only receive a certain number of spherical particles of air, viz. seven for example, so that seven such particles placed in a straight line will exhaust the breadth of the tubes, as shewn at $i\,l$; but, according to our author, it will always happen that the *first* and *eighth* globules will rest upon the margin of the tube, as shewn at AB, and therefore only the six intermediate ones will rest upon the surface of the fluid, as seen at $q\,r$. Hence it will happen that the size of the globules of the air which occupies the circumference of the upper orifice of the tubes, with the superincumbent rows A $m$, B $n$, which rest upon that ring, will press upon the margin of the tubes, and will not produce the smallest pressure upon the surface $q\,r$ of the fluid. In the imaginary atmospherical cylinder or tube EFGH, nothing prevents the seven particles from acting freely upon the surface of the fluid EF. Hence Bernoulli concludes, that as the water without the tube is affected with a greater pressure than the water within the tube, it must necessarily rise to a height proportional to the excess of pressure. He then concludes from this hypothesis, that the water should not rise in wide tubes, as the portion of air prevented from acting by the margin bears a small proportion to the whole column;—that fluids specifically lighter than water ought to rise to a greater height; that the water cannot flow over the top of a capillary tube, however short; and that the surface of mercury ought to stand below its level in tubes of glass, if its particles are larger than those of water; (this effect he explains by Fig. 2. where the row of particles of mercury $s\,t$ is more pressed down by the weight of the air above than it is by the pressure of the mercury from below;) and finally, that the surface of water in capillary tubes ought to be concave, and that of mercury convex. Bernoulli next proceeds to deduce from this hypothesis the magnitude of a globule of air, and by assuming, from his own experiments, that water rises half an inch in a tube $\frac{1}{8}$ of an inch in diameter, he concludes that the magnitude of a particle of air, or rather the distance between the centres of two adjacent particles, is $\frac{1}{12500}$ of an inch. But having convinced himself by other means, that four particles of a very subtile matter is interposed between every two particles of air, he determines the real magnitude of a particle of air to be $\frac{1}{62500}$ of an inch!

A very interesting memoir on capillary attraction was published by M. Louis Carré in the Memoirs of the Academy of Sciences for 1705, entitled *Experiences sur les tuyaux Capillaires.* He ascribes the ascent of the water to its adhesion to the sides of the tubes, and to the mutual attraction of the particles of water. The portion of water contiguous to the sides of the tube is first raised and supported, and therefore presses less upon the bottom of the vessel than the collateral column. He attributes the higher elevation of the water within than without the tube to the mutual adhesion of the aqueous particles, which contributes to their elevation; and he says, that water rises higher in small tubes, since the force of adhesion is measured by the internal surface of the tubes, and the resistance by the supported column of fluid; and he supposes that water has a *greater contact* with glass than alcohol, and therefore rises higher. These views are supported by some new and curious facts: he found, that when the same surfaces were anointed with grease, the water would not rise above its level; that if only part of the surface was anointed, the water rose only on the side where there was no grease; that if the tube was plunged deeper than the point to which the grease reached, the water rose above its level; and that a drop of water descending on the outside of the tube was drawn into the tube when it was not greased, but refused to enter when the tube was greased.*

The following are the principal results which Carré obtained:

WATER.

| Diameter of tube, which was 12 inches long. | Height of ascent. |
|---|---|
| $0\frac{1}{3}$ of a line | 10 lines |
| $\frac{1}{6}$ | 18 |
| $\frac{1}{10}$ | 30 |

| Diameter of tube in parts of a line. | Fluids employed. | Height of ascent. |
|---|---|---|
| | Tube 12 inches long. | |
| $\frac{1}{3}$ | Water | $5\frac{3}{4}$ lines, 1st immersion.<br>7 lines, 2d immersion.<br>10 lines, 3d immersion. |
| $\frac{1}{3}$ | Alcohol | $3\frac{1}{2}$ lines. |
| $\frac{1}{3}$ | Spirit of turpentine | 4 |
| $\frac{1}{3}$ | Oil of tartar | 5 lines. |
| | Spirit of nitre | 4 |
| $\frac{1}{3}$ | Oil of olives | 5 |
| | Tube $9\frac{1}{2}$ inches long | |
| $\frac{1}{3}$ | Water | 10 lines. |
| $\frac{1}{3}$ | Alcohol | 4 lines. |
| | Tube 15 inches long | |
| $\frac{1}{6}$ | Water | 29 lines. |
| $\frac{1}{6}$ | Alcohol | 12 |
| | Tube 5 inches long | |
| $\frac{1}{6}$ | Water | 27 |
| $\frac{1}{6}$ | Alcohol | 12 nearly. |

The phenomena of capillary tubes were investigated with great care by our countryman Mr Hawksbee. In the year 1706, he communicated to the Royal Society an account of some experiments made at Gresham College, by which it was proved that water rose to the same height in capillary tubes *in vacuo* as in the open air; and he likewise observed in bending some small tubes by the flame of a candle in the manner of syphons, that it was necessary for the orifice of the longer leg to be at least so far below the surface of stagnant water as that water in the same tube would spontaneously ascend in it, before it would run. In 1709, Mr Hawksbee laid before the same learned body an account of his experiments on the rise of water between two plates of glass or polished marble, an experiment of which he has the exclusive merit. He shewed that the water rose between them whether the plates were placed *in vacuo* or in the open air; and having found that neither the figure of the vessel, nor the presence of the air, nor the quantity of matter in the tubes or plates, contributed to the production of the phenomena, he endeavours to explain the rise of the water, by supposing the glass to act upon water in the very same way as a magnet acts upon iron.† Mr Hawksbee's attention was next directed to the motion of a drop of oil of oranges between two glass planes. The drop always moved towards the sides of the planes that were nearest pressed together. The velocity of the drop increased as it approached the touching sides, and its surface of course increased in a similar manner, from the greater proximity of the planes. This experiment was also repeated with the same results *in vacuo.*‡ Mr Hawksbee next endeavoured to measure the angle required to suspend a drop of oil of oranges at certain stations, between two glass planes placed in the form of a wedge, as shewn in our Plate CX. Fig. 6. "I procured two glass planes," says Mr Hawksbee, "that measured a radius of 20 inches each; their breadth was about three inches; that which I used for the lower plane was placed with its surface parallel to the centre of its axis and to the horizon. The planes being very clean, they were rubbed with a linen cloth dipped in oil of oranges; then a drop or two of the same oil being let fall on the lower plane near the axis, the other plane was laid on it, and as soon as it touched the oil, the drop spread itself considerably between both their surfaces. Then the upper plane being raised a little at the same end by a screw, the oil immediately attracted itself into a body, forming a globule contiguous to both surfaces, and began to move toward the touching ends. When it arrived two inches from the axis, an elevation of 15 minutes at the

* See Mem. Acad. Par. 1705, p. 241, and 317, 8vo. edit.

† See Phil. Trans. 1707, vol. xxvi. p. 258.

‡ Id. 1711, vol. xxvii. p. 35.

touching ends stopped its progress, and it remained there without motion any way. The planes being let fall again, the drop moved forward till it came to four inches from the centre; then an elevation of 25 minutes was required to give it a fixed station. At 6 inches it required an angle of 35 minutes; at 8 of 45 minutes; at 10 a degree. At 12 inches from the axis the elevation was 1 degree 45 minutes, and so on at the several stations as they stand in the annexed table. This, after numerous trials, I take to be the most correct, though the others succeeded very nearly the same. It is to be observed, that when the globule or drop had arrived to near 17 inches on the planes from their axis, it would become of an oval form; and as it ascended higher, so would its figure become more and more oblong; and unless the drop was small on such an elevation of planes as was required at such a progress of the drop, it would be parted, some of it descending, and the rest of it running up to the top at once; but on a drop that separated these I found the remaining part of it, at 18 inches, would bear an angle of elevation equal to 22 inches, to balance its weight. Higher than that I could not observe. The planes were separated at their axis about $\frac{1}{10}$ of an inch. I found but little difference between small and larger drops of the oil in regard to the experiments. The angles were measured by a quadrant marked on paper, of near 20 inches radius, divided into degrees and quarters.

| Distance in Inches from the axis. | Angle of Elevation. | |
|---|---|---|
| 2 | 0° | 15′ |
| 4 | 0 | 25 |
| 6 | 0 | 35 |
| 8 | 0 | 45 |
| 10 | 1 | 0 |
| 12 | 1 | 45 |
| 14 | 2 | 45 |
| 15 | 4 | 0 |
| 16 | 6 | 0 |
| 17 | 10 | 0 |
| 18 | 22 | 0 |

In the year 1712,* Dr Brook Taylor communicated to the Royal Society the beautiful experiment (See CAPILLARY ATTRACTION, vol. v. p. 409, and Plate CCX. Fig. 6.) respecting the hyperbolic surface of water elevated between two glass planes, inclined at an angle of two and a half degrees. Mr Hawksbee (*Phil. Trans.* 1712, vol. xxvii. p. 539.) repeated the experiment with great care at two different inclinations, of 20′ and 40′, and obtained the following results:

| *Angle of* 20′ | | *Angle of* 40′ | |
|---|---|---|---|
| Distances from the touching ends of the Planes. | Heights of the Water at the preceding Distances. | Distances from the touching ends of the Planes. | Heights of the Water at the preceding Distances. |
| 13 inches | 1 | 9 inches | 1 |
| 9 | 2 | 6 | 2 |
| 7 | 3 | 4¾ | 3 |
| 6 | 3¾ | 3 | 4¾ |
| 5 | 5 | 2½ | 6 |
| 4 | 6¾ | 2 | 7½ |
| 3 | 9 | 1½ | 10 |
| 2½ | 12 | 1¼ | 12 |
| 2 | 15½ | 1 | 15 |
| 1¾ | 18 | ¾ | 19 |
| 1½ | 21½ | ½ | 28 |
| 1¼ | 27½ | ¼ | 50 |
| 1 | 35 | | |
| ¾ | 50 | | |
| ½ | 76 | | |

Mr Hawksbee afterwards found that the curve was an exact hyperbola in all directions of the planes, the asymptotes being the surface of the water, and a line drawn along the touching sides of the planes. Mr Hawksbee's next experiments were made on the heights to which spirit of wine ascended between two plates of glass separated successively to different distances. The following results were obtained:

| Distance of Plates. | Height of Ascent. |
|---|---|
| 0.0625 of an inch | 0.166 of an inch |
| 0.03125 | 0.333 |
| 0.015625 | 0.666 |
| 0.007802 | 1.333 |

As a drop of spirits of wine when placed between the two glass planes, did not move so nimbly as a drop of oil of oranges, Mr Hawksbee was enabled to observe the angles at which it remained suspended at different stations between the plates. The following tables contain the results for inclination of 10′ and 18′.

*Inclination of the Planes* 10′.

| Distance in Inches from the touching ends. | Angle of Elevation. | |
|---|---|---|
| 18½ | 1° | 30′ |
| 16½ | 1 | 50 |
| 14½ | 2 | 10 |
| 12½ | 2 | 40 |
| 10½ | 3 | 10 |
| 9½ | 3 | 30 |
| 8½ | 4 | 0 |
| 7½ | 5 | 5 |
| 6½ | 7 | 40 |
| 5½ | 10 | 50 |
| 4½ | 14 | 0 |
| 4 | 18 | 0 |

In this experiment Mr Hawksbee could not observe nearer than 4 inches from the touching ends.

*Inclination of the Planes* 18′

| Distance in Inches from the touching ends. | Angle of Elevation. | |
|---|---|---|
| 18½ | 0° | 45′ |
| 16½ | 0 | 55 |
| 14½ | 1 | 5 |
| 12½ | 1 | 20 |
| 10½ | 1 | 30 |
| 9½ | 1 | 40 |
| 8½ | 2 | 00 |
| 7½ | 2 | 30 |
| 6½ | 3 | 20 |
| 5½ | 4 | 25 |
| 4½ | 6 | 0 |
| 4 | 7 | 23 |
| 3¾ | 8 | 40 |
| 3½ | 9 | 25 |
| 3¼ | 10 | 30 |
| 3 | 12 | 40 |
| 2¾ | 15 | 0 |
| 2½ | 18 | 50 |
| 2¼ | 23 | 25 |
| 2 | 30 | 0 |

The preceding experiments of our author are not only the most numerous, but the most correct, that have been made on capillary attraction, and have been appealed to by La Place as a proof of the accuracy of his own theory. The opinions of Hawksbee respecting the cause of capillary attraction were equally correct. He ascribed the ascent of the fluid to the attraction of the whole surface of the tube; and he considered the attractive force of the glass as extending, like the refracting force, only to insensible distances.

In the year 1718, Dr James Jurin communicated to the Royal Society his *Inquiry into the Cause of the Ascent and Suspension of Water in Capillary Tubes.* This paper contains many new and ingenious experiments; but its author was unfortunate in the erroneous explanation which he gives of the phenomena. "Since in every capillary tube," says he, "the height to which the water will spontaneously ascend is reciprocally as the diameter of the tube, it follows that the surface, containing the suspended water in

* See Phil. Trans. 1712, vol. xxvii. p. 853.

every tube, is always a given quantity; but the column of water suspended is as the diameter of the tube; therefore, if the attraction of the containing surface be the cause of the water's suspension, it will follow that equal causes produce unequal effects, which is absurd." "Having shewn," continues he, "the insufficiency of this hypothesis, I come now to the real cause of the phenomenon, which is the attraction of the periphery or section of the surface of the tube to which the upper surface of the water is contiguous and coheres. For this is the only part of the tube from which the water must recede upon its subsiding, and consequently the only one which by the force of its cohesion or attraction opposes the descent of the water. This is also a cause proportional to the effect which it produces, since that periphery and the column suspended are both in the same proportion as the diameter of the tube." Dr Jurin afterwards accounts for the spontaneous ascent of the water. He supposes that the water which first enters a capillary tube, when its orifice is immersed in the fluid, has its gravity taken off by the attraction of the periphery with which its upper surface is in contact: Hence it must necessarily rise higher, partly by the pressure of the stagnant water, and partly by the attraction of the periphery immediately above that which is already contiguous to it. These opinions Dr Jurin endeavoured to support by the experiment represented at E, F, G in Fig. 5. of Plate CX. and described under Capillary Attraction. (See *Phil. Trans.* vol. xxx. p. 739.) In a subsequent paper he inquires into the cause of the suspension of water in tubes of glass, and seems to adopt the opinion, that the cohesion may depend on the pressure of a medium subtle enough to penetrate the receiver. "For though such a medium," says he, "will pervade the pores of the water as well as those of the glass, yet it will act with its entire pressure on all the solid particles, if I may so call them, of the surface of the water in the cistern; and whereas so many of the solid particles of the water in the tube, as happen to lie directly under the solid particles of the water above them, will thereby be secured from this pressure, and consequently there will be a less pressure of this medium on any surface of the water in the tube below the capillary, than in an equal surface of the water in the cistern; so that the column of water suspended in the tube may be sustained by the difference between these two pressures."

The subject of capillary attraction was treated at great length by George Bernhard Bullfinger, in a dissertation entitled *De Tubulis Capillarium, dissertatio experimentalis*, which appeared in the *Commentarii Acad. Petropolitanæ* for 1727. This paper contains an examination of the different hypotheses which had been employed to explain the phenomenon of capillary attraction, and several new experiments illustrative of his own opinion. He found that the relative ascent of spirit of wine, red wine, and water, were as 4, 7 and 12. He seems, upon the whole, to prefer the hypothesis of Dr Jurin, although he states a number of difficulties which attend it. Dr Jurin replied to this paper of Bullfinger's in the volume of the *Commentarii Acad. Petropolitanæ* for 1728; and his paper is published with the annotations of Bullfinger. After examining all the objections which had been stated, and apparently to the satisfaction of Bullfinger, Dr Jurin begs that he will no longer consider his explanation as a hypothesis, but as a true and established theory.*

When M. Bullfinger exhibited his experiments before the Academy of St Petersburgh, his colleague, the celebrated Daniel Bernoulli, who was at that time unacquainted with the speculations of his uncle on the same subject, proposed a new theory of capillary attraction. In order to get over the difficulty respecting the ascent of the water under the receiver of an air pump, he ascribed the phenomenon, not to the unequal pressure of the air, as his uncle had done, but to the unequal pressure of an ethereal fluid. He considered the base of the fluid as contiguous to the surface of the water; but he supposed that it was not so full at the sides of the pipe as in its axis; or, in other words, that the æther stood at a greater distance from the glass than water did, or was less dense in the neighbourhood of the glass. This effect he attributed to the particles of the æther being greater than those of water. This hypothesis, which differs in no respect from that of James Bernoulli, excepting in the substitution of æther for air, has the advantage of surmounting the difficulty already mentioned. But, in other respects, it is more inadmissible. Daniel Bernoulli attempted to shew that it explained many of the common experiments, and that the proportion between the magnitude of the particles of different fluids might be deduced from the height of their ascent in capillary tubes. He inferred, from a rude and erroneous experiment, that the particles of mercury were twice as small as those of water.

An excellent dissertation, entitled *Dissertatio Physica de Tubis Capillaribus Vitreis*, was published by M. Muschenbroek, which contains a great variety of interesting experiments upon this subject. He has committed a mistake, however, in maintaining that the height of ascent increases with the length of the tube. The constant quantity for water, as deduced by Dr Young, from his best experiments, is 0.392.

In the year 1736, Josiah Weitbrecht published a valuable paper in the *Commentarii Acad. Petropolitanæ*, entitled *Tentamen Theoriæ qua ascensus aquæ in tubis capillaribus explicatur*. He shews that water is more strongly attracted by glass than it is by its own particles; that the sphere of activity of the attraction of the glass is extremely small, that is, the action of the glass does not extend to the axis of the tube; that the water must be partly supported by the mutual attraction of its own particles; that the water in the capillary tube is drawn downwards, not only by its own gravity, but by the attraction of the water in the vessel; that the water in the tube is elevated by the attractive force of the whole internal surface of the tube successively applied; but that it is suspended solely by the action of the ring of glass immediately above the fluid column. M. Weitbrecht considers the force which suspends the water as represented by $Q-Q'$, $Q$ representing the force with which the water is attracted to the glass, and $Q'$ the force with which it is attracted downwards by the water in the vessel; and as $Q$ is greater than $Q'$ in water and most fluids, the quantity $Q-Q'$ is affirmative, and the water rises above its level. When the tube is taken out of the water, the force $Q'$ he considers as vanishing, and therefore the remaining force is allowed to act without opposition, and consequently the water rises to a greater height in the tube. In mercury $Q'$ is greater than $Q$, and therefore the expression is negative, and the fluid consequently sinks below its level. M. Weitbrecht made the following experiments on the ascent of water.

* "Si ista," says he, "quod speramus, Cl. Bullfinger satisfecerint, pollicemur nobis, pro candore et æquitate Viri humanissimi cum in osterum explicationem hanc phenomenon *non amplius pro hypothesi*, sive *futili ingenii commento, sed pro vera et indubita corundem theoria habitatura.*" Comment. Petrop. 1728, p. 291, 292.

| Diameter of the tube. English Inches. | Height of ascent. Inches. | Constant quantity. |
|---|---|---|
| 0 06 | 0.72 | 0 0432 |
| 0.045 | 0.95 | 0 04275 |
| 0.04 } 0.05 } 0.045 | 0 92 | 0.04140 |
| 0.05 | 0.85 | 0 0425 |
| 0.06 | 0.71 | 0.0426 |
| 0.08 | 0 53 | 0.0424 |
| 0.025 | 1.72 | 0.043 |
| | | 7) .29785 |
| | Mean constant quantity | .04255 |

In a subsequent memoir, entitled *Explicatio Difficilium experimentorum circà ascensum aquæ in tubis Capillaribus*, published in the *Comentarii Acad. Petropolitanæ*, for 1737, M. Weitbrecht resumes the subject. He shews that Muschenbroek was mistaken, in considering the height of ascent as affected by the length of the tube. He points out the effects produced by interposing bubbles of air between the different parts of the elevated column; he examines the phenomena exhibited by conical tubes, and tubes where the diameter of the bore changes rapidly; and he terminates his memoir with several interesting experiments on the effects of capillary syphons and bent capillary tubes.

Hitherto mercury was the only metallic fluid which had been employed in capillary experiments. M. Gellert, however, communicated a memoir to the Academy of Sciences at St. Petersburgh, entitled *De Phenomenis plumbi fusi in Tubis Capillaribus*. In making these experiments, he employed the thinnest glass tubes he could procure, and heated them gradually before he immersed them into the melted lead. In this way he found, that melted lead always stood below its level in a tube of glass, and that the altitudes in different tubes were nearly in the reciprocal ratio of their diameters. When the diameter of the tube was 10.21 of an English inch, the lead sunk 0.27 of an inch, whereas in a tube 0.07 it sunk 0.73 of an inch. These results give 567 and 510 for the constant quantity, the mean of which is 5385. In another paper, entitled, *De Tubis Capillaribus Prismaticis*, M. Gellert treats of the ascent of water in prismatic tubes of a triangular and quadrangular form, made of iron. He found, that they gave results perfectly analogous to those which were made of glass.

Before the time of Clairaut, no attempt had been made to analyse with accuracy the different forces which concur in the elevation of water in capillary tubes, and to subject the phenomena to a rigorous calculation. The merit of doing this belongs wholly to this eminent mathematician, who has published his investigations in the tenth chapter of his *Theorie de la Figure de la Terre tirée des Principes de l'Hydrostatique*, which was published at Paris in 1743, and of which a second edition appeared in 1808. In this chapter, which is entitled *De l'Elevation ou de l'Abaissement des Liqueurs dans les tuyaux Capillaires*, he begins by pointing out the mistake in the reasoning employed by Dr Jurin in the establishment of his hypothesis, and he then proceeds to the analysis of the forces by which the water is elevated and suspended. An account of this analysis has already been given in our article on Capillary Attraction. The resulting formula which he obtains for the altitude I $i$, (Plate CX. Fig. 9.) is I $i$ =

$$\frac{(2Q-Q')\cdot\int dx\,[b,x] + \int dx\,[b,x,Q,Q']}{p}, \text{ where}$$

Q = the intensity of the attraction of the glass.

Q′ = the intensity of the attraction of the water.

$b$ = the interior radius of the tube.

$p$ = the force of gravity.

The function of the distance which expresses the law of attraction both for glass and water is supposed given, and he employs $x$ to denote the distance of a particle from the plane MN, $[x]$ the force at which this particle is attracted by a body, of which this plane is the exterior surface, supposing the intensity of the attraction of this body to be unity. The function $[b\ x]$ expresses the force with which a particle Q, placed at the distance QO or $x$ from the surface CH is attracted by the tube or bulb cylinder CDABGHEF, and $[b, x, Q, Q']$ the force with which a corpuscle $p$ placed at the distance $x$ from VX is attracted by the small mass of water YVXZ.

"Without pushing the calculation farther," says M. Clairaut, "in order to find what will be the quantities $[b, x]$ and $[b, x, Q, Q']$ according to the different functions of the distances by which the law of attraction may be expressed, we may easily see that there will be an infinity of laws of attraction in which the preceding expression of I $i$ will give a sensible altitude, when the diameter $b$ of the tube is very small, and on the contrary, a height almost insensible when the tube is very wide." It follows from the value of I $i$, that if the attraction of the capillary tube is less than that of water, provided it is not twice as small, the water will still ascend; for it is obvious from the term $(2\ Q-Q')\int d\,x\,[b, x]$, that while Q′ is less than 2 Q, I $i$ will be positive.

In the Transactions of the Royal Society of Gottingen for 1751, M. Segner has referred all the phenomena of capillary attraction to the attraction of the superficial particles of fluids. Considering the resemblance at the surface of the drops of fluids and of fluids contained in capillary tubes to the surfaces, which geometers have named *lintearia* or elastic, he was led to consider fluids as enveloped in such surfaces, which, by their tension and elasticity, gave to fluids the form indicated by experiment. It appears, however, that Segner considered this only as a fiction which might represent the phenomena, but which ought only to be admitted in so far as it belonged to a law in which the attraction is insensible at sensible distances. Segner tried to establish this dependance; but in the opinion of La Place, "in following this reasoning it is easy to discover its inaccuracy, which is also proved by the incorrectness of the results to which he arrives. He finds, for example, that we ought to consider only the curvature of the vertical section of a drop, and not its horizontal curvature, which is not exact; and besides this, he did not perceive that the tension of the surface is the same, whatever be the magnitude of the drop."*

The subject of the adhesion of fluids to plates of solid bodies, which was first investigated by our countryman Dr Brook Taylor,† was now resumed with great success by M. Guyton Morveau, in 1773. The same subject was prosecuted by M. Achard of Berlin, and M. Dutour, the last of whom made a great number of experiments both on the adhesion of discs, and on the ascent of fluids. An account of the general results which they obtained, will be found in our article Adhesion.

In the year 1787, M. Monge published in the Memoirs of the Academy of Sciences, a paper entitled *Sur quelques effets d'attraction et de repulsion apparente entre les Molecules de Matiere*. These experiments relate principally to the apparent attraction and repulsion which are exhibited by floating bodies when they approach within a certain distance of each other; to the phenomena of drops; and to

* See *Comment. Gotting.* 1751, tom. i. p. 301.

† See *Phil. Trans.* 1721.

the ascent of water between two planes of glass. An account of his experiments will be found in the present chapter.

The subject of capillary attraction has been ably investigated by Dr Thomas Young, in his paper *On the Cohesion of Fluids*, which appeared in the *Philosophical Transactions* for 1805; and in which he has anticipated many of the views afterwards brought forward by La Place. This paper is divided into 8 sections. Sect. I. Contains the general principles; Sect. II. Treats of the form of the surface of fluids; Sect. III. Contains the analysis of the simplest form; Sect. IV. Contains the application of it to the elevation of particular fluids; Sect. V. Treats of apparent attractions and repulsions; Sect. VI. Treats of the physical foundation of the law of superficial cohesion; Sect. VII. Of the cohesive attraction of solids and fluids; and Sect. VIII. is entitled, additional extracts from La Place, with remarks. A general account of Dr Young's views, and some of his experimental results, will be found under our article on Capillary Attraction.

In December 1805, M. le Comte La Place laid before the National Institute of France a Dissertation on Capillary Attraction, which is marked with the high genius of its distinguished author. In 1806, it was published under the title of *Supplement au dixieme Livre du Traité de Mecanique Celeste, sur l'Action Capillaire.* In the theory advanced by Clairaut, it was supposed that the action of the capillary tube extended to a sensible distance, and even to the fluid particles in its axis; and, instead of attempting to discover the law of that action, he contented himself with observing that there were an infinity of laws of attraction, which, if substituted in his formulæ, would give results corresponding to those obtained from experiment. M. La Place, however, was anxious to ascertain the precise law of attraction which represented the phenomena; and, after long researches, he at last succeeded in discovering, that all the phenomena could be represented by the same law which represents the phenomena of refraction, namely, the law in which the attraction is only sensible at insensible distances; and upon this he has founded a rigorous theory of capillary attraction. The first Section of this work treats of the Theory of Capillary Attraction; and the second contains its application to some of the experiments of Hawksbee, and to others made at La Place's request by MM. Hauy and Tremery. In the year 1807, La Place published his *Supplement á la Theorie de l'Action Capillaire;* the object of which was to perfect the theory which he had given—to extend its application—to confirm it by new comparisons with experimental results—and, in presenting under a new point of view the effects of capillary action, to shew the identity of the attractive force upon which it depends with those which produce chemical affinities.

This Supplement treats, 1. Of the fundamental Equation of the Theory of Capillary Action. 2. Of a new manner of considering Capillary Attraction. 3. Of the Attraction and apparent Repulsion of small Bodies which move on the surface of Fluids. 4. On the Adhesion of Discs to the Surface of Fluids. 5. On the Figure of a large Drop of Mercury, and of the Depression of the Fluid in a Tube of Glass of a great Diameter. The theoretical results obtained from the formulæ investigated by M. La Place agree, in a very wonderful manner, with a series of experiments made, at his request, by M. Gay Lussac, as will be seen from the abstract of this theory with which the present chapter is concluded.

Having thus given a brief account of the progress of this branch of science, we shall now lay before our readers such additional information on the cohesion of fluids and on capillary attraction, as may appear to be necessary for completing the view of the subject which might be expected in a work of this kind.

### Sect. I. *On Capillary Attraction.*

#### 1. *On the Ascent of Fluids in Glass Tubes.*

The experiments which were made during the last century on the ascent of fluids in tubes of glass, differed so widely from each other in their results, that no confidence whatever could be placed in them. Some philosophers did not scruple to assign different heights for the same fluid and the same tube;* and even if the proper mode of cleaning the tube had enabled them to observe the highest point to which the water rose, they had no correct method of measuring the difference of level between the summit of the elevated column and the surface of the fluid. The rise of the water on the outside of the glass tube, rendered it particularly difficult to make such a measurement with the accuracy which such delicate observations required.

The first attempt to construct an accurate instrument, appears to have been about the same time by Dr Brewster and M. Gay Lussac, who, without any knowledge of each other's invention, have employed the very same principles for ascertaining, with the utmost accuracy, the altitude of the fluid above its natural level. We do not know which of these inventions are entitled to the merit of priority. Dr Brewster's instrument was invented some time in 1806. An account of it was submitted to the Royal Society of Edinburgh in February 1811, and a drawing and description of it was published in our article Capillary Attraction in 1812. Gay Lussac's instrument must have been invented in 1807, and probably much earlier, as the experiments contained in La Place's second supplement, which appeared in that year, seem to have been made with it; but so far as we know, no description of the instrument was published till 1816, when it appeared in M. Biot's *Traité de Physique.*

This instrument is represented in Plate CCCXVI. Fig. 3, where ABCD is a large cylindrical vessel of glass for containing the liquid. It is placed upon a base, which can be adjusted by the three *adjusting* screws V, V, V, so that its orifice AB may be perfectly horizontal, which can easily be ascertained by placing a level upon it. The capillary tube TSH with which the experiment is to be made, has a vertical motion in a groove CC, perpendicular to a plate *a b*, which is placed on the orifice AB of the glass vessel. By this means the tube is kept in a vertical position, and it is required only to measure the height of the column HS above the level NN of the fluid. For this purpose Gay Lussac employs a divided rule RR, which can be placed in a vertical position by means of two adjusting screws *v v*, and a plumb line FP. Along the divided scale, a small telescope GH of a short focal length, and with cross wires in the focus of the eye-glass, is made to move by the screw nut *s*, so that the horizontal wire may be made just to touch the lowest point of the surface of the fluid. In order to determine the point H which corresponds to the natural level of the fluid surface, the plate *a b*, along with the tube TT, is pushed aside till it is stopped by the side of the glass vessel, (for if it were taken out, the surface NN would descend,) and the bar *t t* resting upon the plate *a' b'* is placed on the side of the vessel from which the tube has been moved. The bar *t t* is made

* See our account of Carré's experiments, p. 808.

to descend by a screw cut upon it, till the lower point $t$ touches the water, which is known by the water rising instantaneously round it. When this contact is effected, a small portion of the water is removed by the small measure M, at the end of a crooked wire, so that the lower extremity $t$ is above the surface of the liquid by a very small quantity. The horizontal wire of the telescope is then made to come into apparent contact with the end $t$ of the bar, and the distance between this and the division corresponding to S, is a true measure of the altitude HS of the fluid.

It is obvious from the method now described, that the altitude thus found must always be too small, and that a correction depending upon the quantity of water removed by the measure M should be made. This correction must be very small, if the diameter of the glass vessel is great. This instrument is obviously liable to a source of error, from the interposition of the glass vessel between the telescope and the fluid column, as the least inequality or difference of parallelism in the parts of the glass opposite to S and H, would produce a sensible error in the result. This, however, may be easily obviated by cutting a piece out of the glass vessel, and cementing upon it a plate of parallel glass. We would also recommend, in making very accurate observations, that the sides of the glass tube next the telescope should be either ground flat about S, or have any inequality of refraction removed, by cementing upon it a plate of parallel glass.

The method of measuring the cohesion of fluids, which we have described for the first time under Capillary Attraction, will, we have no doubt be found the most correct. The apparatus will be greatly improved by using two solids of the same kind and form instead of one. By this means the termination of the elevated circle of fluid will be more easily ascertained.

With the instrument shewn in fig. 3, M. Gay Lussac has made several experiments on the ascent of water and alcohol in tubes of glass, of which the following are the results. In these experiments, the tubes were well wetted with the fluid.

Water.

| | Diameter of the Tubes in Millimetres. | Height of the Water in Millimetres above the lowest point of its Concavity. | Temperature in Degrees of the Centigrade Thermometer. |
|---|---|---|---|
| Exp. 1. | 1.29441 | 23.3164 | 8°.5 |
| Exp. 2. | 1.90381 | 15 5861 | |

The first of these experiments gives a constant quantity of 0.04641 in English inches, and the second a constant quantity of 0.04604. We have inserted these in the following table of constant quantities, for the purpose of giving a general view of the different results which have been obtained.

| Constant quantity in inches. | Observers. |
|---|---|
| 0.020 | Newton. See *Optics*, p. 366, 3d edit. |
| 0.021 | MM. Hauy and Tremery. |
| 0.026 | M. Hallstrom.* |
| 0.033 | Dr. Brewster, with a tube 0.0561 of an inch in diameter. |
| 0.0392 | Muschenbroek. This is given by Dr T. Young as the result of Muschenbroek's best experiment. |
| 0.040 | Average assumed by Dr T. Young. |
| 0.042407 | Average of Weitbrecht's seven experiments. |
| 0.04641 | Gay Lussac, with a tube 1.90 millimetres in diameter, and for the lower surface of the meniscus. |
| 0.04604 | Do. with a tube 1.29 millimetres in diameter. |
| 0.048 | Benjamin Martin |
| 0.053 | Mr Atwood. |
| 0.0645 | James Bernoulli. |

Our readers will no doubt be much surprised at the great discrepancy among the results in the preceding table, and particularly between those obtained by Dr Brewster and M. Gay Lussac, which were made with instruments founded on the same principle. M. La Place has ascribed these differences to the greater or less degrees of humidity on the sides of the tubes; and he informs us, that, in Gay Lussac's experiments the tubes were very much wetted. Now, it appears to us, that though by this method the water will always stand nearly at the same height in the same tube, yet it does not afford us an accurate measure of the height of ascent. Let us suppose that a tube $\frac{1}{100}$ of an inch in diameter is so perfectly cleared of all grease and extraneous matter, that the attractive force of the glass is allowed to exert itself without any diminution, and that the water stands at the height of 3.3 inches. Let us now suppose that by some means or other a film of water of the thickness of $\frac{1}{300}$ of an inch is introduced at the upper end of the tube, and equably diffused over its interior surface, it is obvious that the water will rise above its former level, and consequently to a height greater than that which is due to the force exerted by the tube and the mutual action of the fluid. We conceive, therefore, that M. Gay Lussac's measures err in excess; and that the error increases inversely as the diameter of the tube.

The discrepancies in the table appear to us also to be partly owing to the different kinds of glass employed. The flint glass of which tubes are composed, varies very much in its density; and there is every reason to believe, both from analogy and from some direct experiments which we have made, that the substance of the tube has a very perceptible influence on the height to which the fluid ascends.

The following were the results which M. Gay Lussac obtained for alcohol.

Alcohol.

| Exp. | Diameter of the Tube in Millimetres. | Height of the Alcohol in Millimetres above the lowest part of its Concavity. | Density of the Alcohol. | Temperature in degrees of the Centigrade Scale. |
|---|---|---|---|---|
| 1. | 1.29441 | 9.18235 | 0.81961 | 8°.5 |
| 2. | 1.90381 | 6.08397 | 0.81961 | 8°.5 |
| 3. | 1 29441 | 9.30079 | 0 8595 | |
| 4. | 1.29441 | 9 99727 | 0.94153 | |
| †5. | 10.508 | 0.3835 | 0.813467 | |

The results of experiments 1 and 2, when reduced to English inches, give .01798 and .01840 for the value of the constant quantity. The constant quantity for alcohol found by Dr Brewster is almost the same as this, namely .0178. Benjamin Martin makes the constant quantity 18, and Muschenbroek 10.

M. Gay Lussac obtained the following result for oil of turpentine.

* M. Hallstrom found that water rose 11.7 Swedish lines in a tube 0.7 of a line in diameter.

† This is a mean of five experiments.

OIL OF TURPENTINE.

| Diameter of Tube in Millimetres. | Altitude. | Density. |
|---|---|---|
| 1.29441 | 9.95159 | 0.869458 |

The following are the experiments which were made at the desire of La Place, by Messrs. Hauy and Tremery:

| Diameter of Tube in Millimetres. | Height of the Water in Millimetres. | Constant Quantity or Height for a Tube 1 millimetre in Diameter. |
|---|---|---|
| | WITH WATER | |
| 2 0000 | 6 75 | 13.500 |
| 1.3333 | 10 00 | 13.333 |
| 0.7500 | 18.00 | 31.875 |
| | | Mean 13.5693 |
| | WITH OIL OF ORANGES. | |
| 2.0000 | 3.400 | 6 8 |
| 1.3333 | 5.000 | 6.6667 |
| 0.7500 | 9.00 | 6.75 |

The following experiments were made by Dr Robison with a tube of a very slender bore.

| | |
|---|---|
| Oil of turpentine | 1.35 inches. |
| Spirits of wine | 2 5 |
| Water | 5.5 |
| Caustic volatile alkali | 6.25 |
| Solution of sal ammoniac | 8.07 |

2. *On the Ascent of Fluids between two Plates of Glass.*

It appears from the experiments mentioned by Newton in his *Optics*, (p. 366. edit. 3d, 1721,) that water rose one inch between two plates of glass, whose distance was $\frac{1}{100}$ of an inch, and that water rose to the same height in a capillary tube, the semi-diameter of whose bore was equal to the distance of the plates, which gives .010 as the constant quantity for the glass plates, and .020 as the constant quantity for capillary tubes.

The following experiments were made by M. Monge, on the rise of water between two plates of glass. The plates of glass were first cleaned with caustic alkali, and carefully washed, and, when separated to different distances, by the interposition of silver wires of different thicknesses, they were plunged in the water of the Seine, which had been previously filtered. The diameters of the silver wires, from which the distance of the plates was inferred, were obtained by rolling a wire round a tube of glass, and finding the number of thicknesses which occupied an exact number of lines. By dividing the number of lines by the number of revolutions, he obtained the exact diameter of the wire, and consequently the distance of the plates. The following are the results which he obtained.

| Distance between the plates of glass in parts of a line. | Height of the water above its level, in lines. | Constant quantity. |
|---|---|---|
| $\frac{4}{33}$ or 0.1212 inch | 15.5 lines. | 18 786 |
| $\frac{4}{39}$ 0.0802 | 33.5 | 26.80 |
| $\frac{1}{38}$ 0.03571 | 74 | 26.427. |

Messrs Hauy and Tremery likewise observed the height to which water ascended between two parallel plates of glass placed vertically, at the distance of 1 millimetre, and obtained the following result:

| Distance between the Plates, Millimetre. | Height of ascent in Millimetres. | Constant quantity in Millimetres. |
|---|---|---|
| 1 | 6.5 | 6.5 |

M. Gay Lussac measured with great care the rise of water between two plates of glass ground perfectly flat, and placed exactly parallel to each other. In order to do this with accuracy, he kept the plates separate by four very fine iron wires cut consecutively from the same piece, so as to have their diameters as equal as possible; and in order to find the thickness of the wire, he placed a great number of them together, and measured the sum of their diameters. The following was the result of his observations.

| Distance of the Plates of Glass in Millimetres. | Height of the Water to the lowest point of the Concavity in Millimetres. | Temperature in the Centigrade Scale. |
|---|---|---|
| 1.069 | 13.574 | 16° |

The constant quantity is here 14.51, or 0.02251, when reduced to English inches, for a distance of $\frac{1}{100}$th of an inch.

It is obvious from these experiments, that water ascends to twice the distance in capillary tubes that it does between two plates, whose distance is equal to the diameter of the tube.

We have already seen, under CAPILLARY ATTRACTION, that if the two plates of glass are inclined to each other at a small angle, the water will rise between them in such a manner that its surface is a hyperbola. Thus, in Plate CCCXVI. Fig. 4. let ABEF, CDEF be the two plates of glass, and DE the surface of the water, then E $n$ $p$ D, E $m$ o B will be the surface of the fluid, which Mr Hawksbee found to be hyperbolic, by measuring the ordinates of abscissæ of the curves.

The hyperbolic form of the surface may be deduced from the observed fact, that the altitudes of the fluids in capillary tubes, or between parallel glass plates, are inversely as the diameters of the tubes, or the distance of the plates. The distance of the plates at $m$ is obviously $m\ n$, or $s\ t$, and their distance at $o$ is $o\ p$ or $q\ r$. But $m\ s$ and $o\ q$, being the altitudes of the fluid at $m$ and $o$, we have $m\ s : o\ q = o\ p : m\ n$, but $F\ t : F\ r = s\ t$ or $m\ n : q\ r$, or $o\ p$. Hence $F\ t : F\ r = m\ n : o\ p$. But in the Apollonian hyperbola, the ordinates are inversely proportioned to their respective abscissæ, and therefore E $m$ $o$ B is the Apollonian hyperbola. Mr Hawksbee's experiments have already been given in p. 809.

3. *On the Depression of Mercury and Melted Lead in Capillary Tubes.*

If a capillary tube of glass is immersed in mercury, or any of the metals in a fluid state, the metallic fluid, instead of being elevated like water, stands considerably lower in the tube than in its natural surface. The most correct experiments on the depression of mercury were made by Lord Charles Cavendish. The following are the results which he obtained:

| Inside Diameter of the Tube in Inches. | Grains of Quicksilver in one Inch of the Tube. | Depression of the Surface of the Mercury in Inches. |
|---|---|---|
| 0.6 | 972 | 0.005 |
| 0.5 | 675 | 0.007 |
| 0.4 | 432 | 0.015 |
| 0.35 | 331 | 0.025 |
| 0.30 | 243 | 0 036 |
| 0.25 | 169 | 0.050 |
| 0.20 | 108 | 0.067 |
| 0.15 | 61 | 0.092 |
| 0.10 | 27 | 0.140 |

Messrs Hauy and Tremery found the following depression of mercury:

| Diameter of the tube. | Depression of the mercury. |
|---|---|
| 2 millimetres. | 3.666 millimetres. |
| 1.333 | 5.5 |

The ultimate product or constant quantity inferred by Dr T. Young from Lord C. Cavendish's experiments is 0.015, whereas Hauy's experiments make it 0.01137.

The results of the experiments of Gellert have already been given in p. 811.

Water suffers also a depression like mercury in tubes of glass that have been coated with grease. This was first observed by Carré, and was afterwards verified by the experiments of Cigna and Dutour.

M. Dutour took two tubes, each of which was about two lines in diameter, and having lined one of them with a thin film of wax, and the other with grease, he plunged them about four lines deep in water. The water was depressed in both the tubes, but less in the first than in the second.

### 4. *On the Adhesion of Discs to the Surface of Fluids.*

In our article Adhesion, we have already given an account of the experiments of Taylor, Morveau, Achard, and Dutour.

The following results were obtained by M. Gay Lussac for a circular plate of white glass, with water, alcohol, and oil of turpentine.

| Fluids. | Diameter of the circular plate. Millimetres. | Weight necessary to raise it. Grammes. | Specific Gravity. |
|---|---|---|---|
| Water | 118.366 | 59.40 | |
| Alcohol | 118 366 | 31.08 | 0.81961 |
| Alcohol | 118.366 | 32.87 | 0.8594 |
| Alcohol | 118.366 | 37.152 | 0.94153 |
| Oil of turpentine | 118.366 | | |

The following result was obtained for a disc of copper:

| | Diameter of disc of copper. | Weight necessary to raise it. | Temperature centigrade. |
|---|---|---|---|
| Water | 116.604 | 57.945 | 18°.5 |

M. Gay Lussac made many experiments on the adhesion of a disc of glass to mercury, but the results which he obtained differed widely from one another. In making his experiments on the adhesion of discs of glass, the disc was suspended at one scale of a balance, and raised vertically by placing, successively and slowly, small weights in the other scale. The sum of these weights at the moment when the disc detached itself, indicated the force of adhesion. In making these experiments on mercury, however, he observed, that the sum of the weights was more or less great according to the slowness with which they were successively added; and in adding them at very great intervals, the sum varied from 158 grammes to 296 grammes for a disc 118.366 millimetres in diameter.

Besile found, that the adhesion of 25 square lines of mercury was 82 French grains, while that of the same surface of water was $8\frac{1}{4}$ grains. In some cases, he found that the apparent adhesion was diminished under the exhausted receiver of an air pump.

### 5. *On the Magnitude and Form of Drops of Fluids.*

The effect of the cohesion of fluids is very finely exemplified in the formation of drops. It is obvious, that drops of fluids that have the least force of cohesion, will have the least magnitude, provided their specific gravities are the same; for the effect of the force of cohesion must be diminished by the weight of the drop which will be sooner detached, and therefore of a less magnitude, than if the fluid had less weight. Dr Young infers, from the law of the superficial cohesion of fluids, "that the linear dimensions of similar drops depending from a horizontal surface, must vary precisely in the same ratio as the heights of ascent of the respective fluids against a vertical surface, or as the square roots of the heights of ascent in a given tube. Hence the magnitudes of similar drops of different fluids must vary as the cubes of the square roots of the heights of ascent in a tube." In water, for example, Dr Young found the weight of a drop to be 1.8 grains, and the weight of a drop of diluted alcohol 0.85 of a grain; whereas the height of the same alcohol was to the height of water in the same tube as 100 to 64. The weight of the drop should have been .82, as inferred from the consideration of the heights of ascent combined with that of the specific gravities. This result is widely different from that which was obtained by Dr Brewster (See p. 742.) with his capillary hydrometer. The magnitude of a drop of water was to the magnitude of a drop of spirit nearly proof as 2.93 to 1; and, therefore, taking the specific gravity of spirit at 0.920, the weights of the drops were to one another as 3.255 to 1, or as 100 to 31 nearly.

The magnitude of drops of fluids depends also upon the form of the surface from which they fall. If the fluid is collected at the extremity of a very minute fibre of glass, the drop will fall when its weight balances the attractive force exerted by the glass, and therefore, in the present case, the drop will be very small; but if the fluid is collected on a hemispherical surface, the surface of glass which is in contact with the fluid is greater; and, therefore, the drop must contain a much greater quantity of water before its weight balances the attractive force of the hemispherical surface.

The form of a drop of fluid, abstracting the consideration of its weight, would always be that of a perfect sphere; and we accordingly find that the drops of rain by which the rainbow is formed, and very small drops of fluids lying upon a surface which does not attract them, have a shape almost perfectly spherical. In other cases the form of a drop is modified by its weight. Dr Young has given the following as the equation of the surface of a drop of water:

$$a a x \ddot{x} + a a \dot{y} y = x y \dot{y} \ddot{z} \text{ when } \ddot{z} = 0, \text{ or}$$

$$a^4 x^2 \ddot{x}^2 + 2 a^4 x \dot{y}^2 \ddot{x} + (a^4 - x^2 y^2) \dot{y}^4 - x^2 y^2 \dot{x}^2 \dot{y}^2 = 0.$$

In order to shew that two drops of water do not attract each other when at a distance, M. Monge put some spirit of wine into a cup, and having taken a capillary tube containing some of the same fluid, he allowed it to fall from a height of a few lines, drop by drop, into the cup; the drops did not immediately mix with the rest of the fluid, but preserved their form, which was nearly spherical; rolled over the surface with great freedom, like balls over a billiard table, impinged against each other; changed their form by the force of impact; and, after being reflected from each other, continued to move upon the surface till they were again mixed with the general mass. This experiment does not succeed so well when the spirit of wine is warm. M. Monge explains this phenomenon by supposing that a thin film of air adheres to the drop; and, by diminishing its specific gravity, causes it to float upon the fluid surface; and hence he concludes, that the experiment will succeed best with those liquids which are most evaporable, or which have the greatest affinity for the surrounding air. A similar phenomenon, as M. Monge observes, is seen in the drops of water which fall from the oars during the rowing of a boat, and in the drops produced by the condensation of the steam of any warm fluid, such as coffee, &c. These drops are real spheres of fluid, and not spherical vesicles like those formed on the surface of water with heavy rains. These results are hostile to the idea of M. Saussure, who, in his Essays on Hygrometry, has stated that drops of the same liquid cannot be pushed against one another, nor remain simply in contact without instantly uniting; and that only hollow vesicular globules are capable of floating upon the surface of the same fluid with themselves.

In repeating the experiments of Monge, Dr Brewster found that the appearances were most beautiful when the capillary tube dischared the drops upon the inclined plane of fluid, which is elevated by the attraction of the edge of the cup. They ran down the inclined plane with great velocity, and sometimes even ascended the similar plane on the opposite side of the vessel. When the drop was discharged at the distance of one or two-tenths of an inch from the surface of the water, they had always the same magnitude when the tube was held in the same position; but when the point of the tube was brought within a tenth of an inch of the surface of the spirit of wine, this surface, instead of attracting the drop to it instantly, as Saussure would have predicted, actually resisted the gravity or weight of drop, and allowed it to attain a diameter nearly twice as great as it would have had, if it had been discharged in the ordinary manner. This swoln globule floated upon the surface in the same manner as the smaller drops, surrounded with a depression of the fluid surface similar to what is produced by a glass globule floating on mercury, or by the feet of particular insects, that have the power of running upon the surface of water. (See Fig. 5.) The floating globules are often produced even when they are discharged from a height of three or four inches; and by letting them fall upon the inclined plane of fluid formerly mentioned, they will often rebound from the surface, and fall over the sides of the cup.

When a drop of mercury is laid upon glass, it assumes a flat spheroidal form, in consequence of its weight. The section of its surface, as M. La Place observed, by a vertical plane drawn through its centre, is very much curved at its summit. The curvature increases on receding from that point, till the tangent to the curve is vertical. At this point, the curvature and the width of the section will be a maximum. Below that point it will approach its axis, and will at last coincide with the plane of the glass, and form with it an acute angle. M. Gay Lussac observed at the temperature of 12°.8 of the centigrade thermometer, the thickness of a large drop of mercury, circular, and a decimeter in diameter, resting upon a plane surface of white glass perfectly horizontal. By a very accurate micrometer, he found its thickness to be 3.378 millimetres. M. Segner had long before obtained nearly the same result, viz. 3.40674 millimetres.

The cohesion of fluids is beautifully shewn in a phenomenon, which is the very reverse of the formation of a drop, and which was first observed by Dr Brewster. If we take a phial, with a wide mouth, half filled with Canada balsam, and allow the balsam to flow to the mouth of the phial and fill it up, then when the phial is placed on its bottom, a fine transparent film of balsam will be seen extending over the mouth of the phial. If we now take a piece of slender wire, and touch the film near the middle, so as to tear away a little part of it, the remaining part of the film which has been elevated by this force will descend to its level position, and the ragged aperture from which the balsam has been torn will be seen to assume a form perfectly circular, having its edge in a slight degree thickened, like a circle with a raised margin turned out of a piece of wood. This fine circular aperture grows wider and wider, and continues to preserve its circular form till the mouth of the phial is again opened.

The following curious experiment, which was performed by Dr Brewster, is intimately connected with the subject of capillary attraction. Above a vessel MNOP, Fig. 6. nearly filled with water, a convex lens LL was placed at the distance of the 10th of an inch, and rays R, R, R, were incident upon its upper surface. The focus of these rays was at F, a little beyond the bottom of the vessel, so that a circular image of the luminous object was seen on the bottom of the vessel, having AB for its diameter. If the lens is now made to descend gradually towards the surface of the water, and the eye kept steadily upon the luminous image AB, a dark spot will be seen at $\varphi$ in the centre of AB, a little while before the lens attracts and elevates the water MN. Sometimes this spot may be seen playing back and forwards by the slight motion of the hand, so that the lens can even be withdrawn from the fluid surface without having actually touched it. In general, however, the sudden rise of the water to the lens follows the appearance of the black spot. When the water is in contact with the glass, the focus of the rays R, R is now transferred to $f$, and the circular image on the bottom is now $a\,b$, and the intensity of the light in this circle is to that in the circle AB, as $AB^2 : a\,b^2$. Now it is obvious, that the darkish spot at $\varphi$ is just the commencement of the transference of the focus from F to $f$; or when the dark spot is produced, the progress of the rays is the same as if the focus were transferred to $f$. This remarkable effect may arise from two causes. 1. The approach of the lens to the surface MN, may occasion a depression $m\,o\,n$ in the surface of the fluid of the same curvature as L $l$ L, which would have the effect of transferring the focus from F to $f$. This depression may be produced by a film of air adhering to the lens, in the same manner as the depression is produced on the surface of alcohol, by a drop of alcohol rolling over it, as shewn in Fig. 5, or by some other repulsive force with which we are unacquainted. 2. The transference of the focus from F to $f$, may be occasioned by the optical contact of the glass and water taking place at a greater distance from the lens than the distance at which the capillary attraction commences. For if the surfaces $l\,l$, $m\,n$, at a certain distance, act upon the rays of light as if they were one surface, then it is manifest that a dark spot ought to appear at $\varphi$, if this distance is less than that at which capillary attraction begins.

### 6. *Account of La Place's Theory of Capillary Attraction.*

In the first supplement published by M. le Comte La Place, his method of considering the phenomena was founded on the form of the surface of the fluid in capillary spaces, and on the conditions of equilibrium of this fluid in an infinitely narrow canal, resting by one of its extremities upon this surface, and by the other on the horizontal surfaces of an indefinite fluid, in which the capillary tube was immersed. In his second supplement, he has examined the subject in a much more popular point of view, by considering directly the forces which elevate and depress the fluid in this space. By this means he is conducted easily to several general results, which it would have been difficult to obtain directly by his former method. Of this method we shall endeavour to give as clear a view as possible.

Let AB, Fig. 7. be a vertical tube whose sides are perpendicular to its base, and which is immersed in a fluid that rises in the interior of the tube above its natural level. A thin film of fluid is first raised by the action of the sides of the tube; this film raises a second film, and this second film a third film, till the weight of the volume of fluid raised exactly balances all the forces by which it is actuated. Hence it is obvious, that the elevation of the column is produced by the attraction of the tube upon the fluid, and the attraction of the fluid for itself. Let us suppose that the inner surface of the tube AB is prolonged to E, and after bending itself horizontally in the direction ED, that it assumes a vertical direction DC; and let us suppose the sides of this tube to be so extremely thin, or to be formed of a film of ice, so as to have no action on the fluid which it contains, and not to prevent the reciprocal action which takes place between the particles of the first tube AB and the particles of the fluid. Now, since the fluid in the tubes AE, CD is in equilibrium, it is obvious, that the excess of pressure of the fluid in AE is destroyed by the vertical attraction of the tube and of the fluid upon the fluid contained in AB. In analyzing these different attractions, M. La Place considers first those which take place under the tube AB. The fluid column BE is attracted, 1. by itself; 2. by the fluid surrounding the tube BE. But these two attractions are destroyed by the similar attractions experienced by the fluid contained in the branch DC, so that they may be entirely neglected. The fluid in BE is also attracted vertically by the fluid in AB; but this attraction is destroyed by the attraction which it exercises in the opposite direction upon the fluid in BE, so that these balanced attractions may likewise be neglected. The fluid in BE is likewise attracted vertically upwards by the tube AB, with a force which we shall call Q, and which contributes to destroy the excess of pressure exerted upon it by the column BF raised in the tube above its natural level.

Now, the fluid in the lower part of the round tube AB is attracted, 1. By itself; but as the reciprocal attractions of a body do not communicate to it any motion if it is solid, we may, without disturbing the equilibrium, conceive the fluid in AB frozen. 2. The fluid in the lower part of AB is attracted by the interior fluid of the tube BE, but as the latter is attracted upwards by the same force, these two actions may be neglected as balancing each other. 3. The fluid in the lower part of BE, is attracted by the fluid which surrounds the ideal tube BE, and the result of this attraction is a vertical force acting downwards, which we may call $-Q'$, the contrary sign being applied, as the force is here opposite to the other force Q. As it is highly probable that the attractive forces exercised by the glass and the water vary according to the same function of the distance, so as to differ only in their intensities, we may employ the constant co-efficients $\varrho$, $\varrho'$ as measures of their intensity, so that the forces Q and $-Q'$ will be proportional to $\varrho$ $\varrho'$; for the interior surface of the fluid which surrounds the tube BE, is the same as the interior surface of the tube AB. Consequently, the two masses, viz. the glass in AB, and the fluid round BE, differ only in their thickness; but as the attraction of both these masses is insensible at sensible distances, the difference of their thicknesses, provided their thicknesses are sensible, will produce no difference in the attractions. 4. The fluid in the tube AB is also acted upon by another force, namely, by the sides of the tube AB in which it is inclosed. If we conceive the column FB divided into an infinite number of elementary vertical columns, and if at the upper extremity of one of these columns we draw a horizontal plane, the portion of the tube comprehended between the plane and the level surface BC of the fluid, will not produce any vertical force upon the column; consequently, the only native vertical force is that which is produced by the ring of the tube immediately above the horizontal plane. Now, the vertical attraction of this part of the tube upon BE, will be equal to that of the entire tube upon the column BE, which is equal in diameter, and similarly placed. This new force will therefore be represented by $+Q$. In combining these different forces, it is manifest that the fluid column BF is attracted upwards by the two forces $+Q$, $+Q$, and downwards by the force $-Q'$; consequently, the force with which it is raised upwards will be $2Q-Q'$. If we represent by V the volume of the column BE, D its density, and $g$ the force of gravity, then $gDV$ will represent the weight of the elevated column; but as this weight is in equilibrio with the forces by which it is elevated, we have the following equation:

$$g\,DV = 2Q - Q'.$$

If the force 2Q is less than $Q'$, then V will be negative, and the fluid will sink in the tube; but as long as 2Q is greater than $Q'$, V will be positive, and the fluid will rise above its natural level; as was long before shewn by M. Clairaut.

Since the attractive forces, both of the glass and the fluid, are insensible at sensible distances, the surface of the tube AB will act sensibly only on the column of fluid immediately in contact with it. We may therefore neglect the consideration of the curvature, and consider the inner surface as developed upon a plane. The force Q will therefore be proportional to the width of this plane, or, what is the same thing, to the interior circumference of the tube. Calling $c$, therefore, the circumference of the tube, we shall have $Q = \varrho c$; $\varrho$ being a constant quantity, representing the intensity of the attraction of the tube AB upon the fluid, in the case where the attractions of different bodies are expressed by the same function of the distance. In every case, however, $\varrho$ expresses a quantity dependent on the attraction of the matter of the tube, and independent of its figure and magnitude. In like manner we shall have $Q' = \varrho' c$; $\varrho'$ expressing the same thing with regard to the attraction of the fluid for itself, that $\varrho$ expressed with regard to the attraction of the tube for the fluid. By substituting these values of Q, $Q'$, in the preceding equation, we have $g\,DV = c\,(2\varrho - \varrho')$.

If we now substitute, in this general formula, the value of $c$ in terms of the radius if it is a capillary tube, or in terms of the sides if the section is a rectangle, and the value of V in terms of the radius and altitude of the fluid column, we shall obtain an equation by which the heights of ascent may be calculated for tubes of all diameters, after the height, belonging to any given diameter, has been ascertained by direct experiment.

In the case of the cylindrical tube, let $\pi$ represent the ratio of the circumference to the diameter, $h$ the height of the fluid column reckoned from the lower point of the meniscus, $q$ the mean height to which the fluid rises, or the height at which the fluid would stand if the meniscus were to fall down and assume a level surface, then we have $\pi r^3$ for the solid contents of a cylinder of the same height and radius as the meniscus; and as the meniscus, added to the solid contents of the hemisphere of the same radius, must be equal to $\pi r^2$, we have $\pi r^3 - \frac{2\pi r^3}{3}$, or $\frac{\pi r^3}{3}$, for the solid contents of the meniscus. But since $\frac{\pi r^3}{3}=\pi r^2 \times \frac{r}{3}$, it follows that the meniscus $\frac{\pi r^3}{3}$ is equal to a cylinder whose base is $\pi r^2$, and altitude $\frac{r}{3}$. Hence, we have $q=h+\frac{r}{3}$;

or, what is the same thing, the mean altitude $q$ in a cylinder is always equal to the altitude $h$ of the lower point of the concavity of the meniscus increased by one third of the radius, or one sixth of the diameter of the capillary tube. Now, since the contour $c$ of the tube $=2\pi \varrho$, and since the volume V of water raised is equal to $q \times \pi r^2$, we have, by substituting these values in the general formula,

$$g\, D\, q \pi r^2 = 2\pi r\,(2\varrho - \varrho'), \quad \text{(No. 1.)}$$

and dividing by $\pi r$ and $g$ D, we have,

$$r q = 2\,\frac{2\varrho - \varrho'}{g\, D} \text{ and } q = 2\frac{2\varrho - \varrho'}{g\, D} \times \frac{1}{r}. \quad \text{(No. 2.)}$$

In applying this formula to Gay Lussac's experiments, we have the constant quantity $2\,\frac{2\varrho - \varrho}{g\, D} = r q = 647205 \times \overline{23{,}1634 + 0{,}215735} = 15{,}1311$ for Gay Lussac's 1st experiment. In order to find the height of the fluid in his 2d tube by means of this constant quantity, we have $r=\frac{1.90381}{2}=0.951905$, and $2\,\frac{2\varrho - \varrho'}{g\, D} \times \frac{1}{3} = q = \frac{15{,}1311}{0.951905} = 15.8956$, from which, if we subtract one sixth of the diameter, or 0.3173, we have 15.5783 for the altitude $h$ of the lower point of the concavity of the meniscus, which differs only 0.0078 from 15.861, the observed altitude.

If we apply the same formula to Gay Lussac's experiments on alcohol, we shall find the constant quantity $2\frac{2\varrho - \varrho'}{g\, D} = 6.0825$ as deduced from the 1st experiment, and $h = 6.0725$, which differs only 0.0100 from 6.08397, the altitude observed.

From these comparisons it is obvious, that the mean altitudes, or the values of $q$, are very nearly reciprocally proportional to the diameters of the tubes; for, in the experiments on water, the value of $q$ deduced from this ratio is 15.895, which differs little from 15.9034, the value found from experiment; and that in accurate experiments, the correction made by the addition of the sixth part of the diameter of the tube is indispensably requisite.

If the section of the pipe in which the fluid ascends is a rectangle, whose greater side is $a$, and its lesser side $d$, then the base of the elevated column will be $= a\, d$, and its perimeter $c = 2\,a + 2\,d$. Hence, the value of the meniscus will be $\frac{a\, d^2}{2} - \frac{a\, \pi\, d^2}{8} = \frac{a\, d^2}{2}\left(1 - \frac{\pi}{4}\right)$, that is, $q = h + \frac{d}{2}\left(1 - \frac{\pi}{4}\right)$. Hence, if in the general equation No. 1. we substitute for $c$ its equal $2\,a + 2\,d$, and for V its equal $a\, d\, q$, we have

$$g\, D\, q\, a\, d = \overline{2\varrho - \varrho'} \times \overline{2\,a + 2\,d},$$

and dividing by $a$ and by $g$ D, we have

$$d\, q = 2\,\frac{2\varrho - \varrho'}{g\, D} \times \overline{1 + \frac{d}{a}}, \text{ and}$$

$$q = \frac{2\frac{2\varrho - \varrho'}{g\, D} \times \overline{1 + \frac{d}{a}}}{d}$$

In applying this formula to the elevation of water between two glass plates, the side $a$ is very great compared with $d$, and therefore the quantity $\frac{d}{a}$ being almost insensible, may be safely neglected. Hence the formula becomes

$$q = 2\frac{2\varrho - \varrho'}{g\, D} \times \frac{1}{d}.$$

By comparing this formula with the formula No. 2. it is obvious, that water will rise to the same height between plates of glass as in a tube, provided the distance $d$ between the two plates of glass is equal to $r$, or half the diameter of the tube. This result was obtained by Newton, and has been confirmed by the experiments of succeeding writers.

As the constant quantity $2\,\frac{2\varrho - \varrho'}{g\, D}$ is the same as already found for capillary tubes, we may take its value, viz. 15,1311, and substitute it in the preceding equation, we then have

$$q = \frac{15.1311}{1.060} t = 14.1544; \text{ and since}$$

$$h = q - \frac{d}{2}\left(1 - \frac{\pi}{4}\right), \text{ subtracting}$$

$$\frac{d}{2}\left(1 - \frac{\pi}{4}\right) = 0.1147, \text{ we have}$$

$h = 14.0397$, which differs very little from 13.574, the observed altitude.

It will be seen from the formula No. 2. that of all tubes that have a prismatic form, the hollow cylinder is the one in which the volume of fluid raised is the least possible, as it has the smallest perimeter. It appears also, that if the section of the tube is a regular polygon, the altitudes of the fluid will be reciprocally proportional to the homologous lines of the similar base, a result which, as we have seen, M. Gellert obtained from direct experiment. Hence in all prismatic tubes, whose sections are polygons inscribed in the same circle, the fluid will rise to the same mean height. If one of the two bases is, for example, a square, and the other an equilateral triangle, the altitudes will be as $2 : 3\frac{3}{4}$, or very nearly as $7 : 8$.

M. La Place has remarked, that there may be several states of equilibrium in the same tube, provided its width is not uniform. If we suppose two capillary tubes communicating with one another, so that the smallest is placed above the greatest, we may then conceive their diameters and lengths to be such, that the fluid is at first in equilibrium above its level in the widest tube, and that in pouring in some of the same fluid, so as to reach the smaller tube, and fill part of it, the fluid will still maintain itself in equilibrium. When the diameter of a capillary tube diminishes by insensible gradations, the different states of equilibrium are alternately stable and instable. At first the fluid tends to raise itself in the tube, and this tendency diminishing, becomes nothing in a state of equilibrium. Beyond this it becomes negative, and consequently the fluid tends to descend. Thus the first equilibrium is stable, since the fluid, being a little removed from this state, tends to return to it. In continuing to raise the fluid, its tendency to descend diminishes, and becomes nothing in the second state of equilibrium. Beyond this it becomes positive, and the fluid tends to rise, and consequently to remove from this state, which is not stable. In a similar manner it will be seen, that the third state is stable, the fourth instable, and so on.

Although the preceding method of considering the phenomena of capillary attraction is extremely simple and accurate, yet it does not indicate the connection which subsists between the elevation and depression of the fluid, and the concavity or convexity of the surface which every fluid assumes in capillary spaces. The object of M. La Place's first method, contained in his first supplement, is to determine this connection.

By means of the methods for calculating the attraction of spheroids, he determines the action of a mass of fluid terminated by a spherical surface, concave or convex, upon a column of fluid contained in an infinitely narrow canal, directed towards the centre of this surface. By this action La Place means the pressure which the fluid contained in the canal would exercise, in virtue of the attraction of its entire mass upon a plane base situated in the interior of the canal, and perpendicular to its sides, at any sensible distance from the surface, this base being taken for unity. He then shews that this action is smaller when the surface is concave than when it is plane, and greater when the surface is convex. The analytical expression of this action is composed of two terms: the first of these terms, which is much greater than the second, expresses the action of the mass terminated by a plane surface,* and the second term expresses the part of the action due to the sphericity of the surface, or, in other words, the action of the meniscus comprehended between this surface and the plane which touches it. This action is either additive to the preceding, or subtractive from it, acording as the surface is convex or concave. It is reciprocally proportional to the radius of the spherical surface; for the smaller that this radius is, the meniscus is the nearer to the point of contact.

From these results relative to bodies terminated by sensible segments of a spherical surface, La Place deduces this general theorem. "In all the laws which render the attraction insensible at sensible distances, the action of a body terminated by a curve surface upon an interior canal infinitely narrow, perpendicular to this surface in any point, is equal to the half sum of the actions upon the same canal of two spheres, which have for their radii the greatest and the smallest of the radii of the osculating circle of the surface at this point."

By means of this theorem, and the laws of hydrostatics, La Place has determined the figure which a mass of fluid ought to take when acted upon by gravity, or contained in a vessel of a given figure. The nature of the surface is expressed by an equation of partial differences of the second order, which cannot be integrated by any known method. If the figure of the surface is one of revolution, the equation is reduced to one of ordinary differences, and is capable of being integrated by approximation, when the surface is very small. La Place next shews, that a very narrow tube approaches the more to that of a spherical segment as the diameter of the tube becomes smaller. If these segments are similar in different tubes of the same substance, the radii of their surfaces will be inversely as the diameter of the tubes. This similarity of the spherical segments will appear evident, if we consider that the distance at which the action of the tube ceases to be sensible, is imperceptible; so that if, by means of a very powerful microscope, this distance should be found equal to a millimetre, it is probable that the same magnifying power would give to the diameter of the tube an apparent diameter of several metres. The surface of the tube may therefore be considered as very nearly plane, in a radius equal to that of the sphere of sensible activity; the fluid in this interval will therefore descend, or rise from this surface, very nearly as if it were plane. Beyond this the fluid being subjected only to the action of gravity, and the mutual action of its own particles, the surface will be very nearly that of a spherical segment, of which the extreme planes being those of the fluid surface, at the limits of the sphere of the sensible activity of the tube, will be very nearly in different tubes equally inclined to their sides. Hence it follows that all the segments will be similar.

The approximation of these results gives the true cause of the ascent or descent of fluids in capillary tubes in the inverse ratio of their diameter. If in the axis of a glass tube we conceive a canal infinitely narrow, which bends round like the tube ABEDC in Fig. 7. the action of the water in the tube of this narrow canal, will be less on account of the concavity of its surface, than the action of water in the vessel on the same canal. The fluid will therefore rise in the tube to compensate for this difference of action; and as the concavity is inversely proportional to the diameter of the tube, the height of the fluid will be also inversely proportional to that diameter. If the surface of the interior fluid is convex, which is the case with mercury in a glass tube, the action of this fluid on the canal will be greater than that of the fluid in the vessel, and therefore the fluid will descend in the tube in the ratio of their difference, and consequently in the inverse ratio of the diameter of the tube.

In this manner of viewing the subject, the attraction of capillary tubes has no influence upon the ascent or depression of the fluids which they contain, but in determining the inclination of the first planes of the surface of the interior fluid extremely near the sides of the tube, and upon this inclination depends the concavity or convexity of the surface, and the length of its radius. The friction of the fluid against the sides of the tube may augment or diminish a little the curvature of its surface, of which we see frequent examples in the barometer. In this case the capillary effects will increase or diminish in the same ratio.

The differential equation of the surfaces of fluids inclosed in capillary spaces of revolution, conducts La Place to the following general result; that if into a cylindrical tube we introduce a cylinder which has the same axis as that of the tube, and which is such that the space comprehended between its surface and the interior surface of the tube has very little width, the fluid will rise in this space to the same height as in a tube whose radius is equal to this width. If we suppose the radii of the tube and of the cylinder infinite, we have the case of a tube included between two parallel and vertical planes, very near each other. This result has been confirmed, as we have already seen, by the experiments of Newton, Hauy, and Gay Lussac. La Place then applies his theory to the phenomena presented by a drop of fluid, either in motion or suspended in equilibrium, either in a conical capillary tube, or between two plates, and inclined to each other, as discovered by Mr Hawksbee;—to the mutual approximation of two parallel and vertical discs immersed in a fluid;—to the phenomena which take place when two plates of glass are inclined to each other at a small angle;—and to the determination of the figure of a large drop of mercury laid upon a horizontal plate of glass.

In the application of his theory to the experimental results obtained by Hawksbee respecting the angles required for suspending a drop of oil of oranges at different stations between two inclined planes of glass, La Place obtained the results contained in the following table.

Column 1st contains the number of the first column of

* M. La Place is of opinion, that the suspension of mercury in a barometer tube, at a height two or three times greater than that which is due to the pressure of the atmosphere, depends on this term. He conceives too, that the refracting force of transparent bodies, cohesion, and in general chemical affinity, depend also upon it.

Hawksbee's table, subtracted from 20 inches; and column 2d contains Hawksbee's 2d column, diminished by 5′ 22″.

| Distance in inches from the middle of the drop to the intersection of the plane. | Angles of Elevation observed. | Angles of Elevation calculated by La Place's formula. | Differences in aliquot parts of the calculated angles. |
|---|---|---|---|
| 18 | 0° 9′ 38″ | 0° 17′ 44″ | $\frac{1}{12}$ |
| 16 | 0 19 38 | 0 22 27 | $\frac{1}{7}$ |
| 14 | 0 29 38 | 0 29 20 | $\frac{1}{99}$ |
| 12 | 0 29 38 | 0 39 55 | $\frac{1}{140}$ |
| 10 | 0 54 38 | 0 57 29 | $\frac{1}{19}$ |
| 8 | 1 39 38 | 1 29 53 | $\frac{1}{10}$ |
| 6 | 2 39 38 | 2 39 45 | $\frac{1}{1368}$ |
| 5 | 3 54 38 | 3 50 6 | $\frac{1}{52}$ |
| 4 | 5 54 38 | 5 59 58 | $\frac{1}{60}$ |
| 3 | 9 54 38 | 10 42 31 | $\frac{1}{12}$ |
| 2 | 21 54 38 | 24 42 49 | $\frac{1}{78}$ |

## Sect. II. *On the Approximation and Recession of Bodies floating near each other in a fluid.*

It was long ago observed by philosophers, that when bodies floating on the surface of a fluid approached either one another or the sides of the vessel, they moved rapidly into contact, as if they had been two floating magnets. This phenomenon, which was in general ascribed to the mutual attraction of the floating bodies, was tolerably well explained by M. Marriotte in his *Traité du Mouvement des Eaux.* It was reserved, however, for M. Monge to describe and explain these phenomena with accuracy, which he has done in his *Memoire sur quelques effets d'attraction ou de repulsion apparente entre les Molecules de Matiere.*

The following are the principal experiments upon this subject:

1. If two light bodies, capable of being wetted with water, are placed one inch distant on the surface of water perfectly at rest, they will float at rest, and experience no motion but what is derived from the agitation of the air; but if the distance at which they are placed is only a few lines, they will approach each other with an accelerated motion. If the vessel which contains the water is capable of being wetted by it, such as glass, and if the floating body is placed within a few lines of the edge of the vessel, it will move towards the edge with an accelerated motion.

2. If the two floating bodies are not susceptible of being wetted with fluid, such as two balls of iron in a vessel of quicksilver, and if they are placed at the distance of a few lines, they will move towards each other with an accelerated motion; and if the vessel is made of glass, in which the surface of the mercury is always convex, the bodies will move towards the sides when they are placed within a few lines of it.

3. If one of the bodies is susceptible of being wetted with water, and the other not, such as two globules of cork, one of which has been carbonised by the flame of a taper, then if we attempt, by means of a wire or any other substance, to make the bodies approach, they will fly from each other as if they were mutually repelled. If the vessel is of glass, and if the carbonised piece of cork is placed in it, it will be found impossible to bring the cork in contact with the sides of the vessel.

In these experiments it is obvious, that the approximation and the recession of the floating bodies are not produced by any attraction or repulsion between the two; for if the bodies, instead of floating on the fluid, are suspended by long and slender threads, it will be found that they have not the slightest tendency either to approach or recede when they are brought extremely near each other. From these experiments the following laws are deducible:

1. If two bodies, floating on the surface of a fluid, and capable of being wetted by the fluid, are placed near each other, they will approach as if they were mutually attracted.

2. If the two bodies are not susceptible of being wetted by the fluid, they will still approach each other when brought nearly into contact, as if they were mutually attracted.

3. If one of the two bodies is susceptible of being wetted and the other not, they will recede from each other as if they were mutually repelled.

*Explanation of the first law.*—If two plates of glass AB, CD, Fig. 8. are brought so near each other that the point H, where the two curves of elevated fluid meet, is on a level with the rest of the water, they will remain in perfect equilibrium. If they are brought nearer each other, however, as in Fig. 9. the water will rise between them to the height G. The mass of water which is thus raised, attracts the sides of the glass plates, and causes them to approximate in a horizontal direction, the mass of water having always the same effect as a curved chain hung to the two plates. The same thing is true of two floating bodies, when they come within such a distance that the fluid is elevated between them. This case is shewn in Fig. 10, where the bodies A, B, placed at a capillary distance, have the water raised between them, and are therefore brought together by the attraction of the fluid upon the sides of the globules.

*Explanation of the second law.*—If the two floating bodies A, B, Fig. 11, are not capable of being wetted by the liquid, the liquid will be depressed between them at H, below its natural level, when they are placed at a capillary distance. The two bodies, therefore, are more pressed inwards by the fluid which surrounds them, than they are pressed outwards by the fluid between, and in virtue of the difference of these pressures they mutually approach each other.

*Explanation of the third law.*—If one of the floating bodies A, Fig. 12. is capable of being wetted, while the other B is not, the fluid will rise round A, and be depressed round B: Hence the depression round B will not be symmetrical; and therefore the body B, being placed as it were on an inclined plane, its equilibrium is destroyed, and it will move towards the right hand, where the pressure is the least.

The results of M. Monge's experiments have been completely confirmed by the theory of capillary attraction given by La Place. From this theory it follows, that whatever be the nature of the substances of which the floating planes are made, the tendency of each of them to one another is equal to the weight of a prism of fluid whose height is the elevation of the fluid between the planes, measured to the extreme points of contact of the interior fluid with the plane, *minus* the elevation of the fluid on the exterior sides of the tube, whose depth is half the sum of these elevations, and whose width is the horizontal distance between the planes. The elevation must be reckoned negative when it changes into a depression as in mercury. If the product of the three preceding dimensions is negative, the tendency of the planes becomes repulsive. La Place also concludes, that when the planes are very near each other, the elevation of the fluid between them is in the inverse ratio of their mutual distance, and is equal to half the sum of the elevation which would have taken place, if we suppose the first plane of the same matter as the second, and the second of the same matter as the first.

It follows from these theorems, that the repulsive force of floating planes is much more feeble than the attractive force which is developed when the planes are very near each other, and which occasions them to approach each other with an accelerated motion. In this case the elevation of the fluid between the planes is very great, relative to its elevation on the outside of the same plane. In neglecting, therefore, the square of this last elevation in relation to the square of the first, the fluid prism, whose weight expresses the mutual tendency of the planes, in virtue of the first of the two preceding theorems, will be equal to the product of the square of the elevation of the interior fluid, by half the horizontal distance of the planes. This elevation being, by the second theorem, reciprocally proportional to the mutual distance of the planes, the prism will be proportional to their horizontal distance divided by the square of that distance. The tendency of the two planes to each other will consequently be in the inverse ratio of the square of their distance; and therefore, like the forces of electricity and magnetism, it will follow the law of universal attraction.

When the two planes are of such a nature that the one is capable of being wetted with the fluid, while the other is not capable of being wetted, then, in consequence of these two opposite actions, the surface of the intermediate fluid will have a point of inflection; and it follows from the theory, that they will repel each other at every distance. But if they are brought near each other by force, the point of inflexion will approach more and more to one of the planes, and will at last coincide with it. If the planes are then brought still nearer each other, the fluid will begin either to ascend, or be depressed between them. From this arises another force, which pushes the planes towards each other, and which, when it comes to surpass the pressure of the exterior fluid, causes the planes to approach each other with an accelerated motion. This change of repulsion into attraction appeared to M. La Place so singular, that he requested M. Hauy to examine the subject experimentally. In order to do this, he employed planes of ivory and talc, the first of which is capable of being wetted with water, while the other possesses that kind of unctuosity which prevents the water from adhering to it.

M. Hauy suspended, by a very fine thread, a small square plate of talc, so that the lower part of it was immersed in the water. Into the same vessel, at the distance of some centimetres, he immersed the lower part of a parallelopiped of ivory, so that one of its faces was parallel to the plate of talc. The ivory was made to advance towards the talc in this state of parallelism, and was stopped at short intervals, in order to shew that the effect of the motion communicated to the fluid was insensible in the experiment. When the parallelopiped of ivory, moving with great slowness, approached very nearly to the talc, the latter moved suddenly into contact with the ivory. In separating the two bodies, the ivory was wetted to a certain height above the level; and in repeating the experiment before wiping the ivory, the attraction commenced sooner, and sometimes exhibited itself at the very first, without being preceded by any sensible repulsion. This experiment was repeated several times with the same result.

Another series of phenomena, which indicate apparent attraction and repulsion, are seen in the motion of small lighted wicks when swimming in a basin of oil, and in the motion of camphor upon the surface of water. Although these phenomena are not produced by capillary attraction, yet we shall give a short account of them at present, on account of their general similarity.

The phenomena of lighted wicks were carefully observed, and minutely described, by Professor Wilson of Glasgow, in the Transactions of the Royal Society of Edinburgh. His *Hydrostatical Lamp*, as he calls it, consists of a small circular disc of common writing paper, about $\frac{3}{8}$ of an inch in diameter, having about a quarter of an inch of soft cotton thread rising up through a puncture in the middle of the disc, to answer the purpose of a wick. If this wick is lighted, and the disc placed in a shallow glass vessel, filled with pure salad oil, it will immediately sail briskly forward in one direction till it meets the side of the vessel, and will afterwards take a circular course, always bearing up to the sides, and will thus perform many revolutions. The circulation is sometimes from right to left, and sometimes from left to right. When the wick is placed out of the centre of the disc, it will sail to that part of the disc which is farthest from the wick, and if the disc is made of an oval form, and the wick placed in one of its foci, the disc will sail in the direction of the nearest extremity of the transverse axis. Dr Wilson observed a very active repulsion between the stem of the disc and the oil of the surface contiguous to it. When fine charcoal dust was scattered around the disc, it left behind it a diverging wake clear of all dust. Other fluids, such as oil of turpentine, ether, alcohol, or any of the inflammable fluids possessing much tenuity, also double rum, melted tallow, bees wax, and rosin, exhibit the same effects when the discs float upon their surface.

Dr Wilson accounts for these phenomena in the following manner: When the oil has an uniform temperature, all its parts are in equilibrio; but when the lamp is lighted, the oil below the disc being most heated, will expand itself, and will be raised above the general level, from the diminution of its specific gravity, and the unbalanced upward pressure of the fluid. The weight of the disc will therefore press down the oil, or even the weight of the oil itself will cause it to rise as it were from below the wick in a thin superficial stream. Hence Dr Wilson conceives, that this constant stream will flow most readily and copiously towards that side of the base of the lamp where the resistance is least, or where it has the shortest way to press forwards, that is, from under the wick or flame, or the edge of the disc which is the nearest. The re-action of the stream of rarefied oil rising most rapidly and most copiously from one side of the disc, will therefore impel the lamp in the contrary direction. When the discs are soaked with oil, or when they are made of a thin plate of talc, they always sink to the bottom as soon as the flame is extinguished. If a wafer much heated is thrown upon any of the fluids above mentioned, it will immediately glide away, and continue in motion till it cools.*

The singular motions of pieces of camphor floating upon the surface of water have been long observed; but they were never completely described and explained, till M. Venturi published, in the Memoirs presented to the Institute of France, his ingenious memoir, entitled *Precis de quelques experiences sur la section que des cylindres de camphre eprouvent a la surface de l'eau et reflexions sur les mouvemens qui accompagnent cette section.*

Having cut some pieces of camphor into the shape of small cylinders, a line in diameter, and an inch high, he fixed each of them to a base of lead, and placed them vertically in plates. He then poured water into the plates, till it reached about half way up each cylinder. After two or

* See the *Edinburgh Transactions*, vol. iv. p. 144, &c.

three hours the cylinders began to diminish at the place where they were cut by the surface of the water, and after about twenty-four hours they were entirely cut through into two parts, none of which had suffered any sensible diminution.

He next took three pieces of camphor, each of which weighed twenty-four grains, and he placed one of them in dry air, another in water, and the third on the surface of water. After four days the piece on the surface of the water was entirely dissipated, while each of the other two had lost only four or five grains.

M. Venturi next placed some of his camphor cylinders on the surface of water, in vessels of different sizes, and he always found that the cylinder was cut through soonest in those vessels that presented the greatest surface. This singular fact arises from the camphor being dissolved by the water, and extending itself over all the fluid surface, when it is the more readily evaporated by its coming into contact with a greater quantity of air. The dissolution of the camphor may be seen detaching itself from the cylinder in the form of a very transparent liquid oil, and spreading itself over the whole surface of the water. When in the contour of the cylinder, there is some place which furnishes this oil more abundantly, if small light substances are thrown upon the surface, they are repelled from this place with great briskness, and then turning round, they come back to the same place, and again enter the current, where they continue to circulate in this manner. If a small piece of camphor previously wetted at its extremity approaches the margin of the vessel, and then touches the vessel itself, it deposits a fluid visible to the eye. This fluid is oily; and on attaching itself to the vessel, it destroys its capillary attraction for the water, and the water retires from it and becomes convex at this place. When the piece of camphor is taken away, the water does not return to its place till the oily liquor is evaporated. When the cylinders of camphor are half immersed in water, the oily liquor which issues from it destroys the cohesion between the water and the cylinder, and a small depression takes place round the cylinder. The dissolution stops for a moment till the oily liquor expanded over the water has evaporated. The water then returns to its elevated state round the cylinder; the camphor is dissolved and diffused; and the same operations are repeated.

The motions of small pieces of camphor observed by M. Romieu are produced by the mechanical re-action of the jet of dissolution against the camphor; and if the centre of percussion of all the jets do not coincide with the centre of gravity, a rotatory and progressive motion will be produced. As the jets are generated only on the circumference of the section of the piece of camphor, it ought to revolve round an axis perpendicular to the horizon; and the smallest pieces will obviously turn round with more velocity than larger ones.

MM. Lichtenburg and Volta ascribed this rotation to an emanation from the camphor, and also from the benzoic and succinic acids, which have the same property. Brugnatelli discovered, that the bark of aromatic plants, when thrown upon water, moved round like camphor; and Venturi remarked a similar motion in the saw-dust of different woods, that had imbibed either a fixed or a volatile oil. Romieu ascribed these motions to electricity. He found that the camphor sometimes refused to turn, and at other times its movements were suddenly stopped, by touching the water with particular bodies. The cause of these irregularities, which long perplexed philosophers, was discovered by Venturi. He found, that whenever the water was touched by any body which was fat or oily, or which diffused a small portion of fixed oil, or a great portion of volatile oil over the surface, the dissolution and the motion of the camphor were immediately stopped. In order to prove that this effect was not produced by electricity, as Romieu and several Italian philosophers believed, Venturi touched the surface of the water both with conductors and non-conductors of electricity, which were well cleared of all oily or greasy matter, and the motions of the camphor were never in the slightest degree affected. When the same substance was afterwards greased with a small drop of oil of olives, and again brought into contact with the water, an oily film immediately advanced over the whole surface of the water, repelled the small bits of camphor, and, as if by a magic stroke, deprived them of their apparent vitality. Venturi repeated this experiment in a basin of water 20 feet in diameter. The camphor turned round in one end of the basin; and when an ounce of oil was poured in at the other extremity, the motions of the camphor were speedily stopped.

If the surface of the water on which the camphor swims, is not sufficiently extensive to allow the liquor from the camphor to evaporate, the dissolution of the camphor is either retarded or stops altogether, or the undissipated liquor forms itself into a thin film upon the surface of the water. In like manner, the particles of the saw-dust of wood soaked in oils, moves quickly when they touch the water: but their motions do not continue, because the film of oil which they spread over the water is not dissipated.

If the water is very pure, and is exposed to a heat even so high as that of boiling water, the dissolution and the motions of the camphor are not prevented. On the contrary, they are often promoted by the application of this heat.

M. Venturi applies the preceding principles to the explanation of the motion of the tremellæ observed by Adanson and by Corti. This aquatic plant rises to the surface of the water during the day, and descends to the bottom at night. If the plant is shut up in a box, whose sides are opaque, and if a pencil of light is admitted through an opening in one of its sides, the tremelli changes its situation in a few hours, and advances to the hole at which the light penetrates. M. Venturi observed with a microscope, that its branches have a small motion belonging to each of them, in virtue of which they sometimes oscillate from one side to another, and sometimes advance to free themselves from the pencil when they are interlaced. These appearances are explained by Venturi on the supposition that the water which it absorbs is decomposed by the assistance of light, and that the plant gives out the oxygen in a direction always opposite to the light. Hence it will follow that the plant must always move towards the quarter from which the light is admitted.

In addition to the works quoted under the article Capillary Attraction, the reader is referred to the following: Pascal, *Traitez de l'Equilibre de Liqueurs et de la pesanteur de la Masse de l'Air*, Avertissement, 2d edit. Paris, 1664. Rohault, *Traité de Physique*, or Dr Clarke's translation of it, under the title of Rohaulti *Physica*. Lond. 1710, Part I. chap. xxii. § 69. 70, 71, 80, 81. Boyle's *New Experiments Physico-Mechanical, touching the spring of the air, and its Effects, made for the most part in a New Pneumatical Engine*, exp. 35. p. 262. Oxford, 1660. Boyle, *Phil. Trans.* 1676, vol. xi. p. 775. Hooke's *Attempt for the explication of the phenomena observable in an experiment published by the Right Hon. Robert Boyle, in the 35th experiment of his Epistolical Discourse, touching the air, in confirmation of a former conjecture made by R. H.* Lond. 1660. Hooke *On Springs*, 4to. 1678. Vossius, *De Nili et aliorum fluminum origine*, Hag. 1666. Fabri, *Dialogi Phy-*

*sici*, Lyons, 1669. Borelli, *De motionibus a Gravitate naturali pendenté*, Lyons, 1670. Sinclair's *Ars nova et magna Gravitatis et Levitatis.* Rotterdam, 1669. Joh. Christophorus Sturmius, *Collegium Experimentale sive Curiosum*, pars i. tentamen viii. p. 44. et auctorium tentam. viii. p. 77. Norimbergæ, 1676. The second part of this work was published at Norimberg in 1685. James Bernoulli, *Dissertatio de Gravitate Etheris*, 1683. De La Hire, *Mem. Acad. Par.* tom. ix. p. 157. Carré, *Experiences sur les tuyaux Capillàires* in the *Mem. Acad. Par.* 1705, p. 241. Daniel Bernoulli in the *Comment. Petropol.* 1727, p. 246. Mariotte, *Traité du Mouvement des Eaux*, vol. ii. p. 105. Par. 1700. Cotes, *Hydrostatical Lectures*, sect. xi. Lond. 1738. Cigna, *Journal de Physique*, tom. iii. p. 109. Lord Charles Cavendish, in the *Phil. Trans.* 1776, p. 382. Monge, *Mem. Acad. Par.* 1787. p. 506. Besile, *Journal de Physique*, vol. xxviii. p. 171 ; xxix. p. 287, 339 ; xxx. p. 125. Wilson, *Edinburgh Transactions*, vol. iv. p. 144. Venturi, *Memoires presentés à l'Institut.* tom. i. p. 125. Paris, 1805. MM. Hauy and Tremery, in La Place's *Suppl.* au Diz. Liv. de la Mecanique Celeste. La Place, *Supplement à la Theorie de l'Action Capillaire*, Par. 1807. Gay Lussac, *Id.* Biot's *Traité de Physique*, tom. i. chap. xxii. Paris, 1816.

## CHAP. VI.

### Description of Instruments, and Experiments for illustrating the doctrines of Hydrostatics.

#### 1. *Description of the Mechanic or Hydrostatic Paradox.*

It appears from Cor. 2. of Prop. iv. p. 770, that the pressure exerted upon the bottoms of vessels filled with fluid, does not depend upon the quantity of fluid which they contain, but solely upon its altitude. This proposition has been called the mechanic or hydrostatic paradox, and the instrument for illustrating it has received the same name.

This instrument is shewn in Fig. 1. where AB is a box, which contains about a pound of water, and *a b c d e* a glass tube, fixed to the end C of the beam of a balance, and the other end to a moveable bottom, by which the water in the box is supported, the bottom and wire being equal in weight to an empty scale suspended at the other extremity of the balance. If a pound weight is put into the empty scale, it will cause the bottom to rise a little, and the water will appear at the lower end of the tube *a*. The water will therefore press with a force of one pound upon the bottom. If another pound is put into the scale, the water will ascend to *b*, twice as high as the point *a*, above the bottom of the vessel. If a third, a fourth, and a fifth pound be put successively into the scale, the water will rise at each time to *c*, *d*, and *e*, the distances *a b*, *b c*, *c d*, *d e*, being equal to one another. This result will be obtained, however small be the bore of the glass tube ; and since when the water is at *b*, *c*, *d*, *e*, the pressures upon the bottom are successively twice, thrice, four times and five times as great as when the water was contained within the box, it follows, that the pressure upon the bottom of the vessel depends wholly on the height of the water in the glass tube, and not upon the quantity which it contains. If a long narrow tube, therefore, be fixed in the top of a cask, and if both the cask and the tube be filled with water, then, though the tube be so small as not to hold a pound of the fluid, the pressure of the water in the tube will be in danger of bursting the cask in pieces ; for the pressure is the same as if the cask was continued up in its full size to the height of the tube, and filled with water : (See Chap. I. Sect. 1. Prop. IV. Cor. 2.) It follows, therefore, from this principle, that any quantity of water, however small, may be made to exert a force of any assignable magnitude, by increasing the height of the column, and diminishing the base on which it presses. This, however, has its limits ; for when the tube becomes capillary, the attraction of the glass will support a great quantity of the included water, and will therefore diminish the pressure upon its base. The preceding machine should be so constructed, that the moveable bottom may have no friction against the inside of the box, and that no water may get between it and the box. The method of effecting this will be manifest from Fig. 2. where ABCD is a section of the box, and *a b c d* its lid, which is made very tight. The moveable bottom E, with a groove round its edges, is put into a bladder *f g*, which is tied close round it in the groove by a strong waxed thread. The upper part of the bladder is put over the top of the box, at *a* and *d*, all around, and is kept firm by the lid *a b c d*, so that if water be poured into the box through the aperture *l l* in its lid, it will be contained in the space *f* E *g h*, and the bottom may be raised by pulling the wire *i* fixed to it at the point E of the moveable bottom. See Ferguson's *Lectures*, vol. ii. p. 100. Edit. Edin. 1806.

#### 2. *Description of the Hydrostatic Press.*

This ingenious and powerful machine, which has been recently brought into notice by the late Mr. Bramah, is founded on the doctrine contained in the corollary to the fundamental principle of the equilibrium of fluids, (see p. 759,) namely, that if any number of pistons are applied to apertures of different sizes in the sides of a vessel full of water, the forces with which the pistons are applied will be in equilibrio, if they are proportional to the apertures to which they are applied. Thus, if a piston G, (Fig. 1.) is applied to an aperture at G, having an area of two square inches, it will be in equilibrio with another piston applied to the whole aperture AB of 2000 square inches, if the force with which the piston G is applied, is to the force with which AB is applied as 2 to 2000, or as 1 to 1000. Hence it follows, that a force of one pound applied at G will raise 1000 pounds placed upon the piston AB. The same result will be obtained if the vessel has the form shewn in Fig. 11. the one piston being applied at *a b*, and the other at AB.

The hydrostatic press founded on this principle was first proposed as a new machine by Pascal, in his *Traitez de l'Equilibre des Liqueurs, et de la Pesanteur, de la Masse de l'Air*, Chap. II. Edit. 2d. Paris, 1664. He describes it as a new sort of machine for multiplying forces, (*Nouvelle sorte de machine pour multiplier les forces*,) and he considers it as a new mechanical power equal in value to the lever or the screw. Although Pascal speaks so highly of his new machine, it is not a little singular, that no attempt appears to have been made for more than a century and a half to apply it to the useful purposes of life. Mr Bramah had the very great merit, not only of re-inventing the machine, (for we believe he was not aware of its having been proposed by any other person,) but of pointing out its application to a great variety of useful purposes, such as working cranes, pulling up the roots of trees, packing goods of all kinds, &c. In our article Crane, we have given a full description of the hydrostatic press, as applied to a crane ; and by studying that part of the article, our readers will have no difficulty in understanding the construction of the instrument.

The hydrostatic press is represented by the parts

GHEFFL of Fig. 1. Pl. CCXV. In the Figure, FF represents the wooden frame which supports the iron cylinder L. This cylinder communicates with a small copper pipe *g g h*, terminating in a common forcing-pump at *h*, which stands in an iron cistern H, containing the water. The power is applied to the handle G of the pump, and the piston, pressing on the surface of the water in the pipe at *h*, communicates its force, through the intervention of the water, to the piston of the cylinder L, to the top of which the work to be performed is applied. See also our article Jack.

3. *Hydrostatic Bellows improved by Ferguson.*

The common hydrostatic bellows consisted of a tube of glass or any other substance, about three feet high, communicating with a cylindrical vessel, whose sides were made of leather like a pair of bellows, while its upper and lower surfaces were formed of circular or oval boards about 15 inches in diameter. When water is poured into the tube, it flows into the bellows, and separates the boards a little. Heavy weights to the amount of 300 pounds, are then placed upon the upper board, and by pouring water into the tube till it reaches the top, the moveable board with all its load will be raised, and kept in equilibrio by the column of fluid, although the fluid itself does not weigh more than a quarter of a pound. In order to shew the experiment with more effect, a man may place himself upon the upper board instead of the weights, and raise himself merely by pouring water into the small pipe.

The following very ingenious machine has been proposed by Mr Ferguson as a substitute for the common hydrostatical bellows: ABCD, Fig. 3. is an oblong square box, into one of whose sides is fixed the upright glass tube *a* I, which is bent into a right angle at the lower end, at *i*. Fig. 4. To this bent extremity is tied the neck of a large bladder K, which lies in the bottom of the box ABCD. Over this bladder is placed the moveable board L, Figs. 3. and 5. in which the upright wire M is fixed. Leaden weights N, N, with holes through their centre, to the amount of 16 pounds, are put upon this wire, and press upon the board L. The cross bar *p* is then put on, in order to keep the glass tube in an upright position; and afterwards the bent piece EFG, for keeping the weights N, N, horizontal, and the wire M vertical. Four upright pins, about an inch long, are placed on the corners of the box, for the purpose of supporting the board L, and preventing it from pressing the sides of the bladder together. When the machine is thus fitted up, pour water into the tube I, till the bladder is filled up to the board L. Continue pouring in more water, and the upward pressure which it will excite in the bladder will raise the board, with all its weights, even though the tube should be so small as to contain no more than an ounce of water. See Ferguson's *Lectures*, vol. ii. p. 104.

4. *Experiments for illustrating the quaquaversus pressure of Fluids, and the Effects produced at different Depths.*

*Exp.* 1. If we take a common wine glass AB, and, holding it in a vertical direction, bring its mouth in contact with the surface of water in the vessel M, it will be seen, that a small quantity of water has entered the wine glass, and that the remainder of the glass is filled with air. By depressing the glass, or sinking it in the fluid, a greater quantity of water will enter it; the included air being condensed into a smaller space as the pressure of the superincumbent column of water is increased. By continuing to depress the glass, it will be seen that the pressure of the water increases with the depth, and by holding the mouth of the glass in different directions, as shewn at CD and EF, Fig. 6. it will appear, that the water presses equally in every direction.

*Exp.* 2. If we insert into an empty vessel a number of tubes of glass bent into various angles, or if we hold them in the hand, and introduce into their lower orifices a quantity of mercury, so that the surface of the mercury may come to the very orifice of the shorter legs; then, if water is poured into the vessel, it will be seen, during the time of its filling, that the mercury is pressed gradually from its lower orifices towards the higher orifices, which are supposed to rise to a greater height than the surface of the water. Now, as the lower orifices of the glass tubes may be made to point in every possible direction, it follows, that the pressure of the superincumbent fluid is also propagated in every direction. When it is required that the lower orifice should point exactly downwards, in order to show the upward pressure of fluids, a straight tube should be used, and the mercury introduced into it must be kept in by the application of the extremity of the finger, till the height of the water above the orifice is equal to 14 times the length of the column of mercury introduced. Upon removing the finger, and continuing to pour in water, the mercury will ascend in the tube. If the finger were removed before it had risen to a height 14 times greater than the length of the mercurial column, the mercury would have fallen out of the tube, as it is 14 times heavier than water, and therefore requires a column 14 times as long to keep it in equilibrio.

*Exp.* 3. The pressure of fluids at different depths may be very simply illustrated, by attaching a bag made of leather, and filled with mercury to the extremity of a glass tube, so that the mercury may just enter the tube when the bag is held in air. By immersing the bag in water, the pressure of the fluid upon the bag will force up the mercury, and the height to which it rises will show the magnitude of the pressure at different depths.

*Exp.* 4. The propagation of pressure through fluids is also illustrated by the amusing experiment of the *Cartesian Devil*, as it has been called, after Descartes, by whom it was discovered. The figure of a man made of glass or enamel, is so constructed that it has the same specific gravity as water, and is therefore suspended in a mass of fluid. A bubble of air, (similar to the air in the glass of Exp. 1) communicating with the water, is placed in some part of the figure, sometimes in a small globe, as shewn at *m*. At the bottom B (Fig. 7.) of the vessel is a diaphragm of bladder, which can be pressed upwards by applying the finger to the extremity *e* of a lever *e o* moving round *o* as its centre of motion. The pressure applied to *a* is communicated through the water to the bubble of air, which is thus compressed: The specific gravity of the figure is therefore increased, and it sinks to the bottom. By removing this pressure, the figure again rises, so that it may be made to oscillate or dance in the vessel without any visible cause. Fishes made of glass are sometimes substituted in place of the human figure, and when a common jar is used for the experiment, the pressure is applied to the upper surface of it at A. The construction of the apparatus shewn in Fig. 6. is obviously the best, as the spectator does not observe the means which are employed to alter the specific gravity of the figure.

*Exp* 5. The pressure of fluids at very great depths is finely illustrated by an experiment which has often been made at sea, of making an empty bottle well corked descend to a great depth. The pressure of the water drives in the cork, and the bottle when brought up is always filled with water. Mr Campbell, the respectable author of

*Travels in the South of Africa*, tried this experiment on his voyage home from the Cape of Good Hope. He drove very tight into an empty bottle a cork, which was so large that half of it remained above the neck. A cord was then tied round the cork, and fastened to the neck of the bottle, and a coating of pitch was put over the whole. When it was let down to about the depth of 50 fathoms, the captain felt, by the additional weight, that it had instantaneously filled; and, upon drawing it up, the cork was found in the inside of the bottle, which was of course filled with water.

Another bottle was prepared in a similar manner; but in order to secure the cork, a sail needle was passed through the cork, so as to rest on the mouth of the bottle, and the whole was covered over with pitch. When the bottle had descended 50 fathoms, the captain again felt that it had filled with water; but, upon bringing it up, the cork and needle were found in the same position, and no part of the pitch appeared to be broken, although the bottle was completely filled with water. The water had in this case obviously insinuated itself through the pores of the pitch and the cork, and not, as Mr Campbell imagines, through the pores of glass. The experiment of forcing mercury through wood by the common pressure of the atmosphere, takes away the apparent improbability of this explanation. See Campbell's *Travels*, p. 507. Note. Lond. 1815.

5. *Experiment for illustrating the equality of the pressure of fluids in every direction.*

If a soft or frangible substance is exposed to any force in one direction more than another, it will either lose its shape, or be broken to pieces; but if the force with which the body is pressed is applied to every part of the body, it will preserve its form if it is soft, and will not be broken if it is frangible. Hence it follows, that if any body is exposed to a pressure sufficiently powerful to change its shape or crush it to pieces, and if it preserve its form and its integrity under this pressure, we are entitled to infer that the pressure is equal in every direction.

Let a piece of very soft wax, of an irregular shape, and an egg, be placed in a bladder filled with water. Let the bladder be then laid in a brass box, and a cover of brass put upon the bladder, so as to be entirely supported by it. If a hundred or a hundred and fifty pounds weight be laid upon this cover, so as to press upon the bladder, this enormous force, though propagated through the fluid, and acting upon the soft wax and egg, will produce no effect. The egg will not be broken, nor will the wax change its figure.

6. *Apparatus for illustrating the Doctrine of Specific Gravities.*

In order to shew that when a solid body is immersed in a fluid, the loss of weight which it sustains is equal to the weight of the water which it displaces, or of a quantity of water of the same bulk with the body, the following very simple apparatus has been employed.

A cylindrical or cubical body of any kind, either entirely solid, or made hollow and loaded within, so as to sink in the fluid, is exactly fitted to a hollow cylinder or cubical vessel, so that the solid contents of the hollow cylinder or cubical vessel is exactly equal to the solid contents of the cylindrical or cubical solid. Plate CCCXVII. Fig. 8. The cylindrical or cubical vessel is then suspended to the hook of a hydrostatic balance, or any other balance, and the solid cylinder or cube is suspended to a hook in the bottom of the cylindrical or cubical vessel. Weights are now put into the opposite scale of the balance till an equilibrium is produced in air. Every thing remaining in this situation, the solid cylinder or cube is completely immersed under water, and consequently the equilibrium is destroyed; that is, the scale of the balance to which the apparatus is suspended will require to have added to it a weight equal to the loss of weight sustained by the solid, in order to restore this equilibrium. By filling with water, therefore, the cylindrical or cubical vessel, it will be found that the equilibrium is exactly restored. Hence it is obvious to the eye, that the loss of weight sustained by the solid is exactly equal to the weight of water displaced.

7. *To make a Body lighter than Water lie at the bottom of a Vessel filled with Water.*

We have seen in Prop. IV. p. 772, that when a body has a less specific gravity than a fluid, it will float upon the surface of the fluid, as it is pressed upwards with a force greater than its own weight. If by any means, however, we can prevent the upward pressure from acting upon the lighter body, it is manifest that it must remain at the bottom of the vessel in the same manner as it would rest upon any other body in the open air, for the body is not only pressed down by its own weight but by the weight of the superincumbent fluid.

In order to show how to prevent the upward pressure from acting upon the solid, let us take two pieces of wood planed perfectly flat and smooth, so that no water can get in between them when their smooth surfaces are put together. If one of the pieces of wood is cemented to the bottom of a glass vessel, so as to have its smooth side uppermost, and if the other piece is placed above it, and held in that situation till the vessel is filled with water, it will be found to lie as quietly and firmly as if it were a plate of lead or stone. If the edge of the upper plate, however, is raised in the slightest degree, so as to allow the water to insinuate itself between the plates, the wood will instantly spring to the surface.

This experiment is sometimes made in a different manner. A flat and smooth brass plate is fixed at the bottom of the vessel, and a large mass of cork has a thin smooth brass plate fixed to its bottom, so that the specific gravity of the cork and its brass base may be much less than that of water. The brass plate on which the cork rests is then placed on the fixed brass plate; and when water is poured into the vessel, the cork will remain at the bottom. The two brass plates should be oiled a little on their touching surfaces, and should be ground upon one another, but not very accurately, for in this case the force of cohesion would prevent their separation, independent of the weight of the superincumbent pressure of the fluid, as it is well known that one brass plate can lift another in the open air, even when it is two or three pounds weight. The experiment as made with the brass plates is therefore not so satisfactory as the one with pieces of wood, for the reason which we have now assigned; and though we are satisfied that the cork and the brass plate are together lighter than water, yet the result appears less striking, as we are always in the habit of seeing brass sink to the bottom.

A similar result may also be obtained by fixing a glass plate at the bottom of a glass vessel, using a plate of ivory instead of wood, and pouring mercury into the vessel in place of water.

8. *Experiment for illustrating the parabolic form of a fluid surface influenced by a centrifugal force.*

In order to show that a horizontal surface of water assumes a parabolic form when it is acted upon by a centrifugal force, along with the force of gravity, we have only to take a bucket containing water, whose surface *c d* is of course horizontal when the bucket is at rest. If by means of a rope R, (Plate CCCXIII. Fig. 3.) however, fastened to the handle AB, we give the bucket a rotatory motion round a vertical line, the surface will lose its horizontal form, and the water becoming concave in the centre, will rise round the sides of the vessel, and have its surface of the form of a parabolic conoid, whose section *m n o* is a parabola. See Chap. I. Prop. I. cor. p. 769.

9. *Description of Dr Hooke's Semicylindrical Counterpoise.*

The principal object of this ingenious contrivance was to keep a vessel always full of water, or any other fluid; but as it is not only of use in hydrostatical experiments, but also illustrative of the principles of the equilibrium of fluids, we have thought it necessary to give a drawing and description of it in this place. In Plate CCCXVII. Fig. 9. ABG is a vessel of any form. Upon a horizontal axis C, a semicylinder or a hemisphere, whose section is DEF, is made to revolve, and the weight of the semicylinder is so adjusted that it is exactly equal to the weight of a portion of the fluid of half its magnitude. When the vessel is filled with water, the semicylinder is half immersed, and since it has half the specific gravity of the fluid, the semicylinder is in the same circumstance as if it were floating, and therefore exerts no pressure on the horizontal axis C. As the vessel is emptied either by evaporation, or by discharge from an orifice, the quantity of the semicylinder immersed will be diminished, and the equilibrium of consequence destroyed; and it will therefore move round the axis C till half of it is again immersed, and the equilibrium restored. In this way the semicylinder will always descend as the water runs out, and consequently the fluid must necessarily stand at the same height AB in the vessel.

10. *Experiments illustrative of the Pressure of the Superior Strata of Fluids upon the Inferior Strata.*

*Exp.* 1. If we pour coloured water into a glass vessel, and put a tube of glass, with a bore exceeding $\frac{2}{10}$ of an inch, the coloured water will stand in the tube at the same height as it does in the vessel. Let oil of turpentine be now poured above the water, and its pressure upon the surface of the water will cause the coloured fluid to ascend in the tube, but always to a height less than that of the surface of the oil of turpentine; the column of the coloured fluid raised, being to the thickness of the mass of oil in the inverse ratio of their specific gravities. The same experiment may be made by substituting quicksilver in place of the coloured water, and water in place of the oil of turpentine.

*Exp.* 2 If a vessel contains any fluid, a heavier fluid may be introduced below the lighter one, without any admixture taking place, and their separating surface will be horizontal. If a vessel for example contains water, let a quantity of milk be drawn up into a glass tube by suction, and if the open end of the tube is placed at the bottom of the vessel, and the milk allowed to discharge itself gradually, it will occupy the lower part of the vessel.

11. *Description of the Hydreoles invented by M. Mannoury Dectot.*

In Prop. I. of Chap. I. Sect. II. it has been demonstrated, that when two fluids are placed in the opposite branches of a bent glass tube or syphon, the altitudes above the point of junction will be in the inverse ratio of their specific gravities; that is, a fluid lighter than water will rise to a greater height in one of the branches than the water in the other.

M. Mannoury Dectot has employed this principle very ingeniously in raising water above its natural level, by mixing air with the water, so as to diminish its specific gravity, and thus cause it to rise to a considerable height in one of the branches of the syphon. In order to make an intimate mixture of water and air, he introduces the air in the form of minute bubbles, which lodge among the molecules of the water, and being kept separate from each other, they are retained by adhesion in such a manner that they are only disengaged slowly, and do not unite with each other and escape until the water which contains them has been raised to the proper height.

M. Mannoury Dectot has given two forms to this machine, one of which he calls the hydreole by suction, and the other the hydreole by pressure. In the hydreole by suction, the water passes through a mass of air, absorbs part of it, and becomes in some measure gaseous, and therefore it will rise to a greater height than the reservoir from which it flows.

In the hydreole by pressure, the air is driven by force through a number of small holes, so as to mix itself with the water in a number of minute bubbles. In order to form a proper idea of this machine, let us suppose that ABCD, Plate CCCXIII. Fig. 11. is a reservoir filled with water, and that the bent tube *a b c d* is joined to it at D. The water will obviously rise to the same level *a b*, A B in both vessels. Let us suppose, that a pair of bellows M is applied to an opening N in the tube, closed with a plate of iron, perforated with a great number of small holes, the air discharged from the bellows will enter the water in the form of very minute bubbles, which will be kept separate from each other by the mutual adhesion of the particles of water. The water above N will thus be rendered specifically lighter, and will therefore rise in the tube *a b c d*. Instead of using a pair of bellows, M. Mannoury Dectot obtains a current of air in the following manner. Between the opening N and the reservoir ABCD, he places a close vessel, communicating by one pipe with the reservoir, and by another with the opening at N. A column of water from the reservoir runs into the close chamber, compresses the included air, and this compressed air rushing through the other tube, enters through the holes in the aperture at N, and mixes itself with the water to be raised.

We have not been able to obtain any account of the preceding machine, but the very general one contained in the report of MM. Prony, Perier, and Carnot, which was approved of by the Institute of France, on the 28th December 1812. An account of M. Mannoury Dectot's new hydraulic machines will be found in Part III. of this article, on Hydraulic Machinery.

12. *Description of the Common Syphon.*

The syphon is a tube of glass or metal, bent in such a manner that one of its legs or branches is longer than the other. It is represented in Fig. 10. by ABCD. The shorter leg AB is immersed in the fluid in the vessel MNOP, and by applying the mouth to the orifice D, and sucking out the air in the syphon, the water ascends, and will continue to be discharged at D till the vessel is completely emptied.

Let us suppose that the syphon had legs of equal length, such as AB, BC, and that the water was drawn up by suction till it reached the extremity C; then it is obvious, that as the pressure of the air on the surface of water is equal to the pressure of the air at the extremity C, and as the columns AB, BC of the fluid are equal, there is no force which could enable the water to discharge itself at C. When the leg BC, however, is lengthened, so as to be equal to BD, then the water is discharged at D by the pressure of the additional column CD, and the velocity with which it is discharged will be in proportion to the difference between the legs of the syphon.

13. *Description of an Improved Syphon.*

The improved syphon is shewn in Fig. 11. where D is a stop-cock fixed at the extremity of its longer branch AB. A small bent tube ED lying along the outside of the branch, communicates with the cavity of the branch AB, above the stop-cock. When the aperture C is placed in the fluid to be drawn off, the mouth of the stop-cock D is closed, and the air is drawn out of the longer branch by suction at E. Instead of a stop-cock at B, the finger may be applied till the air is sucked out at E.

14. *Description of a Syphon acting by Capillary Attraction.*

If a bunch of cotton or worsted threads, or any absorbing fibres, is placed with one extremity in a vessel of water, and with the other hanging over the edge of it, the fluid will rise among the threads by the force of capillary attraction, and the water will be discharged from the longer branch in successive drops. Mr Leslie has very ingeniously employed this syphon for keeping moist the bulb of his hygrometer.

15. *Explanation of intermitting or reciprocating Springs upon the principle of the Syphon.*

A reciprocating spring, is a spring which alternately flows and ceases to flow. The name is also given to those springs which have a periodical swell, or which discharge a great quantity of water at one time, and a small quantity at another, after regular intervals. The first of these kinds of springs is easily accounted for, by supposing that the channel which carries off the water from a cavern has the form of a syphon. In this case, the water will only flow when it rises in the cavern to a height equal to that of the syphon, and the flow will stop till the cavern is again filled to the same height. The following explanation of the second kind of intermitting springs was suggested about a century ago to Dr Atwell of Oxford, by the phenomena of Laywell Spring at Brixam, near Torbay, in Devonshire. Let AA, Plate CCCXVII. Fig. 12. be a large cavern near the top of a hill, which derives its supply of water from rains or melted snow percolating through the chinks of the mountain, and let CC be the small channel which conveys the waters of the cavern to the opening G in the hill, where they are discharged in the form of a small spring. From the cavern AA let there be a small channel D, which carries water into another B, and let the water of the second cavern be carried off by a bent channel E*e*F wider than D, and joining the first channel CC at *f*, before it issues from the mountain, the point of junction *f* being below the level of the bottom of both the caverns. As the cavern B fills with water, the fluid will ascend to the same height in the channel E*e*F, but it will not be discharged by this channel till the surface in B is on a level with *e*, the highest part of the channel. The water will then be carried off by the natural syphon E*e*FG, till the whole is discharged, and consequently there will be a great swell in the spring at G. This swell will now cease, as the channel D does not convey the water into B so fast as the syphon E*e*F carries it off; and it will again commence as soon as the water in B rises to a level with the summit *e*. Mr Ferguson has illustrated this operation by a simple machine, a description of which will be found in his *Lectures*, vol. ii. p. 106, 107.

16. *To construct a Vessel, from which the Water will escape when it reaches a certain height.*

This vessel, which is called Tantalus's cup, consists of a metallic vessel, ABCD, divided into two compartments by the partition EF. A glass tube H *h*, open at both ends, is inserted in the opening H, in the partition EF, the lower end being allowed to reach a little below EF. The tube H *h* must then be covered by a small glass receiver *a b c*, or a wide tube hermetically sealed above, a small aperture being left at the bottom of this tube to admit the water. This mechanism is generally covered by the figure of a man representing Tantalus, as shewn in the drawing. If water is now poured into the vessel, it will get admittance into the receiver or wide tube, and will always stand at the same height in this tube that it does in the vessel. The water will therefore be retained in the vessel as long as it does not enter the tube H *h*, but as soon as the water rises in the vessel to the same level as the point *h*, it will flow down the tube H *h*; which acting like a syphon will discharge the whole fluid in the vessel. If water is poured slowly in with the intention of making it rise to the lips of Tantalus, it will never reach them, provided the syphon carries off the water faster than it is poured in. In the lower compartment of the vessel, there ought to be a small air-hole near the top, to allow the air to escape when the water takes its place.

17. *To construct a vessel which retains water when it is upright, but discharges it when it is inclined.*

Let ABCD be the vessel divided as formerly into two compartments by the partition EF. Into this partition insert the longer branch *b c* of a syphon *a b c*, whose shorter branch *b a* reaches nearly to the bottom of the vessel. If water is now poured into the vessel till it stands a little below the lower side of the bent part of the syphon, it is obvious that no water will descend through the syphon, as it has not risen high enough through the shorter branch to enable it to pass through the bent portion. If the vessel, however, is inclined to one side, as it is in the act of drinking, the water will rise higher in the short branch *a b*, pass over the bent part of the syphon, descend in the longer branch, and carry off all the water into the lower compartment of the vessel. Fig. 14. In order that this experiment may succeed, the sides of the vessel ought not to be symmetrical round the point *a* at the summit of the syphon; for in this case no inclination of the vessel, however great, will cause the water to flow over the point *a*. The syphon should therefore be placed towards one side of the vessel, and the vessel inclined to the same side.

A similar effect may be produced much more elegantly by using the double cup shewn in Fig. 15. where *a b c* represents the syphon. The person who tries to drink, must apply his lips to the side *b* of the syphon, otherwise the experiment will not succeed.

18 *To construct a machine in which all the water projected into a basin from a jet d'eau appears to be drank by a bird.*

This ingenious and elegant machine is shewn in Fig. 16. where ABCD is a vessel divided into three compartments by the partitions EF and GH. In the partition EF insert two tubes, one of which LM, forms a communication between the bottom of the compartment BG and the bottom of EC; while the other tube IK forms a communication between the upper part of EC and the upper part of HF. A third tube NO is fixed in the cover AB, extending from near the bottom of HF, and rising with a tapering bore to the point O, through the middle of the vessel SR, intended to receive the water which falls from the pipe NO. The figure of a bird with its bill immersed in the water in the basin SR, is placed on one side, and through its body passes a bent syphon QP, the lower branch of which goes into the compartment BG.

When the two upper compartments are nearly filled up to a little below K with water, through two apertures for that purpose, and when these apertures are shut, it is obvious that when the cock of the pipe LM is opened, the water will descend through LM, and occupying the compartment EC, will drive the air up through the pipe IK, and compress the air contained in the cavity HF. This condensed air pressing on the surface HK of the water, will raise it in the tube NO, and cause it to be projected upwards in a jet d'eau. The water from the jet, after being carried to a height due to the pressure which it experiences, will fall down into the vessel SR. But as the water escapes from the compartment BG, the air in that compartment will be rarefied, and will therefore not be sufficient to balance the pressure, if the exterior air upon the surface of the water is SR. This unbalanced pressure will therefore force the water up the syphon QP, through which all the water in the vessel SR will be conveyed into the cavity BG, as if it had been drank by the bird.

For farther information respecting the subjects treated of under this chapter, the reader is referred to the following works: Pascal's *Traitez de l'Equilibre des Liqueurs*, &c. &c. Paris, 1664; S. Gravesende's *Physices Elementa Mathematica*, lib. iii. Leid. 1742; *Phil. Trans.* 1732, vol. xxxvii. p. 301; Desagulier's *Course of Experimental Philosophy*, vol. ii. lect. 7 and 8, Lond. 1763; Ferguson's *Lectures on Select Subjects in Mechanics, Hydrostatics, Hydraulics*, &c. vol. ii. Edin. 1806; Dr Thomas Young's *Course of Lectures on Natural Philosophy*. vol. i. Description of Plates; Leslie's *Short Account of Experiments and Instruments depending on the relations of Air to Heat and Moisture*, Edin. 1813; Campbell's *Travels in the South of Africa*; and Ozanam's *Mathematical Recreations*, edited by Montucla and Hutton. See also Part III. of this article on Hydraulic Machinery.

## Part II. ON HYDRAULICS.

HYDRAULICS, from ὑδωρ *water*, and αυλος, which sometimes signifies a *torrent*, is that branch of the science of hydrodynamics which treats of fluids considered as in motion. It therefore embraces the phenomena exhibited by water issuing from orifices in reservoirs, projected obliquely or perpendicularly in jet d'eaux, moving in pipes, canals, and rivers, oscillating in waves, or opposing a resistance to the progress of solid bodies.

### CHAP. I.

### On the Motion of Fluids issuing from Reservoirs by Vertical or Horizontal Orifices.

*General Principles.*

When a vessel is filled with a homogeneous fluid, and is in equilibrium, all the particles of fluid which it contains are equally pressed in every direction. But if a small aperture is made in the bottom of the vessel, the particles which rested upon the part of the bottom which is removed being no longer supported, will descend by their own gravity. The particles immediately above them will also descend, and all the fluid in the vessel will descend in lines nearly vertical; and when they arrive within three or four inches of the orifice, they will gradually turn into a direction more or less oblique, and make directly for the orifice. The same thing happens when the orifice is made on the side of the vessel. The preceding results were obtained experimentally by M. Bossut, who employed a glass vessel kept constantly, and rendered the motion of the fluid particles visible, by throwing into the water minute substances specifically heavier than it; such as filings, and small fragments of pounded slate.

When the vessel was allowed to empty itself by an orifice in the bottom of the vessel, the surface of the fluid preserved its horizontality during its descent, and when it came to within six lines, or half an inch of the orifice, a funnel-shaped hollow or cavity appeared in the surface of the fluid. When the water issued from an orifice in the side of the vessel, the water also preserved its horizontality; and when the surface reached the upper edge of the orifice, the water inclined a little from the orifice, forming an approximation to a hollow.

As the various particles of fluid which rush towards the orifice move in directions which converge to a point without the orifice, it is obvious that the column of fluid which issues from the vessel ought to have a smaller diameter than the orifice itself. This diminution in the diameter of the column was first observed by Sir Isaac Newton, and was called by him the *vena contracta*, or the contraction of the fluid vein. The distance from the orifice at which the greatest contraction takes place, is equal to the semidiameter of the orifice, and the area of the section of the vein at this place was to the area of the orifice as 10 to 14.14 according to Newton, or as 10 to 16 according to Bossut. When the orifice, instead of being a mere aperture in a thin plate, is a short cylindrical tube, Bossut found that the area of the section of the vena contracta was to that of the orifice as 10 to 12.3.

In proceeding to give a very short view of the theory of fluids issuing from orifices, we must warn the reader not to expect that strict coincidence between theory and practice which is to be found in many other branches of science. In optics and astronomy, and even in those parts of hydrostatics which we have already considered, the theoretical results scarcely differ at all from those which are obtained from accurate experiments; but in every branch of hydraulics the deductions of theory are so uncertain, that they are of no use whatever in any of the important purposes to which this science is applicable. It is only the general laws deduced from experiment that can be safely employed in the various operations of hydraulic architecture.

We shall therefore pass over very rapidly the theoretical part of the subject, and endeavour to lay before our readers a full account of the practical parts of hydraulics, availing ourselves of the invaluable labours of the Abbé Bossut.

*Definitions.*

1. A *vertical orifice* is an orifice placed in a vertical direction, so as to allow the water to issue in a horizontal stream.

2. A *horizontal orifice* is an orifice placed in a horizontal direction, so as to allow the fluid to escape in a vertical direction.

3. An *ajutage* is a name given to any orifice, or cylinder, or cone, from which water issues.

4. An *additional tube* is a tube of any form, inserted in a simple orifice made in the sides or bottom of a vessel.

5. A *head of water* is a term used to denote the height of the fluid above the orifice, or in general the height of a spring or source of water above the lowest point where it can be employed to exert a mechanical force, either by its impulse or by its weight.

6. If water issues with a velocity V, equal to that which a heavy body would acquire by falling through a height H, the velocity is said to be the velocity *due to the height H*, and the height is said to be *due to the velocity V*.

Prop. I.

If a fluid moves in an open canal, or through a tube, kept constantly full, whose diameter gradually varies, and if the fluid has the same velocity in every point of the same section, the velocities in different sections will be in the inverse ratio of the areas of the sections.

Since the canal and tube are always full, the same quantity of fluid must pass through every section in the same time. But as the quantity of fluid which passes through any section, whose area is A, is proportional to that area, and also to the velocity V with which it flows, it must be proportional to A and V jointly, or $A \times V$. In like manner the quantity of fluid which runs through the area $a$ of any other section in which $v$ is the velocity, will be proportional to $a \times v$. Hence $V : v = a : A$.

Scholium.

The case stated in the proposition is one which is purely theoretical, and can never occur in practice. In every canal the velocity of the surface is always greatest, and in every tube the particles in its axis always move most rapidly.

Prop. II.

If a fluid is discharged from a vertical or horizontal orifice infinitely small, in a vessel where the fluid is kept constantly at the same height, the velocity with which the fluid issues, is equal to that which a heavy body would acquire by falling through a height equal to the height of the fluid above the orifice.

Let ABDC, Fig. 1. be a vessel in which the surface of the water always stands at AB, and let $m\,n$ be the very small orifice through which the fluid is discharged. Let us suppose the fluid divided by horizontal planes into an infinite number of laminæ, then since the area of the orifice $m\,n$ is infinitely small compared with the area of the laminæ, it will follow, from Prop. I. that the velocity with which the laminæ descend must be infinitely small. Now it is obvious that the lowest film of fluid $m\,n$ is pressed out by the weight of the column $m\,n\,p\,o$. (See Chap. I. Sect. I. Prop. IV.) Let M be the mass of the column of fluid $m\,n\,h\,g$, which is discharged at every instant by the pressure of $m\,n\,p\,o$, or by the force $m\,n \times m\,o$, and let $m$ be the mass of a lesser column of fluid $m\,e\,f\,n$, which would have been discharged in the same time, solely by its own gravity, which may be represented by the line E $m$. Then if V be the velocity of the column $m\,g\,h\,n$, and $u$ the velocity of the column $m\,e\,f\,n$, the quantity of motion of the column $m\,g\,h\,n$ will be $V \times M$, and the quantity of motion of the column $m\,e\,f\,n$ will be $u \times m$. But the moving forces are $m\,n \times m\,o$, and $m\,n \times E\,m$; and as they must be proportional to the quantities of motion which they produce, (see Dynamics,) we have

$$m\,n \times m\,o : m\,n \times E\,m = V \times M : u \times m \text{ or}$$
$$V \times M : u \times m = m\,o : E\,m.$$

But the masses M, $m$ discharged in the same time are as the area of the orifice multiplied by the velocity; that is, $M : m = m\,n \times V : m\,n \times u$, or $M : m = V : u$, and as magnitudes have the same ratio as their equimultiples have, (Euclid, V. 15,) we have

$M\,V : M\,u = V^2 : u^2$; but it has already been shewn that $M\,V : M\,u = m\,o : E\,m$, hence
$V^2 : U^2 = m\,o : E\,m$.

Now if $v$ is the velocity which a heavy body would acquire by falling through the height $m\,o$, we have, by Dynamics, Case 4,

$$v^2 : u^2 = m\,o : m\,E, \text{ consequently}$$
$$V^2 : u^2 = v^2 : u^2,$$

and $V^2 = v^2$ and $V = v$, that is, the velocity V, with which the fluid issues from the orifice $m\,n$, under the pressure of the column $m\,n\,p\,o$, is equal to the velocity $v$, which a heavy body would acquire by falling through the height $m\,n$.

It is obvious, that the preceding reasoning is applicable to a vertical orifice, or to an orifice in any position, provided its depth is equal to $m\,n$, for the pressure of the fluid is the same in all directions.

*Cor.* 1. If the vessel ABDC, instead of being kept constantly full, is allowed to empty itself by the orifice $m\,n$, the velocity will always diminish; and when the surface has assumed a lower level GH, the velocity will be that which is due to $h\,m$.

*Cor.* 2. As the velocities of heavy bodies, descending by the force of gravity, are as the square roots of the spaces or heights through which they fall, (see Dynamics, Case 4,) the velocity of the issuing fluid will be as the square roots of the altitude of the surface of the fluid above the orifice. That is, if the water stands successively at the heights $o\,m$, $h\,m$, the velocities will be as $\sqrt{mo} : \sqrt{mh}$.

*Cor.* 3. As the quantities of fluid discharged are proportional to the velocities when the orifices remain the same, they will also be proportional by *Cor.* 2. to the square roots of the height of the fluid in the vessel.

*Cor.* 4. If the orifice is horizontal, but opening upwards, so as to discharge the fluid in a vertical direction, the water will rise in a jet to the same height as the surface of the fluid in the reservoir. As all heavy bodies acquire in falling a velocity which would carry them upward to the same height from which they fell, the same must be true of fluids. In practice, however, the resistance of the air, and the friction of the fluid upon the sides of the orifice, prevent this from being true.

*Cor.* 5. If the fluid, when it issues from the orifice, should continue to move uniformly with the velocity with which it issues, it would describe a space equal to 2 $mo$, in the same time that a heavy body would fall through the height $om$.

In studying the preceding proposition, the reader must consider it as giving the velocity, not at the orifice itself, but at the *vena contracta*, where the velocity is greatest. Sir Isaac Newton having found that the velocity at the *vena contracta* was that which was due to the whole height of the fluid, and that the velocity at the *vena contracta* was to the velocity of the orifice as $\sqrt{2} : 1$, or as 1.414 : 1, necessarily concluded that the velocity at the orifice is only that which is due to *half* the altitude of the fluid.

### Prop. III.

If a cylindrical or prismatic vessel, of which the horizontal section is every where the same, is filled with fluid, and empties itself by an orifice, the velocity with which the surface descends, and also the velocity with which the water issues, is uniformly retarded.

Since the velocity of the surface of the fluid is to the velocity at the orifice, as the area of the orifice is to the area of the horizontal section of the vessel, or the area of the surface, the velocity of the surface must vary as the velocity at the orifice. But the velocity at the orifice varies as the square root of the height of the fluid in the vessel, by Prop. II. Cor. 2.; consequently the velocity of the surface must also vary according to the height of the fluid, that is, with the space through which it descends. But as the velocity of heavy bodies projected upwards varies in this manner, the velocity of the fluid surface must be uniformly retarded in the same manner as heavy bodies.

### Prop. IV.

If a fluid issues from a cylindrical or prismatic vessel, whose horizontal section is every where the same, and in which the fluid is always kept at the same height, the orifice will discharge twice the quantity contained in the vessel, in the same time that the vessel would have emptied itself.

As the surface of the fluid is uniformly retarded, and as its velocity becomes nothing at the bottom, the space which the descending surface would describe, with the first velocity, continued uniform during the time that the vessel takes to empty itself, is twice the space that the surface really describes in the time in which the vessel empties itself. In this time, therefore, the quantity of fluid discharged in the former case is twice that which is discharged in the latter case, as the quantity discharged when the vessel is kept constantly full may be measured by what would be the descent of the surface, if it could descend with the velocity with which its descent commences.

The preceding demonstration is given by Mr Vince. M. Bossut deduces the proposition as a corollary from formulæ which express the quantity of water discharged under the circumstances stated in the proposition.

### Prop. V.

To determine the quantity of water discharged by a small vertical or horizontal orifice, the time of discharge, and the height of the fluid in the vessel, when any two of these quantities are known.

Let A represent the area of the small orifice $mn$; W the quantity of water discharged; T the time of discharge, H the height of $mo$ fluid in the vessel, and $g = 16.087$ feet, the space described by gravity in a second. Then since, by dynamics, the times are as the square roots of the spaces, we have $\sqrt{g} : \sqrt{H} = 1 \text{ second} : \sqrt{\frac{H}{g}}$, the time in which a heavy body would fall through the height H. But since the velocity is uniform, the space described will be double in the time that a heavy body would describe the height H, and therefore a column of fluid $= A \times 2H$ will be discharged in the time $\sqrt{\frac{H}{g}}$. Now, as the quantities of fluid discharged in different times are proportional to the times, we have $2AH : W = \sqrt{\frac{H}{g}} : t$. Hence,

$$W = \frac{2AHt}{\sqrt{\frac{H}{g}}} = \frac{2AHt \times \sqrt{g}}{\sqrt{H}}, \text{ and since } \frac{H}{\sqrt{H}} = \sqrt{H},$$

we have $W = 2At\sqrt{gH}$

$$A = \frac{W}{2t\sqrt{gH}}$$

$$t = \frac{W}{2A\sqrt{gH}}$$

$$H = \frac{W^2}{4gt^2A^2}.$$

*Cor.* By means of these formulæ, we may determine the quantity of water $W'$ which is discharged in the same time T, from any other vessel in which $A'$ is the area of the orifice, and H the altitude of the fluid; for since $t$ and $g$ are constant, we shall have

$$W : W' = A\sqrt{H} : A'\sqrt{H'}.$$

### Prop. VI.

To determine the time in which the surface of water in a vessel will descend through a given height, where the fluid is discharged through a small orifice in the bottom.

Let ABCD, (Plate CCCXVII. Fig. 2.) be the vessel, and let it be required to determine the time in which the surface of the fluid descends from AB to RS. Draw MN, $\mu\nu$ parallel and infinitely near to each other, then since $P\pi$ is infinitely small, we may consider the height $\pi o$ as constant during the time that the lamina of fluid $MN\mu\nu$ flows through the orifice; and consequently its velocity is uniform. The time $t$, therefore, in which the height $P\pi$ is described, will, by Prop. IV. be $t = \frac{MN \times P\pi}{2A\sqrt{g}\sqrt{Pm}}$; for in the present case $W = MN \times P\pi$, and $H = Pm$. In a similar manner we may obtain the times $t'$, $t''$ for all the other elementary laminæ into which the sum ABNM may be supposed to be divided, and therefore the sum of all these elementary terms, which may be obtained either by fluxions or by a geometrical construction, will be the time required in the proposition.

In order to find the time geometrically, draw EF equal and parallel to BC, and construct upon EF as an axis a parabola FTG, with a given parameter $p$. Prolong the lines AB, MN, $\mu\nu$, and RS, till they meet the parabola in G, $c$, $d$, and T. Construct a second curve XZY, so that each of the ordinates H $a$, K $b$, L Z, may be equal to the corresponding sections MN, $\mu\nu$, RS, divided by their corresponding ordinates in the parabola H $c$, K $d$, LT. Now, since

$H a = \frac{MN}{H c}$, and $MN = H a \times H c$, and since by the property of the parabola, (See Conic Sections, Prop. XIII. $H c^2 = HF \times p$, and $\sqrt{HF} = \sqrt{Pm} = \frac{H c}{\sqrt{p}}$, we have, by substituting, in the above value of $t$, the preceding values of MN, and $\sqrt{P m}$, $t = \frac{H a \times H c \times HK \times \sqrt{p}}{2 A \times \sqrt{g} \times H c}$, and dividing by $\sqrt{p}$ and H $c$

$$t = \frac{\sqrt{p}}{2 A \sqrt{g}} \times HK \times H a$$

which consists of the constant factor $\frac{\sqrt{p}}{2 A \sqrt{g}}$ multiplied into the variable curvilineal area H $a$ $b$ K. But as the same may be shewn for every other element of the time, it follows, that the time of descent from AB to RS will be equal to $\frac{\sqrt{p}}{2 A \sqrt{g}} \times$ ELZX.

*Cor.* It follows from this proposition, that the times in which the surface AB will descend through the heights $o$ P, $o$ $s$, will be proportional to the corresponding areas EH $a$ X, ELZX, and that the time of descent through any of these heights is to the time in which the vessel is completely emptied, as the corresponding area EH $a$ X or ELZX, is to the whole area EFYX.

### Prop. VII.

To determine the time in which the surface of water in a prismatic or cylindrical vessel will descend through a given height, viz. from AB to RS in Fig. 3.

This problem, as Bossut has remarked, may be very easily resolved by the method of fluxions; but we shall follow this excellent mathematician in the elementary demonstration which he has given of it. Let us suppose, that a body, not heavy, ascends through the height $m$ $o$, Fig. 3. and describes that space in the very same way as a heavy body would descend through the height $o$ $m$. Then it is obvious that the different velocities of the ascending and descending body may be expressed by the ordinates of a parabola GTF. When the ascending body has arrived in $\pi$, it will describe the small space $\pi$ P or KH, with a velocity represented by the ordinate H $c$; but the time of describing $m$ $o$ is $\sqrt{\frac{m o}{g}}$; and if the final velocity of the ascending body were continued uniform, the body would describe a space $= 2$ $m$ $o$ in the time $\sqrt{\frac{m o}{g}}$. But in uniform motions, the spaces divided by the velocities are as the times of description. Hence $\frac{2 m o}{EG} : \frac{HK}{H c} = \sqrt{\frac{m o}{g}}$ : Time HK, (or the time of describing GV.) Consequently

$$\text{Time HK} = \frac{HK \times EG}{2 H c \sqrt{g} \times \sqrt{m o}},$$

and substituting for $\sqrt{m o}$ its value $\frac{EG}{\sqrt{p}}$, $p$ being the parameter of the parabola, we have

$$\text{Time HK} = \sqrt{\frac{p}{g}} \times \frac{HK}{2 H c};$$

but by Prop. VI. the time in which the water descends through the same space P $\pi$, or HK, is

$$\frac{\sqrt{p}}{2 A \sqrt{g}} \times H a \times HK = \frac{\sqrt{p}}{2 A \sqrt{g}} \times \frac{MN}{H c}.$$

If we now substitute in place of H $a$ its equal $\frac{MN}{H c}$; and multiply the first of these expressions by MN, and the second by A, the products will be equal, or

$$\frac{MN}{2} \frac{\sqrt{p} . HK}{\sqrt{g} H c} = \frac{MN . A \sqrt{p} . HK}{2 A \sqrt{g} . H c}.$$

Hence, by Euclid, (VI. 16) the time of the body's ascending through $m$ $o$, is to the time in which the surface descends through P $\pi$, as the area A of the orifice is to the area MN of the base of the cylindrical or prismatic vessel; and as the same is true of all the other elementary times which the ascending body and the descending surface employ in describing small equal spaces, it follows, that the whole time in which the ascending body will describe the height $m$ $o$, is to the time in which the vessel will be completely emptied, as the area A of the orifice is to the area of the base of the vessel. The time, therefore in which the vessel will empty itself will be $\sqrt{\frac{m o}{g}} \times \frac{B}{A}$, being the area of the base.

If RDSC is the vessel, then the time in which it will be entirely emptied will be $\sqrt{\frac{m s}{g}} \times \frac{B}{A}$, consequently the differences of these times, or the time in which the surface A B will descend into the position RS, will be

$$\text{Time } m s = B \frac{(\sqrt{m o} - \sqrt{m s})}{A \sqrt{g}}.$$

### Prop. VIII.

To construct a clepsydra, or water clock, of a cylindrical form.

The equation in the preceding proposition enables us to do this in a very simple manner. Let us suppose that it is required to measure 12 hours, and that the height AD is divided into 144 equal parts; then the height of the surface of the water at the commencement of the time will be 144 parts. At the end of one hour the height will be 121; at the end of the second hour it will be 100, as in the following Table:

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hours to run . . . . . . . . . . . . | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Hours from commencement . . . . . | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Height of the surface from the bottom | 144 | 121 | 100 | 81 | 64 | 49 | 36 | 25 | 16 | 9 | 4 | 1 | 0 |
| Length of each hour in parts . . . . . | 23 | 21 | 19 | 17 | 15 | 13 | 11 | 9 | 7 | 5 | 3 | 1 | |

Since the velocity with which the surface AD descends is as the square roots of the altitudes, then, as the velocities are proportional to the times, the times in which these altitudes are described will also be as the square roots of the altitudes. Hence, since 12, 11, 10, &c. are the times in which the different heights are to be described, the heights should be as $12^2$, $11^2$, $10^2$, or as 144, 121, 100, 81.

The exact time of describing each part of the altitude A is easily deduced from the formula. If the time is to be one hour, then we must proportion the area B of the base, and the height $h$ of the vessel, to the area A of the orifice; so that 1 hour $= B\frac{(\sqrt{h}-\sqrt{\frac{121}{144}})}{A\sqrt{g}}$, or 1 hour $= \frac{B\sqrt{h}}{12\,A\sqrt{g}}$; from which any of the three quantities B, $h$, and A may be found, when two of them are given.

Scholium.

In practice, the 11 first divisions should only be employed, on account of the effect of the funnel-shaped cavity upon the regularity of the discharge. See p. 828.

Prop. IX.

If a prismatic or cylindrical vessel ABCD is kept constantly full, it will discharge twice as much water as it contains in the time that it takes to empty itself completely.

It follows from Prop. VII. that the time in which it empties itself is $\frac{B\sqrt{h}}{A\sqrt{g}}$, $h$ being equal to the height $m\,o$; and from Prop. V. that the quantity of fluid discharged in the same time, when the vessel is kept constantly full is $\frac{B\sqrt{h}}{A\sqrt{g}} \times 2\,A\sqrt{g\,h} = 2\,B \times h$; but this quantity is double of the prism ABCD, which is equal to $B \times h$.

Scholium.

In practice, the effect of the funnel-shaped cavity must be considered. See Chap. III. Sect. V.

Prop. X.

If water is discharged from two prismatic or cylindrical vessels, the times in which their surfaces descend through similar heights, will be in the compound ratio of the areas of the bases, and the difference between the square roots of the height of each surface at the beginning and end of its motion directly, and inversely as the areas of the orifices.

Let the corresponding quantities in the two vessels be distinguished by accents, then, by Prop. VI. time $o\,s$ : time $o'\,s' = B\frac{(\sqrt{o\,m}-\sqrt{s\,m})}{A\sqrt{g}} : B'\frac{(\sqrt{o'\,m'}-\sqrt{s'\,m'})}{A'\sqrt{g}}$ or dividing by $\sqrt{g}$, as $B\frac{(\sqrt{o\,m}-\sqrt{s\,m})}{A} : B'\frac{(\sqrt{o'\,m'}-\sqrt{s'\,m'})}{A'}$.

Scholium.

In practice, the effects of the contraction of the fluid vein must be considered, as in Chap. III. Sect. V. p. 656.

Prop. XI.

To determine the quantity of water which is discharged in a given time from a large rectangular orifice in the side of a vessel.

Hitherto we have supposed, that the orifice from which the water was discharged, when it issued from the side of a vessel, was so small, compared with the diameter of the vessel, that every part of the orifice might be considered as at the same depth below the surface. As this supposition, however, is inadmissible in the case of large orifices, we must now suppose a large orifice divided into an infinite number of small rectangles, (if the orifice is rectangular,) and regarding each of these as an orifice, all the points of which are equidistant from the fluid surface, we must determine the quantity of water discharged by means of the preceding propositions. The sum of all these elementary quantities will then be the total quantity of fluid discharged during the given time.

In order to shew the mode of doing this, by a geometrical construction, we shall take the case of a rectangular orifice as given by Bossut. Let LNOM be the given orifice in the vessel ABCD, Fig. 4. kept constantly full of water. Draw XZ, $x\,z$, infinitely near each other, and parallel to LM, so as to form the elementary rectangle XZ$z\,x$. Then if RI is the height, which may be considered as the distance of all the points of the small orifice from the surface AD, the quantity of water discharged in the time $t$ will be $2\,XZ \times I\,i \times t\sqrt{g} \times \sqrt{RI}$. In order to find the sum of all these elementary quantities, construct upon the axis RV the parabola RT, whose parameter is $p$, and produce KM, IZ, $i\,z$, VO to Y, S, $s$, and T. The small parabolic area IS, $s\,i$ may be considered as a rectangle $= IS \times I\,i$. But $IS = \sqrt{RI} \times \sqrt{p}$; hence $IS \times I\,i = I\,i \times \sqrt{RI} \times \sqrt{p}$. Calling $e$ this parabolic area, and $q$ the elementary quantity of water which flows through the elementary orifice XZ $z\,x$, we shall have $e : q = I\,i \times \sqrt{RI} \times \sqrt{p} : 2\,XZ \times t\sqrt{g} \times I\,i \times \sqrt{RI}$, which gives us

$$q = e \times \frac{2\,XZ \times t\sqrt{a}}{\sqrt{p}}.$$

If we can determine, therefore, the sums of all the $e$'s or the parabolic surface KVTY, we shall easily determine the sum of the $q$'s or the total quantity Q, which is discharged in the time $t$ from the aperture LNOM.

Complete the rectangle RVTH, and draw SG $s\,g$ parallel to VR. Now the area RHT is composed of the elements SG, $s\,g$, which are proportional to the squares of the distances RG, R $g$: (see Conic Sections, Sect. IV. Prop. XII. Cor.) Hence these elements increase as the sections of a pyramid, whose summit is R, and whose height is RH. Consequently the form of all the GS's which make up the area RHT, are equal to $\frac{1}{3}\,RH \times HT$; therefore the area $RVT = \frac{2}{3}\,VR \times VT$. The space KVTY, or the sum of the $e$'s, is therefore $= \frac{2}{3}(RV \times VT - RK \times KY)$; but

$$q = e \times \frac{2\,XZ \times t\sqrt{g}}{\sqrt{p}}.$$

Hence we have

$$Q = \tfrac{2}{3}\,(RV \times VT - RK \times KY) \times \frac{2\,XZ \times t\sqrt{g}}{\sqrt{p}}.$$

If we substitute in this expression $\sqrt{VR} \times \sqrt{p}$ instead of VT; $\sqrt{RK} \times \sqrt{p}$ instead of KY; and if we call $VR = H$, and $RK = h$, and $XZ = b$, we have

$$Q = \frac{4\,b\,t\sqrt{g}\,(H\sqrt{H} - h\sqrt{h})}{3}.$$

In this expression, $g$ is always $= 16.087$.

Prop. XII.

To determine the horizontal distance to which water will be projected from orifices in the side of a vessel, and the nature of the curve which it will describe.

Let ABCD, Fig. 5. be a vessel of water, which is discharged at O through the bent tube GEO, in the direction OP. If the water were influenced by no other force but that with which it is projected, it would move uniformly in the direction $m\,o$ P, with a velocity equal to that which a heavy body would acquire in falling through the height QO. But as it is acted upon by gravity, as soon as it escapes from the orifice O it will obviously describe some curve line O $n\,p$. Make the elementary space O$m$ = $m\,o$, and O P = 2 OQ. Draw PM parallel to ON, and join QM. Let fall from the points $m$, $o$, P, the vertical lines $m\,n$, $o\,p$, PV, which will be parallel to OM, and complete the parallelograms O $m\,n$ R, O $o\,p$ S, OPVT. Let us now suppose, that in the time in which the water would have described the space O $m$, the force of gravity would have caused it to fall through the height OR; and that in the time in which it would have described the space O $o$, it would have descended through OS by the force of gravity alone. Now, since the fluid at O is solicited by two forces, one of which, viz. the force of projection, would carry it through the space O $m$ in a certain time, while the other, viz. the force of gravity, would carry it through the space OR in the same time, the fluid will at the end of the given time be found at $n$. In like manner it may be shewn, that at the end of the time in which the water would have described O $o$ uniformly, it will be found in the point $p$. But since O $m$, O $o$ represent the times in which the water reaches the points $m$, $p$ of its path, and since in these times the force of gravity has caused the water to fall through the spaces $m\,n$, $o\,p$, then, as the spaces are proportional to the squares of the times, we have $mn,\ op = \mathrm{O}m^2 : \mathrm{O}o^2$, that is, on account of O $m\,n$ R, O $o\,p$ S, being parallelograms $\mathrm{OR} : \mathrm{OS} = \mathrm{R}n^2 : \mathrm{S}p^2$, which is the relation between the abscissæ and the ordinates of the Apollonian hyperbola. (See Conic Sections, Sect. IV. Prop. XII. Cor.)

It would be unnecessary to proceed any farther in explaining and demonstrating the geometrical construction which is usually given for finding the amplitude either of oblique or horizontal jets, as the construction and the demonstration of it are exactly the same as that which we have given in our article Gunnery, for the parabolic path of projectiles. The two classes of phenomena, and the mathematical laws by which they are regulated, are exactly the same.

### Prop. XIII.

To determine the pressure exerted on the interior of conduit pipes by the water which they convey.

Let the fluid column, Plate CCCXVIII. Fig. 5. No. 2. be divided into an infinite number of equal and vertical laminæ GF $gf$. Then, if we abstract friction, it is obvious that all the points of the same lamina have the same velocity, and that this velocity is the same in all the laminæ. If $q\,r$ represent the section of the contracted vein at the orifice $p\,n$, the velocity of the laminæ is to the velocity in $q\,r$, as the area of the orifice $q\,r$ is to the area of the section GF; for at every instant there passes out of $q\,r$ a small prism of water equal to GF $g\,f$, and therefore these prisms have velocities reciprocally proportional to their bases. (See Prop. I. p. 488.) If we therefore call $h$ the constant height of water in the reservoir, D the diameter of the tube, $d$ that of the orifice $q\,r$, and if we consider that the velocity in $q\,r$ is that due to the height $h$, and may be expressed by $\sqrt{h}$, then $\mathrm{D}^2 : d^2 = \sqrt{h} : \frac{d^2\sqrt{h}}{\mathrm{D}^2}$, the velocity of the water in the pipe. But as the velocity $\sqrt{h}$ is due to the height $h$, the velocity $\frac{d^2\sqrt{h}}{\mathrm{D}^2}$ will be due to the altitude $\frac{d^4 h}{\mathrm{D}^4}$. But since each particle of fluid that reaches the extremity PN of the pipe tends to move with the velocity $\sqrt{h}$, while it moves only with the velocity $\frac{d^2\sqrt{h}}{\mathrm{D}^2}$, every point of P$p$ or N$n$ upon which it rests must be pressed with a force equal to the difference of the pressure due to the velocities $\sqrt{h}$, and $\frac{d^2\sqrt{h}}{\mathrm{D}^2}$, that is, every part of the pipe will be pressed with a force equal to $h - \frac{d^2 h}{\mathrm{D}^4}$.

*Cor.* 1. If an aperture very small in relation to each of the orifices PN, $p\,n$ is made in the side of the pipe, the water will issue with a velocity due to the height $h - \frac{d^4 h}{\mathrm{D}^4}$. This height will vanish when $d = \mathrm{D}$, or when the whole aperture PN is opened.

See Bossut's *Traité d'Hydrodynamique*, Tom. II. chap. xi. p. 197, &c. from which the preceding proposition is taken.

### Scholium.

In page 854, 855, of the present article, will be found a set of valuable experiments by Bossut, in which he has measured the quantity of water discharged by apertures in the side of the pipe. The agreement between the formula and the observed results is very striking.*

* In a series of very recent and interesting experiments on the discharge of liquids through small orifices, made by M. Hachette, of which some account will be found in the following chapter, he has discovered that the quantity of fluid discharged by orifices varies, by placing an obstacle at some distance from the orifice. Daniel Bernoulli made an experiment on this subject, and concluded from it, that an obstacle does not alter the quantity of fluid discharged. In his experiment, however, the time of the flow was too short for obtaining correct results.

M. Hachette employed a circular orifice, 20 millimetres in diameter, which discharged water from a large vessel into a vessel placed at a great distance from the orifice. The surface of the water in the vessel sank about six decimetres in 10′ 21″. The plane face of an obstacle was presented at different distances from the orifice, and the jet fell perpendicularly on this plane. The following were the results:

| Distance of the Obstacle in Millimetres. | | | | |
|---|---|---|---|---|
| 128 | 80 | 50 | 24 | 4 |
| Corresponding Times in which the Surface of the Water sunk Six Decimetres. | | | | |
| 10′ 21″ | 10′ 25″ | 10′26″ | 11′ 13″ | 15′54″ |

Hence it follows, that at the distance of 128 millimetres (5.039 inches), the obstacle produces no effect; but that, at the distance of four millimetres 0.157 of an inch, the time is increased rather more than one-half.

## CHAP. II.

### On the Lateral Communication of Motion in Fluids.

This branch of hydrodynamics has been cultivated almost solely by M. Venturi, professor of natural philosophy at Modena, who published an account of his ingenious investigations in 1798. Sir Isaac Newton was acquainted with the fact that such a lateral communication took place, and has deduced from it the propagation of rotatory motion from the interior to the exterior strata of a whirlpool; but M. Venturi has the sole merit of explaining the different phenomena which it produces, and of applying it to the explanation of many curious phenomena. The following propositions contain a brief and general view of the subject.

### Prop. I.

The motion of a fluid is communicated to the lateral parts which are at rest.

In order to establish this proposition by direct experiment, Venturi introduced the horizontal cylindrical pipe A *c* (Plate CCCXVIII. Fig. 5. No. 3.) into a vessel DEFB, filled with water as high as DB. Opposite the aperture C, and at a little distance from it, is placed a small rectangular canal of tinned iron SMBR, open at the top SR, and having its inclined bottom MB resting on the edge B of the vessel. The breadth of this canal is 24 lines, the diameter of the tube AC is 14.5 lines, and the extremity A is inserted in a reservoir, of which the water is kept at a constant height. When the water of the reservoir is permitted to flow through AC, the current rises along the canal MB, and of course rushes out of the vessel in the current BV. In this way a current is created in the fluid in the vessel DEFB. This fluid is carried into the canal SR, and issues at B along with the water in the reservoir. In a few seconds, therefore, the water DD falls to MH. A similar effect will be obtained if we bring any light bodies near a stream of water issuing from a reservoir. These bodies will be carried along by the air which descends with the stream.

From these experiments it follows, that the lateral parts of a fluid are carried along with any stream that flows through the fluid, and consequently that the motion of the fluid is communicated to the lateral parts which are at rest.

### Scholium.

Venturi has applied the principle in the proposition to explain the theory of the water-blowing machine. He has also shewn that the eddies of the water in rivers are produced by motion communicated from the more rapid parts of the stream to the lateral parts which are more at rest; and has pointed out a method, which he has actually tried with success, of draining, by means of a fall of water without the help of machines, a piece of ground, even though the ground should lie on a lower level than the established current below the fall. See Prop. VI.

### Prop. II.

In descending cylindrical tubes, the upper extremities of which have the form of the contracted vein, the velocity of the effluent water is that which corresponds with the height of the fluid above the inferior extremity of the tube.

M. Venturi has established this proposition upon the principle of virtual ascension, combined with the pressure of the atmosphere, in the following manner. Let BLKO, Plate CCCXVIII. Fig. 6, be a conical tube, having the form of the vena contracta, and let the cylindrical tube LCQK have the same diameter as the contracted part LK. Now, the fluid stratum LK continuing to descend through the height LC, will tend to have its motion accelerated in the same manner as all other bodies falling by the force of gravity. Hence, when it passes from LK to LM, it tends to detach itself from the stratum which lies immediately above it; or, which is the same thing, it tends to produce a vacuum between LK and MN, and the same effect is produced through the whole length LC of the tube. The pressure of the atmosphere becomes active, as far as is necessary, to prevent the vacuum, and its action is the same, both at A, the surface of the fluid, and at C, the inferior extremity of the tube. The atmospherical pressure at A increases the velocity of the fluid which issues at CQ, while the atmospherical pressure at C destroys the sum of the accelerations which would be produced along L C, so that the fluid remains continuous in the tube.

Let T be taken to represent the time in which the continuous column of fluid LCQK passes through the tube LC, whatever be the velocity at L, and the successive acceleration from L to C. Then, if we suppose this column to return upwards from D to E, it will pass through the space DE, which is equal to LC in the same time T, and during this time it will lose all the acceleration which it acquired in its descent from L to C. The pressure of the column ED, continued during the time T, is therefore the force necessary to destroy the successive acceleration from L to C, and to prevent the fluid from losing its continuity in the tube LC. Hence it follows, that the part of the pressure of the atmosphere which is exerted at CQ to destroy the sum of the accelerations along LC, is equal to the pressure of a column ED of a fluid of the same nature as that of the reservoir from which the water flows. And since the same pressure must also be exerted upon the surface A of the reservoir, if we take $FA = LC$, the fluid at LK will issue with a velocity due to the height $FL = AC$, abstracting the retardation produced by the external inequalities of the tube LCQK.

### Scholium.

The theory of Venturi has been recently controverted by M. Hachette, who supposes, that the principal cause of the increased expenditure by tubes is the adhesion of the fluid to the sides of the tubes arising from capillary attraction. The following account of Hachette's experiments, taken from M. Poisson's Report, will enable the reader to determine which of the two theories is the most plausible. We conceive, that new experiments are necessary to decide the question.

Exp. I. The fluid in motion was mercury, and the pipe was made of iron. When the mercury was perfectly pure, it had no affinity for the iron, and flowed out as it would have done from a small orifice equal to the diameter of the pipe. But when the mercury was covered with a pellicle, formed of an alloy of tin and other metals, this alloy covered the inside of the pipe, and the mercury then flowed with a full stream.

Exp. II. The fluid next used was water, and the pipe was coated within with wax. The water flowed as if through a small orifice, without filling the tube. But whenever the water was made to moisten the wax, the pipe was instantly filled, owing to the wax being replaced by the first coat of water which covers it. Hence the reason why a disc of glass at last adheres to water with the same force whether it is covered or not with a coating of wax; for as soon as the wax is wetted, it is merely the action of water on water which determines the phenomena, as M. La Place has explained in his *Theory of Capillary Action.*

Another important fact determined by M. Hachette is, that in a vacuum, or in air rarefied to a certain degree, the phenomena of pipes cease to take place. Thus, if water is made to run in a full stream through a tube under the receiver of an air pump, then, upon rarifying the air in the receiver, the fluid vein was observed to detach itself from the sides of the pipe, when the internal pressure was reduced from 0.76 of a metre to 23 centimetres of mercury. By thus diminishing the internal pressure the effect of the external pressure is increased, which is transmitted to the pipe by means of the fluid contained in the vessel, and to which is added the pressure of the fluid. But there is a point at which these two pressures are sufficiently powerful to detach the fluid vein from the sides of the pipe, in the same manner as a disc of glass or metal may be detached from the surface of a fluid to which it adheres by the application of a sufficient force. The phenomena, therefore, exhibited in a vacuum, or in rarefied air, agree perfectly with the explanation of M. Hachette, and does not prove, as might be supposed, that the phenomena of pipes are produced by the pressure of the air in which the fluid is discharged; an opinion which is inconsistent with the two preceding experiments, for in these experiments the action of the air was the same, and yet the phenomena were different, according to the nature of the fluid, and the matter of which the pipe was composed.

When the fluid vein has been detached by rarefying the air, M. Hachette observed, that the water does not again begin to flow in a full stream when the air is re-admitted. This contraction of the vein, which took place in the rarefied air, continues to subsist though the pressure of the atmosphere is restored. Hence he concludes, that the adhesion of the water to the sides of the pipe takes place only at the commencement of the motion, before the fluid has acquired a sensible velocity in a direction which separates it from the sides. In order to verify this conjecture, M. Hachette made the following experiment:—The water flowed in a full stream through a pipe without the receiver of an air-pump. A small hole was made in this pipe very near the orifice. The external air then entered into the pipe, as ought to have happened according to the theory of D. Bernoulli. It interposed itself between the water and the sides of the pipe. The contraction of the vein takes place in the inside of the tube, and the water ceases to flow in a full stream. This being the case, the small hole was exactly shut. The adhesion of the water to the pipe was not again produced, and the flowing of the water continued as if the pipe had not existed, so that it might have been removed or replaced without any change in the flow of the water. This experiment succeeded equally well whatever was the direction of the jet; but care must be taken not to agitate the apparatus, for a very small lateral motion of the fluid causes it to adhere again to the moist sides of the pipe. It was probably from having neglected this precaution, that M. Venturi obtained a result apparently different from the preceding. See Thomson's *Annals of Philosophy*, July 1817, vol. x. p. 34.

PROP. III.

If water is discharged from a short tube of a conical form, the pressure of the atmosphere will increase the expenditure in the ratio of the exterior section of the tube to the section of the contracted vein, whatever be the position of the tube, provided that its internal figure be adapted throughout to the lateral communication of motion.

Having already shewn that the atmospherical pressure increases the expenditure through additional tubes, whatever be their position, Venturi next proceeds to examine the mode of action by which the atmosphere produces this augmentation, and he begins with the case best adapted to favour the action of the atmosphere, which is that of conical diverging tubes.

Let AB, Plate CCCXVIII. Fig. 14, the extremity of the tube ABEPF, be applied to an orifice in a thin plate, and let the part ABCD have the form nearly of the contracted vein, which is found by experiment to make no perceptible alteration upon the expenditure by the simple orifice AB. The water which issues through CD is disposed to continue its course in a cylindrical form CGHD; but if the lateral parts CFGDFH continue, the cylindrical stream CGHD will communicate its motion to the lateral parts successively from part to part, as shewn in Prop. I. Hence, if the divergence of the sides CE, DF be such as is best adapted to the speedy and complete lateral communication of motion, all the water contained in the truncated conical tube CDEF will at last acquire the same velocity as that of the stream which continues to issue through CD. Upon this supposition, while the fluid stratum CDQR, preserving its velocity and thickness, would pass into RQTS, a vacuum would be formed in the solid zone R $m\,r$ SQ $n\,o$ T. Or if it should be supposed that the stratum CDQR, preserving its progressive velocity, should enlarge in RQTS; this cannot happen without its becoming thinner and detaching itself from the stratum which succeeds it, and by that means leaving a vacuum equal to the zone R $m\,r$ SQ $n\,o$ T. A similar effect would obviously take place throughout the whole of the tube CE, and if the quantity C $m$ is supposed invariable, the sum of all these empty spaces will be equal to the solid zone VE $x$ G $z$ YFH.

From this reasoning it follows, that the lateral communication of motion produces the same effect in a conical tube, whether horizontal or vertical, as is produced by the action of gravity in a descending cylindrical tube, as described in Prop. II. In this case, also, a part of the pressure of the atmosphere is active on the reservoir, and at the outer extremity EF. If the action of the atmosphere upon the surface of water in the reservoir increases the velocity at the section CD, this velocity will likewise communicate itself to the whole fluid CDFE, and the tendency to a vacuum will take place as before; but since the atmospherical action is as powerful at EF, it will take away at EF all the velocity which it added at CD; so that being deducted from the same mass, and in the same time at EF, the fluid will not cease to be continuous in the pipe. It is found by computation, that this will happen when the velocity of CD is increased in the ratio of CD to $EF^2$.

By applying the general laws of motion to the lateral fluid filaments of the stream which issues through AB. it is found that they tend to describe a curve which commences within the reservoir, for example at A, and continues towards CSE. In order to determine the nature of this curve, it is necessary to know and to combine together, by calculation, the mutual convergency of the fluid filaments in AB, the law of the lateral communication of motion between the filaments themselves, and their divergent progression from C to E. These combinations and calculations are considered by Venturi as beyond the efforts of analysis. When the tube ABFE has a figure different from this natural curve, the experimental results will always differ more or less from those deduced from theory.

PROP. IV.

The quantity of fluid discharged through cylindrical tubes is less than through conical tubes which diverge from the commencement of the contracted vein, and have the same external diameter.

The general theory is the same for tubes both of a cylindrical and a conical form, but the loss of living force is greater in the cylinder, and the effect of the communication of motion in these tubes cannot approach its maximum as in the cone. Let the compound tube ACNM, Plate CCCXVIII. Fig. 11. have the part ACFD of the form of the *vena contracta*, and let the cylindrical part GINM have its diameter MN greater than DF. Hence it follows, from the reasoning in the preceding proposition, that the lateral communication of motion tends to produce a vacuum in the solid zone ROYSXQTZ. If the communication of motion in the tube were completely made, it would follow that the pressure of the atmosphere would increase the velocity of the contracted vein in the ratio of $DF^2$ to $MN^2$. The form, however, of the cylindrical tube always destroys a considerable part of the effect; for the fluid filaments AD, in describing the curve DR, strike the sides of the tube GM at R with considerable force, and thus lose a part of their motion. Eddies or circular whirls are produced in the space DGR, as in a basin which receives water by a channel. These eddies are to a certain extent a failure in the effect, and retard the efflux of the water. A much less increase of the expenditure takes place in the cylindrical tube than corresponds to the ratio of $DF^2$ to $MN^2$.

The reader will be able to form a general notion of the effects of these internal shocks and eddies upon the efflux of a cylindrical tube, by attending to the experiments in Table XII. p. 844, of this article.

M. Venturi next considers, whether, in the internal part of the simple cylindric tube KLV, Fig. 12. there is the same augmentation of velocity, and the same contraction of the stream, as in the compound tube of Fig. 11. By reasoning according to the principles which he has established, he concludes, 1. That in the section KL of Fig. 12. there is the same increase of velocity as takes place in the section AC of Fig. 11. (See Prop. II.) The fluid particles which pass through these sections have in both cases the same direction; for this direction can depend only on the impulse received within the reservoir, which is the same in both cases. In Fig. 12. the fluid particles, after having passed through the section KL, immediately begin to experience the effect of the lateral communication of motion, and therefore they must deviate laterally through the curve L $x$ $z$, before they arrive at the place of contraction, which they assume at DF, Fig. 11. and which they likewise assume when the orifice is made in a thin plate. If we suppose a tube of glass $y$ K, Fig. 12. to have one of its extremities applied at K, and the other opening into the reservoir, it will be seen that the pressure of the atmosphere which is exerted upon the coloured fluid T, (see p. 844. Table XII. exp. 7.) must act likewise upon the surface of the reservoir, and aid the pressure of the fluid in the reservoir in forcing the water into the tube $y$ K, as it presses the coloured liquor into TS. In like manner, the pressure of the atmosphere must increase the impulse of all the fluid particles which arrive at KL, and consequently must increase the expenditure. As a part of the active force of the fluid must always be destroyed by the eddies in an additional cylindric tube, it follows that the effluent column can never have the velocity which is due to the real head, and which is observed nearly entire in orifices in a thin plate; and the diminution of velocity corresponds with the increase of the time beyond that indicated by the theory.

SCHOLIUM.

The theory of the lateral communication of motion in fluids must apply in a similar manner to ascending and descending tubes, whenever the form admits of this lateral communication. In descending tubes, the increase of expenditure, occasioned by this cause, must be added to that which is produced by the acceleration of gravity, and which has been estimated in Prop. II. But in ascending tubes, we must subtract this effect from that which is produced by gravity.

PROP. V.

By means of proper adjutages applied to a given cylindrical tube, it is possible to increase the expenditure of water through that tube in the proportion of 24 to 10, the head or the altitude of water in the reservoir remaining the same.

The truth contained in this proposition is deduced from the experiments which we have given in Table XII. p. 844 and 845 of this article, and the form of the adjutages is explained in p. 845, and represented in Plate CCCXVIII. Fig. 16.*

SCHOLIUM.

"At Rome," says Venturi, "the inhabitants purchased the right of conveying water from the public reservoirs into their houses." The law prohibits them from making the pipe of conveyance larger than the aperture granted them at the reservoir, as far as the distance of 50 feet. The legislature was therefore aware, that an additional pipe of greater diameter than the orifice would increase the expenditure; but it was not perceived that the law might be equally evaded by applying the conical frustum CD beyond the 50 feet. From the structure of this compound pipe, we learn, that it is not proper to make the flues of chimnies too large in the apartments; but that it will be sufficient if they be enlarged at their upper terminations, according to the form CD, Fig. 16. This divergency of the upper part will carry off the smoke very well, even when it is not practicable to afford chimnies of sufficient length to the upper apartments. The same observation is applicable to chemical furnaces for strong fire.

PROP. VI.

The eddies of the water in currents and rivers are produced by motion, communicated from the more rapid parts of the stream to the lateral parts, which are more at rest.

"The water which moves in the channel MNH, Fig. 5. No. 4. meets the obstacle BA, which impedes its course,

* Mr Clement, in some very recent experiments on the discharge of water through cylindrical and conical tubes, has succeeded in increasing the expenditure of water in a much greater ratio by changing the form of the compound tube used by Venturi. See Poisson's Report on M Hachette's Memoir, Part III.

and causes it to rise and discharge itself in the direction AC, with an increased velocity. Suppose the water in BDCA to be dormant, the current AC communicates its motion to the lateral particles E, (Prop. 1.) and conveys them forward; the surface of the dormant water becomes depressed at E, and the most remote particles towards D are urged, according to the laws of the equilibrium of fluids, to fill the depression. The current AC continues to carry them off, and the space BDCA continues to be exhausted. The water of the current AC, by virtue of the same laws, is acted upon by a constant force which urges it towards the cavity E, while its natural course or projection carries it towards AC. Under the agency of these two forces, the water AC acquires a curve-lined motion in CD, and descends as it were through an inclined plane, becoming retrograde in DE, whence it would proceed to strike the obstacle BA, and the current AC, after which it would undergo several oscillations previous to acquiring a state of equilibrium and repose. But the current AC continues its lateral action; a second time it draws away the water through CD into E, and forces it to renew its motion through the curve CDE; in which manner the eddy continues without ceasing.

If the river should pass through a contraction of its bed at N, it will produce eddies at both sides, at P and at Q, similar to those we have considered at DC.

Suppose the stream of water, after having struck the bank GH, to be reflected into a new direction HS, the lateral communication of motion will excite eddies in the angle of reflection R.

When two currents of unequal velocity meet obliquely in the middle of the river, the most rapid current will produce eddies in that which is the least rapid.

Suppose a stream of water to flow over a bed of unequal depth. If the longitudinal section of the inequalities of the bottom exhibit a gentle slope, as at ABC, Fig. 5. No. 5. the superior water will impress its motion by lateral communication upon the inferior water which is near the bottom, beneath the line AC, and a current will take place through the whole depth of the section MB. The current, which is formed near the bottom at B, is turned out of its course by the slope BC, and proceeds to rise above the surface at Q, sometimes in the form of a curling wave, or vertical whirlpool. If the extremities of the hollow place form an abrupt angle, as DEFG, eddies will be produced even at the bottom, in the vertical direction at D, and sometimes also at G. These phenomena may be observed in an artificial channel with glass sides.

*Every eddy destroys a part of the moving force of the current of the river.* For the water which descends by a retrograde motion in the inclined plane CDE, Fig. 5. No. 4. cannot be restored in the direction of the current of the river but by a new impulse. It is as it were a ball, which is forced to rise on an inclined plane, whence it continually falls back again to receive new impulsions.

Hence we deduce, as a primary consequence, *that in a river, of which the course is permanent, and the sections of its bed unequal, the water continues more elevated than it would have done, if the whole river had been equally contracted to the dimensions of its smallest section.* The cause of this phenomenon is the same as that which retards the expenditure through the tube with enlarged parts. (Prop. 7. No. 4.) The water which descends from the elevation above the contracted part N into the basin PQ, Fig. 5. No. 4. loses nearly the whole of the velocity it acquired by descending from it; because the narrow part has a curved slope towards the lower part of the river, which directs the velocity of the stream in an horizontal direction. Guglielmini has well remarked, that a fall does not influence the velocity of the lower stream, because the eddies of the water in the basin PQ destroy the velocity produced by the fall. This velocity increases the depth, and enlarges the width of the channel at PQ. Eddies are formed on each side, at the bottom, and at the surface, both in the horizontal and vertical directions. It would be to no purpose to attempt to prevent this hollowing out and enlargement of the channel by such a fall, by adopting the means of close walls, for the basin would then obtain its enlargement where these constructions might end.

If the channel have a number of successive contractions and dilatations MN, without cascade or dam, there will still be formed, at each dilatation, eddies which will diminish the velocity more than if the channel had an uniform section equal to that in M or N. It will therefore follow, that the surface of the water, after each dilatation, must rise, in order to recover the velocity it lost by the eddies. If we call the height to which the water must rise, above the elevation necessary to have overcome the retardations of a bed of uniform section, $= a$, and the number of equal and successive alternate dilatations and contractions be $= m$, the height of the rise in the stream thus alternately dilated beyond that of the same river uniformly contracted, will be $= am$. We here suppose the bottom of the river to be uniform. If this bottom be of such a nature to be attacked by the current, the contracted parts will be hollowed out, and the matter will be deposited in the enlarged parts.

The second consequence which we draw from the principle here established, respecting the loss of force caused by the eddies, is of considerable importance in the theory of rivers, and appears to have been neglected by those who have treated on this subject. The friction of the water along the wet banks, and over the bottom of rivers, is very far from being the only cause of the retardation of their course, which consequently requires a continued descent to maintain its velocity. One of the principal and most frequent causes of retardation in a river is also produced by the eddies, which are incessantly formed in the dilatations of the bed, the cavities of the bottom, the inequalities of the banks, the flexures or windings of its course, the currents which cross each other, and the streams which strike each other with different velocities. A considerable part of the force of the current is thus employed to restore an equilibrium of motion, which that current itself does continually derange."

## CHAP. III.

### Account of Experiments on the Discharge of Water from Vessels through simple Orifices and additional Tubes.

#### Sect. I. *On the Vena Contracta.*

In the first chapter of Hydraulics we have explained the cause of the contraction of the fluid vein, or *vena contracta*, and have stated in general the effect which this contraction produces upon the quantity of water discharged from vessels. The following are the measures of the contraction according to different authors; A being the area of the orifice, and $a$ the area of the section of the contracted vein:

| | A. | $a$. |
|---|---|---|
| Sir Isaac Newton, . . . . . | 141 | 100 |
| Poleni, . . . . . . . | 140 | 100 |
| Highest found by Bossut, . . . | 150 | 100 |
| Mean of six experiments by Bossut, | 150.6 | 100 |

| | A. | a. |
|---|---|---|
| Lowest found by Bossut, . . | 151.5 | 100 |
| Bernoulli, . . . . . . | 156 | 100 |
| Michelotti, . . . . . . | 156 | 100 |
| Du Buat, . . . . . . | 150 | 100 |
| Venturi, . . . . . . | 158.5 | 100 |
| Eytelwein, . . . . . . | 156.2 | 100 |

The measures given by Bossut were taken by a pair of spherical compasses, with which he measured directly the diameter of the contracted vein, which he found to preserve the same diameter for some lines. The altitude of the water in the reservoir which Bossut used was 11 feet 8 inches. He measured the *vena contracta* also, when the water issued by vertical orifices placed 4 feet below the surface of the fluid, and he obtained the very same results.

The ratio of A to $a$ is however by no means constant. It undergoes perceptible variations, by varying the form and position of the orifice; the thickness of the plate in which the orifice is made; the form of the vessel; and the velocity of the issuing fluid.

Sect. II. *On the quantity of Water discharged by orifices of different forms, from vessels kept constantly full.*

In order to determine the quantity of water discharged by orifices of different forms, M. Bossut employed very clear water, which was excellent for drinking. The experiments were made at Mezieres, in the beginning of September, in very fine weather, which is the only information from which we can conjecture the temperature of the water. The orifices were perforated in plates of copper half a line thick; the time was ascertained sometimes by a seconds watch, and at other times by a simple seconds pendulum; and the most exact measures were used in ascertaining the quantity of water discharged. The fundamental measure which he employed was a hollow cube of copper, having one of its sides exactly six inches within. It contained the eighth part of a cubic foot when it was entirely full, and on its four interior faces were traced four vertical scales for ascertaining the quantity of water which it contained when it was full. M. Bossut also used other two measures, one of which was a small barrel containing exactly a cubic foot, or eight times the contents of the cubical vessel; and the second was a barrel containing eight cubic feet. Each of these barrels had two small tubes rising from their upper end, through one of which the water was poured, and upon which was the mark to shew when it contained exactly the number of cubic feet. The second tube allowed the included air to escape as the water was poured in.

Table I. *Shewing the quantity of Water discharged in one Minute by Orifices differing in form and position.*

| Constant Height of the Fluid above the centre of the Orifice. | Form and position of the Orifice. | Diameter of the Orifice. | No. of Cub. In. discharged in a Minute. |
|---|---|---|---|
| Ft. In. Lin. | | Lines. | |
| 11 8 10 | Circular and Horizontal, | 6 | 2311 |
| | Circular and Horizontal, | 12 | 9281 |
| | Circular and Horizontal, | 24 | 37203 |
| | Rectangular and Horizontal, . . . . . | 12 by 3 | 2933 |
| | Horizontal and Square, | 12 side | 11817 |
| | Horizontal and Square, | 24 side | 47361 |
| 9 0 0 | Vertical and Circular, | 6 | 2018 |
| | Vertical and Circular, | 12 | 8135 |
| 4 0 0 | Vertical and Circular, | 6 | 1353 |
| | Vertical and Circular, | 12 | 5436 |
| 5 0 7 | Vertical and Circular, | 12 | 628 |

From these results we may conclude,

1. That the quantities of water discharged in equal times by the same orifice from the same head of water, are very nearly as the areas of the orifices; and,

2. That the quantities of water discharged in equal times by the same orifices under different heads of water, are nearly as the square roots of the corresponding heights of the water in the reservoir above the centres of the orifices.

If we call Q, $q$ the quantities of water discharged in the same time from the two orifices A,A′ under the same height of water in the reservoir; $q$ and Q′ the quantities of water discharged during the same time by the same aperture A, under the different heads of water $h$, $h'$, we have by the first of the above results, $Q : q = A : A'$; and by the second, $q : Q' = \sqrt{h} : \sqrt{h'}$; from which we obtain $q = \frac{A' \times Q}{A}$, and $q = \frac{Q' \sqrt{h}}{\sqrt{h'}}$ then since $\frac{A' \times Q}{A} = \frac{Q' \sqrt{h}}{\sqrt{h'}}$, we have by Euclid, B. V. $Q : Q' = A \sqrt{h} : A' \sqrt{h'}$, that is, in general.

3. The quantities of water discharged during the same time by different apertures under different heights of water in the reservoir, are to one another in the compound ratio of the areas of the apertures, and of the square roots of the heights in the reservoirs.

This general rule may be considered as sufficiently correct for ordinary purposes; but, in order to obtain a great degree of accuracy, Bossut recommends an attention to the three following rules.

1. Friction is the cause, that, of several similar orifices, the smallest discharges less water in proportion than those which are greater, under the same altitudes of water in the reservoir.

2. Of several orifices of equal surface, that which has the smallest perimeter ought, on account of the friction, to give more water than the rest, under the same altitude of water in the reservoir.

3. That, in consequence of a slight augmentation which the contraction of the fluid vein undergoes, in proportion as the height of fluid in the reservoir increases, the expence ought to be a little diminished.

In the following Table, given by the Abbé Bossut, he has compared the theoretical with the real discharges from an orifice one inch in diameter, and the different altitudes of the fluid in the reservoir. The real discharges in column 3d were not determined by direct experiment, but were ascertained with the precaution indicated in the three preceding rules, and may be considered to be as accurate as if they had been obtained from direct experiment. The fourth column was computed by M. Prony.*

TABLE II. *Comparison of the Theoretic with the Real discharges from an Orifice one inch in diameter.*

| Constant height of the Water in the Reservoir above the centre of the Orifice. | Theoretical discharges through a circular Orifice one inch in diameter. | Real discharges in the same time through the same Orifice. | Ratio of the theoretical to the real discharges. |
|---|---|---|---|
| Paris Feet. | Cubic Inches. | Cubic Inches. | |
| 1 | 4381 | 2722 | 1 to 0.62133 |
| 2 | 6196 | 3846 | 1 to 0.62073 |
| 3 | 7589 | 4710 | 1 to 0 62064 |
| 4 | 8763 | 5436 | 1 to 0.62034 |
| 5 | 9797 | 6075 | 1 to 0.62010 |
| 6 | 10732 | 6654 | 1 to 0.62000 |
| 7 | 11592 | 7183 | 1 to 0.61965 |
| 8 | 12392 | 7672 | 1 to 0.61911 |
| 9 | 13144 | 8135 | 1 to 0.61892 |
| 10 | 13855 | 8574 | 1 to 0.61883 |
| 11 | 14530 | 8990 | 1 to 0.61873 |
| 12 | 15180 | 9384 | 1 to 0.61819 |
| 13 | 15797 | 9764 | 1 to 0.61810 |
| 14 | 16393 | 10130 | 1 to 0.61795 |
| 15 | 16968 | 10472 | 1 to 0.61716 |
| 1 | 2 | 3 | 4 |

It appears from this Table, that the real as well as the theoretical discharges are nearly proportional to the square roots of the heights of the fluid in the reservoir. Thus for the heights 1 and 4, whose square roots are as 1 to 2 feet, the real discharges are 2722 and 5436, which are to one another as 1 to 1.997, very nearly as 1 to 2.

By means of the formula in the preceding page, we may easily apply the above Table to the determination of the quantities discharged under different altitudes of water in the reservoir, and from orifices of different sizes. Let it be required, for instance, to determine the quantity of water discharged from an orifice of 3 inches in diameter, under an altitude of 30 feet. Then, since the real quantities discharged are in the compound ratio of the orifices, and the square roots of the altitudes of the water, and since the theoretical discharge by an orifice 1 inch in diameter, under an altitude of 15 feet, is 16968 cubical inches in a minute, we have $1\sqrt{15} : 9\sqrt{30} = 16968 : 215961$, the theoretical discharge. But since the theoretical is to the real discharge as 1 to .62, the above value being diminished in that ratio, gives 133309 cubic inches for the real quantity of water discharged by the orifice.

The following formulæ have been given by M. Prony, as deduced from the preceding experiments of Bossut,†

$$Q=0.61938\ AT\sqrt{2g}\ H,$$

A being the area of the orifice in square feet, H the altitude of the fluid in feet, T the time, $g$ the force of gravity at the end of a second, and Q the quantity of water in cubic feet. As $\sqrt{2g}$ is a constant quantity, and is equal to 7.77125, we have

$$Q=4.818\ AT\sqrt{H}\ \text{for orifices of any form.}$$

If the orifices are circular, and if $d$ represents their diameter, then

$$Q=3.7842\ d^2\ T\sqrt{H}.$$

From the second of these equations we obtain

$$A=\frac{Q}{4.818\ T\sqrt{H}}$$

$$T=\frac{Q}{4.818\ A\sqrt{H}}$$

$$H=\frac{Q}{(4.818\ AT)^2}$$

These formulæ will be found to give very accurate results; but if we wish to obtain a still higher degree of accuracy, we must not use the mean co-efficient 0.6194, but the one in the Table which comes nearest to the circumstances of the case. Thus, if the head of water happens to be small, such as 1 foot, then we must take the co-efficient 0.62133, and if it happens to be great, we must use the least co-efficient 0.61716.

In order to determine the velocity with which the fluid is discharged, we must first obtain the theoretical velocity, which is $V=\sqrt{32.174}\sqrt{H}=8.016\sqrt{H}$ in English inches. That is, the velocity acquired by falling through any height H is found by multiplying the square root of the height by 8.016. But as the real velocity of the issuing fluid is to its theoretical velocity as 0.6194 to 10, we have $4.965\sqrt{H}$ as the measure of the real velocity, or in round numbers $5\sqrt{H}$; that is, the velocity in a second of time in English feet is five times the square root of the height of the fluid in the reservoir; or, if we prefer expressing these values in inches, then since 32.2 feet = 772 inches, and $\sqrt{772} = 27.78$, we have $V = 27.78\sqrt{H}$ for the theoretical velocity, and $V = 17.206\sqrt{H}$ for the velocity at a simple orifice.

In order, however, to obtain the velocity more accurately, we should deduce the co-efficient of $\sqrt{H}$, not from the medium co-efficient in the preceding Table, but from the co-efficient in the Table which approaches nearest to the circumstances of the experiment.

The following Table contains a series of experiments by M. Michelotti, which were made on a most magnificent

* See his *Architecture Hydraulique*, tom. i. p. 369.

† The measures are in French feet, which are to English feet as 1066 is to 1000.

scale, and with the utmost accuracy. As they extend to apertures of three inches both square and circular, and to altitudes twice as great as those employed by Bossut, they form an excellent supplement to his experiments. We consider them indeed as much more valuable than those of Bossut, as the quantities of water discharged in each experiment were prodigiously greater than his. The reservoir employed was 20 feet high, and three feet square within, and had openings at different distances from the top. The water flowed into a cistern whose area was 289 square feet, and whose figure was uniform, and the quantity of it was ascertained in French feet, by measuring its height in the cistern.

Table III. *Containing the Experiments of Michelotti on the quantities of Water discharged by different vertical orifices under different heads of Water.*

| Head above the Centre of the orifice. | | | | Size and nature of the orifice. | Time of running. | Cubic feet of water expended. | | |
|---|---|---|---|---|---|---|---|---|
| Feet. | Inch. | Lines. | Parts. | | Minutes | Feet. | In. | Lin. |
| 6 | 7 | 4 | 3 | Square, of 3 inches. | 10 | 463 | 7 | 3 |
| 6 | 10 | 2 | 8 | | 12 | 566 | 5 | 6 |
| 11 | 8 | 1 | 6 | | $8\frac{1}{2}$ | 516 | 9 | 6 |
| 11 | 9 | 9 | 10 | | 10 | 612 | 1 | 5 |
| 21 | 8 | 3 | 6 | | 5 | 415 | 5 | 3 |
| 21 | 8 | 7 | 0 | | 6 | 499 | 2 | 8 |
| 6 | 7 | 6 | 0 | Square, of 2 inches. | 15 | 329 | 9 | 8 |
| 11 | 5 | 1 | 4 | | 15 | 423 | 5 | 7 |
| 21 | 5 | 3 | 7 | | 10 | 385 | 4 | 0 |
| 6 | 9 | 1 | 0 | Square, of 1 inch. | 30 | 158 | 6 | 7 |
| 11 | 10 | 8 | 1 | | 24 | 163 | 9 | 6 |
| 21 | 6 | 1 | 0 | | 60 | 562 | 11 | 4 |
| 6 | 8 | 4 | 0 | Circular, of 3 inches diameter. | 15 | 542 | 10 | 6 |
| 11 | 7 | 1 | 0 | | 12 | 570 | 11 | 8 |
| 21 | 7 | 4 | 0 | | 8 | 521 | 3 | 7 |
| 6 | 9 | 5 | 0 | Circular, of 2 inches diameter. | 30 | 488 | 8 | 3 |
| 11 | 8 | 8 | 0 | | 28 | 589 | 6 | 5 |
| 21 | 10 | 10 | 0 | | 20 | 575 | 5 | 10 |
| 6 | 10 | 6 | 0 | Circular, of 1 inch diameter. | 60 | 247 | 4 | 3 |
| 11 | 8 | 11 | 0 | | 60 | 324 | 1 | 5 |
| 22 | 0 | 2 | 0 | | 60 | 444 | 6 | 5 |

The preceding Table gives a co-efficient of 0.625, which is not very different from 0.619, the mean co-efficient obtained by Bossut.

The following experiments were made by Messrs Brindley and Smeaton. The water extended over a very large surface, and the heights above the orifice were measured from the surface to the tops of the orifices.

| Height of the surface above the tops of the orifices in Feet. | Nature of the orifices. | Time of running. | | Quantity of Water discharged in cubic feet. |
|---|---|---|---|---|
| 1 | 1 in. square | 9 min. | 22 sec. | 20 |
| 2 | 1 do. | 6 | 40 | 20 |
| 3 | 1 do. | 5 | 20 | 20 |
| 4 | 1 do. | 4 | 44 | 20 |
| 5 | 1 do. | 4 | 14 | 20 |
| 6 | $\frac{1}{2}$ do. | 17 | 33 | 20 |

The co-efficient deduced from these experiments is 0 63.

Sect. III. *On the quantities of Water discharged through openings in Reservoirs when very large, and in reaching to the surface.*

The following experiments were made by Messrs. Brindley and Smeaton on the quantities of water discharged by rectangular notches, through which the water flowed from a very extensive surface. The first column contains the width of the notches in inches: the second contains their depth; the third contains the quantity of water discharged; and the fourth the time in which that quantity was discharged.

Table IV. *Containing Messrs Brindley and Smeaton's Experiments on the Quantities of Water discharged by rectangular Notches.*

| Width of the notches in inches. | Depth in inches. | Quantity of water in cubic feet. | Time of discharging. | |
|---|---|---|---|---|
| 6 | 1 | 20 | 7 min. | 16 sec. |
| 6 | $1\frac{3}{8}$ | 20 | 4 | 55 |
| 6 | $2\frac{5}{16}$ | 20 | 2 | 19 |
| 6 | $3\frac{1}{8}$ | 20 | 1 | 33 |
| 6 | $6\frac{1}{2}$ | 20 | 0 | 30 |
| 6 | 5 | 20 | 0 | 46 |
| 6 | $1\frac{1}{4}$ | 20 | 5 | 26 |
| 6 | $1\frac{5}{8}$ | 20 | 3 | 55 |
| 6 | $5\frac{5}{8}$ | 20 | 0 | 42 |

The experiments of Bossut were not extended to any of the cases included in the present Section; but we are fortunately in possession of some good experiments by Du Buat on the quantity of water discharged over weirs and bars, which are cases in which the orifice extends to the surface.

A *weir* or jetty is represented in Figs. 7. and 8. of Plate CCCXVIII. Weirs are most commonly erected as in Fig. 4. where BCD is a weir of solid masonry or of timber, with a strong plank AB, called the wasteboard, over which the water flows. In this case, therefore, the depth of the orifice is measured by the depth of the upper edge of the plank AB below the level surface of the water in the river or reservoir. Du Buat made four accurate experiments on this subject, the result of which is given in the following Table, reduced to English inches, the length of the orifice being $18\frac{1}{3}$ inches.

Table V. *Containing Experiments by Du Buat on the quantity of Water discharged over Weirs.*

| Depth of the orifice in English feet. | Discharge of water in cubic feet observed. | Discharge calculated by the formula. |
|---|---|---|
| 1.778 | 506 | 524 |
| 3.199 | 1222 | 1218 |
| 4.665 | 2153 | 2155 |
| 6.753 | 3750 | 3771 |

M. Buat has given the following formula reduced to English inches, by which column 3d has been calculated, which shews its near agreement with observation. The formula, as altered by Dr Robison, is

$$D = l\sqrt{130.032\,H^3}\text{, or}$$

$$D = 11.4172\,l\,H^{\frac{3}{2}},$$

where D is the quantity of water discharged in cubic feet, $l$ the length of the wasteboard, and H its depth. That is, *multiply the square root of the cube of the depth of the upper edge of the wasteboard below the surface by* $11\frac{1}{2}$, *and by the length of the wasteboard, and the product will be the quantity discharged in English inches.*

In deducing the preceding formula, M. Du Buat has assumed that AF, Fig. 7. is one half of AL, and that the quantity by which we must divide the square of the mean velocity per second, to have the height of fall which is due to it, was 726. Dr Robison, however, had occasion to examine a numerous set of experiments, in which AF was always less than $\frac{1}{2}$ of AL, and was nearly $\frac{2}{7}$, and in which the quantity of water discharged was greater than what is given by Du Buat's formula.

It appeared, indeed, that AF depended on the form of the wasteboard, as might have been expected. When the board was very thin and had a considerable depth, AF was much greater than when the board was thick or narrow, and placed on the top of a broad damhead, as in Fig. 8.

Du Buat's general formula, viz.

$D = \frac{2}{3} l \sqrt{2} G \left(1 - (\frac{1}{2})^{\frac{3}{2}}\right) H^{\frac{3}{2}}$ may be accommodated to any ratio between AF and AL, in place of the ratio of $\frac{1}{2}$ adopted in the formula. Thus, if AF $= m \times$ AL, $m$ being a fractional co-efficient less than 1, the formula becomes

$$D = \frac{2}{3} l \sqrt{2G}\ (1 - m^{\frac{3}{2}}) H^{\frac{3}{2}}$$

Dr Robison has calculated the following Table from Du Buat's formula, which is suited to English inches.

TABLE VI. *Containing the quantity of Water discharged over a Weir.*

| Depth of the upper edge of the wasteboard below the surface in English inches. | Cubic feet of water discharged in a minute by every inch of the wasteboard, according to Du Buat's formula. | Cubic feet of water discharged in a minute by every inch of the wasteboard, according to experiments made in Scotland. |
|---|---|---|
| 1 | 0,403 | 0.428 |
| 2 | 1,140 | 1,211 |
| 3 | 2,095 | 2,226 |
| 4 | 3,225 | 3 427 |
| 5 | 4,507 | 4,789 |
| 6 | 5,925 | 6,295 |
| 7 | 7,466 | 7,933 |
| 8 | 9,122 | 9,692 |
| 9 | 10,884 | 11,564 |
| 10 | 12,748 | 13,535 |
| 11 | 14,707 | 15,632 |
| 12 | 16,758 | 17,805 |
| 13 | 18,895 | 20,076 |
| 14 | 21,117 | 22,437 |
| 15 | 23,419 | 24 883 |
| 16 | 25,800 | 27,413 |
| 17 | 28,258 | 30,024 |
| 18 | 30,786 | 32,710 |

We have added to this Table a third column, containing the quantities of water discharged, as inferred from experiments made in this country, and examined by Dr Robison, who found that they in general gave a discharge $\frac{1}{16}$ greater than that which is deduced from Du Buat's formula. We would recommend it therefore to the engineer to employ the third column in his practice.

The preceding Tables and formula suppose that the water from which the discharge is made is perfectly stagnant; but if it should happen to reach the opening with any velocity, we have only to multiply the area of the section by the velocity of the stream.

When the quantity of water discharged over a weir is known, the depth of the edge of the wasteboard, or H, may be found from the following formula.

$$H = \left(\frac{D}{11.4172\, l}\right)^{\frac{2}{3}}$$

The experiments of Michelotti give $0.2703 \sqrt{H}$ for the number of cubical inches discharged in a second over a weir when the height H is one inch, and the real discharge to the theoretical discharge as 9536 to 1000. These numbers, however, suppose the length of the weir to be infinite, or to be so great that the contraction at its two ends produces no perceptible effect in diminishing the discharge. The formula, therefore, of Michelotti includes only the contractions produced by the upper edge of the wasteboard.

In order to calculate the discharge of rectangular orifices reaching to the surface, M. Eytelwein represents the velocity, which varies as the square root of the height, by the ordinates of a parabola and the quantity of water discharged by the area of a parabola $\frac{2}{3}$ of that of the circumscribing rectangle. Hence the quantity of water discharged may be found by taking $\frac{2}{3}$ of the velocity due to the mean height, and allowing for the contraction of the vein. This mode of calculation M. Eytelwein has found to agree wonderfully with the experiments of Du Buat already given, as well as with several accurate experiments of his own.

M. Eytelwein takes the case of a lake, in which a rectangular opening is made without any lateral walls, three feet wide, and reaching two feet below the surface of the water. In this case, as appears from the following Table of co-efficients given by that engineer, the co-efficient for finding the velocity as corrected for contraction, is 5.1. Hence H being the height, we have $\frac{2}{3}\sqrt{H} \times 5.1$; and since $H = 2$ feet in the present instance, we have the corrected mean velocity $= 4.8$ feet; and as the area is $3 \times 2 = 6$, the quantity of water discharged in a second is 28.8 cubic feet. Putting C for the co-efficient corrected for contraction, W the width of the aperture, and H its depth below the surface, we have the general formula,

$$Q = \frac{2}{3} \sqrt{H} \times C \times \overline{H \times W}$$

for the quantity of water in cubic feet according to Eytelwein.

As the same co-efficient answers for a weir of considerable extent, we may deduce from the preceding formula the depth or breadth necessary for the discharge of a given quantity of water. Thus let it be required in a lake with a weir three feet broad, and in which the water stands five feet above the weir, to know how much the weir must be widened in order that the water may stand a foot lower, we have the velocity $= \frac{2}{3}\sqrt{5} \times 5.1$, and the quantity of water $= \frac{2}{3}\sqrt{5} \times 5.1 \times 3 \times 5$; but as it is required that the height H shall be reduced one foot, or from 5 to 4, we have the velocity suited to this $= \frac{2}{3} \sqrt{4} \times 5.1$, and consequently the section will be

$$\frac{\frac{2}{3}\sqrt{5} \times 5.1 \times 3 \times 5}{\frac{2}{3}\sqrt{4} \times 5.1} = \frac{\sqrt{5} \times 3 \times 5}{\sqrt{4}} = 7.5 \sqrt{5},$$

and the height is 4, the breadth must be $\frac{7.5}{4} \sqrt{5} =$ 4.19 feet.

If the surface of water always stands at the same height AB in the vessel ABCD, Fig. 9. and if the lateral orifice, of considerable magnitude, is *m n o p*, then we have only to determine by the preceding methods the quantities of water discharged by the open orifices *r p o s*, *r m n s*, and the difference between these quantities will give the discharge for the orifice *m n o p*. The same result may be obtained with nearly the same accuracy, by taking the velocity due to the centre of gravity of the orifice below AD, and correcting it by its proper co-efficient.

The following Table contains Eytelwien's co-efficients for different cases connected with those which belong to the present section. The whole velocity due to the height is 8.04, and the diminished velocity arising from contraction is shewn in the last column.

TABLE VII. *Containing Eytelwein's Co-efficients for Orifices of different kinds.*

| No. | Nature of the Orifices employed. | Ratio between the theoretical and real discharges. | Co-efficients for finding the velocities in Eng. Feet. |
|---|---|---|---|
| 1. | For the whole velocity due to the height . . . . | 1 to 1 00 | 8.04 |
| 2. | For wide openings whose bottom is on a level with that of the reservoir | 1 to 0.961 | 7.7 |
| 3. | For sluices with walls in a line with the orifice . . . | 1 to 0.961 | 7.7 |
| 4. | For bridges with pointed piers . . . . . | 1 to 0.961 | 7.7 |
| 5. | For narrow openings whose bottom is on a level with that of the reservoir | 1 to 0.861 | 6.9 |
| 6. | For smaller openings in a sluice with side walls . . . | 1 to 0 861 | 6.9 |
| 7. | For abrupt projections and square piers of bridges . . . | 1 to 0.861 | 6 9 |
| 8. | For openings in sluices without side walls . . . . | 1 to 0.635 | 5.1 |

SECT. IV. *On the Quantities of Water discharged from Vessels kept constantly full, by additional Tubes adapted to circular Orifices.*

IT was observed, even by Julius Frontinus, that a short tube inserted into an orifice produced a greater discharge of fluid than would have been obtained by a simple orifice of the same area.* Guglielmini noticed the same fact, and explained it by an augmentation in the weight of the atmosphere. He regarded the velocity at the end C Q, (Fig. 6.) of the tube BOQC, as that which is due to the whole height AC, upon the erroneous supposition that the pressure at C is the same in a state of motion as in a state of rest. Guglielmini did not consider the diminution of discharge arising from the friction of the same surface of the tube BOQC, nor the augmentation of discharge arising from the form of the tube, and, by a singular concurrence, these errors mutually compensated each other in his experiments.

M. Mariotte considers the water as issuing at CQ, with a velocity which is a mean proportional between the velocities due to the heights AB and AC. Daniel Bernoulli explained the increased expenditure from additional tubes, by the theory of the conservation of living forces; and Euler and d'Alembert† were of opinion, that the pressure of the atmosphere were concerned in the production of the effect. It was reserved, however, for Venturi, as we have already seen in the preceding chapter, to explain the phenomenon in the most satisfactory manner. Before we proceed to give an account of his experiments, we shall lay before our readers a full view of the experiments of M. Bossut.

M. Bossut inserted in the bottom CD (Fig. 10.) of the reservoir ABCD, a cylindrical tube *m n o p* made of copper, well polished within: it was two inches in diameter, and two inches long. Having stopped the aperture *m n* by means of a cork, and filled the reservoir with water to the height of eleven feet eight inches ten lines above *m n*, he found, upon removing the cork, that the water did not follow the sides of the tube, but that the vein was contracted as in a simple orifice, and could not be made to fill the tube without giving it a greater weight. He therefore took a cylinder *m n o p*, one inch in diameter, and two inches long, in which the water readily filled the tube. In repeating these experiments, however, he thought of stopping the discharge within the reservoir, instead of without, by means of a circular plate M, covered with felt, and placed at the end of a handle L. Upon withdrawing the plate M, he was surprised to find that the water sometimes followed the sides of the tube, and sometimes refused to follow them; and he was at last able to produce the effect at pleasure, even when the length of the tube was reduced from 2 inches to 1 inch and 6 lines. When the length of the tube was reduced to half an inch, he could never succeed in making the water touch its sides. Between the interval of half an inch and 1½ inches, it is not easy to observe what takes place with certainty.

The following Table shews the results which M. Bossut obtained.

TABLE VIII. *Containing the Quantities of Water discharged by Cylindrical Tubes one inch in diameter and of different lengths, whether the tubes were inserted in the bottom or in the sides of the vessel*

| Constant altitude of the fluid above the superior base of the tube 11 feet 8 inches and 10 lines. | | |
|---|---|---|
| Lengths of the Tubes expressed in lines. | | Cubical inches discharged in a minute. |
| The tube filled with the issuing fluid . . | 48 | 12274 |
| | 24 | 12188 |
| | 18 | 12168 |
| The tube not filled with the issuing fluid . | 18 | 9282 |

* Sed et calicis positio habet momentum, si in rectum et ad libram collocatus est; modum servat; et ad cursum aquæ si oppositus devexusque, amplius rapit; ad latus autem pretereuntis aquæ conversus et supinus, nec ad haustum pronus; segniter exiguumque sumit. Julius Frontinus *De Aquæductibus Urbis Romæ*, lib. i. juxta fin.

† See D'Alembert *Traité de l'Equilibre et du mouvement des Fluides*, § 149.

These results clearly prove, that the expenditure increases with the length of the tube, and that the quantities of fluid discharged are nearly as the square roots of the altitudes of the fluid above the interior orifice of the vertical tube.

It follows also from the above measurement, that *when the height of the reservoir and the orifice are the same, the theoretical discharge, the discharge by an additional tube, and the discharge by a simple orifice*, are nearly as the numbers 16, 13, 10. Hence Bossut concludes that the effect of contraction is not wholly destroyed by the tube, as the difference between the theoretical and the real discharges is too great to be ascribed to friction.

The following Table contains the effects produced by tubes of different diameters, and under different altitudes of fluid in the reservoir.

TABLE IX. *Containing the Quantities of Water discharged by Cylindrical Tubes two inches long, with different Diameters and under different heads of Water.*

| Constant altitude of the water above the orifice. | | Diameter of the tube. | | No. of cubic inches discharged in a minute. |
|---|---|---|---|---|
| Feet. | Inches. | Lines. | | |
| | | 6 | The tube not filled with the issuing fluid. | 1689 |
| 3 | 10 | 10 | | 4703 |
| | | 6 | | 1293 |
| | | 10 | | 3598 |
| | | 6 | | 1222 |
| 2 | 0 | 10 | | 3402 |
| | | 6 | | 935 |
| | | 10 | | 2603 |

From these results we may conclude,

1. That the discharges by different additional tubes under the same head of water, are nearly proportional to the areas of the orifices, or to the squares of the diameters of the orifices.

2. That the discharges by additional tubes of the same diameter under different heads of water are nearly proportional to the square roots of the heads of water.

*It follows, from the two preceding corollaries, in general, that the discharges during the same time, by different additional tubes, and under different heads of water in the reservoir, are to one another nearly in the compound ratio of the squares of the diameters of the tubes, and the square roots of the heads of water.*

M. Bossut has deduced from the above experiments the following Table, which contains a comparative view of the theoretical discharges from a tube one inch in diameter, with the real discharges by an additional tube of the same diameter, under different heads of water. The last column, containing the ratio between these two discharges, was computed by M. Prony.

TABLE X. *Comparison of the Theoretical with the Real Discharges from an additional Tube of a cylindrical form, one Inch in Diameter and two Inches long.*

| Constant altitude of the Water in the Reservoir above the Centre of the Orifice. | Theoretical Discharges through a circular Orifice one inch in Diameter. | Real Discharges in the same time by a cylindrical Tube *one* Inch in Diameter and *two* Inches long. | Ratio of the theoretical to the real Discharges. |
|---|---|---|---|
| Paris Feet. | Cubic Inches. | Cubic Inches | |
| 1 | 4381 | 3539 | 1 to 0.81781 |
| 2 | 6196 | 5002 | 1 to 0.80729 |
| 3 | 7589 | 6126 | 1 to 0.80724 |
| 4 | 8763 | 7070 | 1 to 0.80681 |
| 5 | 9797 | 7900 | 1 to 0.80638 |
| 6 | 10732 | 8654 | 1 to 0.80638 |
| 7 | 11592 | 9340 | 1 to 0.80573 |
| 8 | 12392 | 9975 | 1 to 0.80496 |
| 9 | 13144 | 10579 | 1 to 0.80485 |
| 10 | 13855 | 11151 | 1 to 0.80483 |
| 11 | 14530 | 11693 | 1 to 0.80477 |
| 12 | 15180 | 12205 | 1 to 0.80403 |
| 13 | 15797 | 12699 | 1 to 0.80390 |
| 14 | 16393 | 13177 | 1 to 0.80382 |
| 15 | 16968 | 13620 | 1 to 0.80270 |
| 1 | 2 | 3 | 4 |

Hence it follows, that the velocity in English inches will be $V = 22.47\sqrt{H}$ for additional tubes. See p. 498. col. 2.

M. Prony has given the following formulæ, as deduced from the preceding Table. The letters have the same values as in p. 498.

$Q = 0.81\, AT\sqrt{2gH}$; but since $2g$ is constant, and is $= 7.77125$, we have

$$Q = 4.9438\, d^2 T\sqrt{H},$$

From which we obtain

$$d = \sqrt{\frac{Q}{4.9438\, T\sqrt{H}}},$$

$$T = \frac{Q}{4.9438\, d^2\sqrt{H}},$$

$$H = \frac{Q}{(4.9438\, d^2 T)^2}.$$

When the interior surface of the additional tube is of a conical form, the quantities of water discharged undergo considerable variations. M. Bossut made no experiments whatever with tubes of this kind, but the defect is fortunately supplied by those of the Marquis Poleni, which are published in his work *De Castellis per quæ derivantur Fluvium Aquæ*.

TABLE XI. *Containing the Experiments of the Marquis Poleni, on the Quantities of Water discharged by Conical Tubes of different Diameters.*

| Head of Water. | Length of the tube. | Nature of the Orifices employed. | Diameter of the Inner Orifice. | Diameter of the Outer Orifice. | Quantity discharged in a Minute in Cubic Feet, as calculated by Bossut. | Time in which 73035 Cubic Inches were discharged. |
|---|---|---|---|---|---|---|
| Constant height of the water in the reservoir, 256 lines, or 1 foot 9 inches and 4 lines. French. | Length of each tube 92 lines, or 7 inches 8 lines. French. | Orifice in a thin plate, | 26 lines | | 15877 | 4′ 36″ |
| | | Cylindrical tube, | 26 | | 23434 | 3 7 |
| | | 1st Conical tube, | 33 | 26 lines | 24758 | 2 57 |
| | | 2d Conical tube, | 42 | 26 | 24619 | 2 58 |
| | | 3d Conical tube, | 60 | 26 | 24345 | 3 0 |
| | | 4th Conical tube, | 118 | 26 | 23687 | 5 3 |

The discharge in the preceding Table, for a simple orifice, is less than that which is given by Bossut, which appears to arise from his having used a measure of the cubic inch of water, which errs in excess. From Poleni's results, we may conclude,

1. That the real discharges are always less with conical tubes than the theoretical discharges, which, in the present case, is 27425 cubical inches in a minute; and,

2. That in augmenting to a certain degree the diameter of the inner orifice of the conical tube, the quantity of water expended is also augmented; but that, when this enlargement is pushed too far, there is a tendency to produce an exterior contraction of the vein of fluid, and thus to make the circumstances of the case the same as in simple orifices, in which the discharges are the least possible.

When the conical tube is placed with its smallest orifice in the reservoir, it will yield more water than a cylindrical tube, the diameter of whose orifice is equal to the smallest orifice of the conical tube.

The best experiments on additional tubes have been made by M. Venturi, and fully described in his valuable work on the lateral communication of motion in fluids. We have thrown them, in an abridged state, into the following Table, and have computed the numbers in the last column.

TABLE XII. *Containing the Experiments of Venturi on additional Tubes of various forms.*

| Height of Water. | Nature and Dimensions of the Tubes and Orifices. | Time in which 4 Paris cubic feet were discharged. | Number of cubic inches discharged in a minute. |
|---|---|---|---|
| Inches. | 1. Circular orifice, 18 lines in diameter, . . . . . . . . . | 41″ | 10115 |
| | 2. Cylindrical tube, 18 lines in diameter, and 54 lines long, . . . . . | 31 | 13378 |
| | 3. Compound tube, Fig. 11. in which AC = GI = MN = 18 lines; DF = 14.5; AB = 11; BG = 10; GM = 37; AM = 58; the conical portion having nearly the form of the contracted vein, . . . . . . . | 31 | 13378 |
| | 4. Conical tube AC DF, Fig. 11. with the rest removed, . . . . . | 42 | |
| 32.5 | 5. A cylindrical pipe, 18 lines in diameter, and 54 lines long, having 12 small holes made in its circumference, at the distance of 9 lines from its inner orifice, . . . . . . . . . . . . . . . | 41 | 10115 |
| | No water passed through the holes, and the stream did not fill the tube. The same effect was produced when all the holes are open, as when any number of them is shut, provided *one* is open. | | |
| | 6. The same pipe, with all the holes shut with wet skin. The stream now filled the pipe, . . . . . . . . . . . . . . . | 31 | 13378 |
| | 7. Cylindrical tube, Fig. 12, 18 lines in diameter, and 57 lines long. The glass tube QRS was joined to the additional tube, and immersed in a coloured liquid T. The coloured liquid rose to S, 24 inches above T, and the time in which 4 cubic feet were expended was . . . . . . . . | 31 | 13378 |
| | 8. The compound tube of No. 3, or Fig. 11. in the same circumstances as No. 7. | 31 | 13378 |
| 27.5 | 9. The tube, No. 6, with its apparatus, was applied so as to throw the water upwards. The liquor rose 20 inches, . . . . . . . . | 34 | 12198 |
| | 10. Simple orifice, 18 lines in diameter, . . . . . . . . . . | 45 | 9216 |
| 40.0 | 11. Simple orifice, 18 lines in diameter, . . . . . . . . . . | 38 | 10915 |
| | 12. Horizontal tube, partly conical and partly cylindrical, like Fig. 13. diameter at A = 18 lines, AD = 31 inches, . . . . . . . . . . | 43 | 8640 |
| | 13. Same tube, placed vertically, . . . . . . . . . . . | 48 | 8640 |
| | 14. Simple orifice, 11.2 lines in diameter, . . . . . . . . . | 98 | 4232 |
| | 15. Tube of No. 12. placed horizontally, had AC of the form of the contracted vein, and the diameter A, 11.2 lines in diameter, . . . . . . | 130 | 3190 |
| | 16. Tube of No. 15. placed vertically, . . . . . . . . . . . | 129 | 3213 |
| | 17. Vertical tube BOCQ, diameter 18, length BC, 3 inches, Fig. 6. . . . | 41 | 10115 |
| | 18. Ditto, 18, 12, Fig. 6. . . . | 38 | 10915 |
| | 19. Ditto, 18, 24, Fig. 6. . . . | 35 | 11828 |
| | 20. Horizontal tube BOCQ, 18, 3, Fig. 6. . . | 42.5 | 9758 |
| | 21. Ditto, 18, 12, Fig. 6. . . . | 45 | 9216 |
| | 22. Ditto, 18, 24, Fig. 6. . . . | 48 | 8640 |
| AB&F 32.5 | 23. Compound tube, Fig. 14. where AB = EF = 18 lines, AC = 11; CO = 15 5, CG = 49 . . . . . . . . . . . . . . . | 27.5 | 15080 |
| | 24. A tube, consisting of a cylindrical tube 3 inches long and 15.5 lines in diameter, interposed between the two conical tubes of the preceding experiment . . . . . . . . . . . . . . . | 28.5 | 14551 |
| | 25. The tube of Fig. 15, ABCD had the same form as before, but CDEF was 78 lines long and 23 lines in diameter. Three glass tubes were added, as in the Figure, and immersed in mercury. The mercury rose 53 lines in DX, 20.5 in NP, and .7 in OZ . . . . . . . . . . . . | 25 | 16560 |
| | 26. The same tube with the portion PNFE cut off . . . . . . . | 31 | 13378 |

| Height of Water. | Nature and Dimensions of the Tubes and Orifices. | Time in which 4 Paris cubic feet were discharged. | Number of cubic inches discharged in a minute. |
|---|---|---|---|
| Inches. | 27. The tube, Fig. 15. 148 lines long, and 27 in diameter at EF; the rest as in the last experiment . . . . . . . . . . . . . | 21″ | 19748 |
| | 28. When the last tube is prolonged to any length beyond 148 lines . . | 21 | 19748 |
| | 29. Same tube 204 lines long, by fixing a prominence within the tube at O, so as to make the fluid fill the tube . . . . . . . . . . . | 19 | 21830 |
| 32.5 | 30. Horizontal tube, Fig. 15. being made more divergent, 117 lines long and 36 in diameter, the rest remaining as before. The stream did not fill the whole section . . . . . . . . . . . . . . . . . | 28 | 14811 |
| | 31. By cutting off successive portions of the pipe until CE was only 20 lines long, and the external diameter 18 lines, the time always was . . . . | 28 | 14811 |
| | 32. When CE was 20 lines, and EF 20, the stream was detached from the sides of the tube, and the time was . . . . . . . . . . | 42 | 9874 |
| Height above lower extremity. | | | |
| 41.5 | 33. The tube, Fig. 15. was applied in place of BCQO of Fig. C . . . .. | 22 | 18850 |
| 23.0 | 34. The same tube, Fig. 15. applied to form an ascending jet . . . | 30 | 13824 |
| Above upper extremity. | | Time in which one cubical foot of water was discharged | |
| 31.7 | 35. Simple orifice, 4.5 lines in diameter from vertical jet . . . . | 161 | 644 |
| | 36. Ditto with an additional cylindrical tube of the same diameter, and ten lines long . . . . . . . . . . . . . . . . . | 121 | 856 |
| 56. | 37. The orifice of No. 35. with a vertical jet . . . . . . . . . | 123 | 843 |
| | 38. Ditto with an additional cylindrical tube of § 36. . . . . . . | 91 | 1139 |

The preceding Table contains a general abstract of the numerous experiments of Venturi, which were made publicly in the Theatre of Natural Philosophy at Modena. The following are the conclusions which he has deduced from them.

1. If the part of the additional tube nearest the reservoir has the form of the contracted vein, the expenditure will be the same as if the tube were not contracted at all.

This proposition is deduced from experiments 1, 2, 3, 4.

2. The pressure of the atmosphere increases the expence of water through a simple cylindrical tube when compared with that which flows through a simple orifice, whatever be the direction of the tube.

This proposition is deduced from experiments, 5, 6, 7, 8, 9, 10.

3. In descending cylindrical tubes, the upper ends of which have the form of the contracted vein, the quantity of water discharged is that which corresponds with the height of the fluid above the inferior extremity of the tube.

This proposition, which has been established theoretically in the preceding Chapter, is likewise deducible from experiments 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22.

4. In additional conical tubes, the pressure of the atmosphere increases the expenditure in the proportion of the area of the external section of the tube to the area of the section of the contracted vein, whatever be the position of the tube, provided that its internal figure is adapted throughout to the lateral communication of motion.

This proposition is established by experiments 23—33. These experiments also shew, that, by varying the divergence of the sides of the tube, the lateral communication of motion has a maximum and a minimum effect. The minimum is seen in experiment 32. The lateral communication of motion appears to cease to produce its effect when the angle of the sides of the tube exceeds 16°. Experiment 23d nearly determines the maximum effect when the same angle is about 30°.

5. The quantity of water discharged is less through cylindrical tubes than through conical tubes which diverge from the commencement of the contracted vein, and have the same exterior diameter.

This is established by experiments 35, 36, 37, 38.

6. By applying proper adjutages to a given cylindric tube, the expenditure of water through that tube may be increased in the ratio of 25 to 10, the head of water remaining the same.

In order to produce this singular effect, the inner extremity of the tube AD, Fig. 16. must be filled with a conical piece of the form of the contracted vein, which will increase the expenditure from the ratio of 12.1 to 10. At the other extremity of the pipe BC apply a truncated conical tube CD, of which the length must be nearly nine times the diameter at C, and its external diameter D must be 1.8 C. This additional tube will increase the expenditure in the ratio of 24 to 12.1, by experiment 27. Hence the expenditure will be increased by the two pieces in the ratio of 24 to 20.

### *Experiments on the Expenditure of Bent Tubes.*

In order to ascertain the effects of bent tubes, M. Venturi employed two tubes ABC, DEF, Fig. 17. 15 inches long, and 14.5 lines in diameter. The portions A, D have the form of the *vena contracta*, and were applied to the orifice of a reservoir, which was 18 lines in diameter, and in which the water was 32.5 inches high. The elbows or flexures BC, EF were made in the plane of the horizon. The tubes were made of copper soldered with silver, and the curvature BC was produced by filling the tube with melted lead, in order that the tube might preserve its diameter during the act of bending. The elbow DEF was rectangular. A rectilineal tube of similar dimensions was also tried, and the following were the results.

| | Four cubical feet were discharged in |
|---|---|
| Rectilineal tube . . . . . | 45″ |
| Curved tube . . . . . | 50 |
| Rectangular tube . . . . . | 70 |

The following results were obtained by Du Buat, respecting the effects produced by bent tubes 1 inch in diameter, and of different lengths.

| | Number of Bendings. | Angle of the bending. | Velocity per second, both in straight and bent tubes in inches. | Augmentation of the head of water which overcomes the resistance at the flexure. | Augmentation of the head calculated from the formula. |
|---|---|---|---|---|---|
| | | | | Inches. | Inches. |
| Tube 1 inch in diameter and 117 inches in length. | 3 | 36° 0 | 84 945 | 2.49 | 2.49 |
| | 2 | 36 0 | 84 945 | 1.5 | 1.66 |
| | 4 | 24 34 | 84 945 | 1.5 | 1.66 |
| | 3 | 24 34 | 84.945 | 1.12 | 1.24 |
| | 1 | 36 0 | 84.945 | 0.75 | 0.83 |
| | 2 | 24 34 | 84.945 | 0 75 | 0 83 |
| | 1 | 24 34 | 84 945 | 0.37 | 0.41 |
| | 10 | 36 0 | 71 59 | 5.905 | 5.905 |
| Tube 138 inches long. | 4 | 36 0 | 58.808 | 1.64 | 1.59 |
| Tube 117 inches long. | 4 | 36 0 | 58.438 | 1.5 | 1.57 |
| | 2 | 36 0 | 58.438 | 0 75 | 0.78 |
| | 4 | 24 34 | 58.438 | 0.75 | 0.78 |
| | 1 | 36 0 | 58.438 | 0.37 | 0.39 |
| Tube 138½ inches long. | 4 | 36 0 | 29.33 | 0.41 | 0.396 |
| Tube 737 inches long. | 4 | 36 0 | 28.657 | 0.39 | 0.378 |

The last column of the preceding Table is computed from the formula $\frac{V^2 s^2 n}{m}$; V being the velocity, $s$ the sine of the angle of the bending. $n$ the number of bendings, and $m$ a constant quantity, which is found to be nearly 300. Hence $\frac{V^2 s^2}{300}$ is the measure of the resistance.

M. Venturi employed a tube of the form shewn in Fig. 18. The orifice A has the form of the contracted vein, and the rest of the tube is interrupted by various enlargements of its diameter. The following are its dimensions:

| | Lines. |
|---|---|
| Diameter at A . . . . . . . | 11.2 |
| Diameter at B, C, F, G, . . . | 9 |
| Diameter of the enlarged parts . | 24 |
| Length of BC, FG, &c. . . . | 20 |
| Length of CD, EF, GH, . . . | 13 |

The length of the enlarged parts was variable, being at one time 38, and another 76 lines, with the same effect in both.

By means of this tube, the following results were obtained under a pressure of 32.5 inches.

| Number of enlarged parts. | Time in which four cubical feet of water were discharged. |
|---|---|
| 0 . . . . . . . . . . . . | 109″ |
| 1 . . . . . . . . . . . . | 147 |
| 3 . . . . . . . . . . . . | 192 |
| 5 . . . . . . . . . . . . | 240 |

Venturi afterwards applied to the same orifice a tube having the same form and the same diameter as ABC, but cylindrical throughout, and without any enlargements. It was 36 inches long, and the time in which four cubic feet were expended was 148″.

"When the fluid passes from C," says Venturi, "to the middle of the enlarged part DE, part of the motion is directed from the direction CF towards the lateral parts of the enlargement. This part of the motion is consumed in eddies, or against the sides. Consequently there remains so much the less motion in the following branch FG. This is also the cause which destroys or weakens the pulse in the arteries beyond an aneurism.

"From this consideration we are justified in concluding, that if the internal roughness of a pipe diminishes the expenditure, the friction of the water against these asperities does not form any considerable part of the cause. A right lined tube may have its internal surface highly polished. Throughout its whole length it may every where possess a diameter greater than the orifice to which it is applied; but, nevertheless, the expenditure will be greatly retarded if the pipe should have enlarged parts or swellings. This is a very interesting circumstance, to which, perhaps, sufficient attention has not been paid in the construction of hydraulic machines. It is not enough that elbows and contractions are avoided; for it may happen by an intermediate enlargement, that the whole advantage may be lost which may have been procured by the ingenious dispositions of the other parts of the machine."

*Eytelwein's Experiments on additional Tubes.*

The experiments of M. Eytelwein on additional tubes confirm the general results obtained by Venturi. The following are the leading results which he obtained:

| | Ratio of the Discharges. | Co-efficients for the velocity. |
|---|---|---|
| Shortest tube that will cause the stream to adhere every where to its sides . . | .8125 to 1.0000 | 6.5 |
| Short tubes, having their lengths from 2 to 4 times their diameters . . . | .82 | 6.6 |
| Conical tube approaching to the form of the *vena contracta* . . . . . . | .92 | 7.38 |
| The same tube with its edges rounded off . . . . | .98 | 7.86 |
| A tube projecting within the reservoir . . . . . | .50 | 4.0 |

M. Eytelwein is of opinion, that Venturi's assertion that the discharge of a cylindric tube may be increased in the ratio of 24 to 10, is not generally correct, and that when the tube is very long, scarcely any additional expenditure is obtained by the addition of such a tube. From a great number of experiments which he made with different pipes he infers, that a compound conical pipe, such as that shewn in Fig. 16, may increase the discharge to 2½ as much as through a simple orifice, or as 24 to 10, as stated by Venturi, or to more than half as much more as would fill the whole section with the velocity due to the height; but that where a considerable length of pipe intervenes, the additional orifice appears to have little or no effect.

Michelotti made many experiments for determining the real form of the *vena contracta*. He constructed a great variety of ajutages resembling it, till he found one which gave the greatest discharge. This ajutage was formed by the revolution of a trochoid round the axis of the jet. The diameter of the outer orifice was 36, that of the inner orifice 46, and the length of the axis was 96. This ajutage gave .9831 to 1000 as the ratio of the real to the theoretical discharge. The following are Michelotti's results:

| | |
|---|---|
| Theoretical discharge . . . . . . | 1.0000 |
| Trochoidal ajutage . . . . . . . . | 9831 |
| Tube 2 diameters long . . . . . . . | 8125 |
| For a tube projecting into the reservoir, and flowing full . . . . . . . | 6814 |
| For do. when the vein was contracted | 5134 |

SECT. V. *Experiments on the Exhaustion of Vessels.*

We have already seen, in stating the general principles of hydraulics, that a funnel-shaped cavity is formed in the surface of a fluid, when, in the course of its descent, it has nearly reached the orifice from which the fluid is discharged. This circumstance renders it impossible to determine the exact time in which a vessel is completely emptied. The superincumbent pressure of the head of water being removed by the formation of the funnel-shaped cavity above the orifice, the water is at last discharged in successive drops. M. Bossut therefore abandoned the idea of attempting to measure the time of emptying vessels, and confined his experiments to the determination of the time in which the upper surface of the fluid descends through a certain vertical height in prismatic vessels, in which the area of the horizontal section is constant. The following Table contains the results of his experiments.

TABLE XII. *Shewing the times in which Prismatic Vessels are partly exhausted.*

Altitude of the water in the reservoir 11.6666 Paris feet. Constant area of a horizontal section of the vessel in square feet.

| Diameter of the circular orifice. | Depression of the upper surface of the fluid. | Time in which the depression takes place, according to experiment. | | Time of the depression of the surface by the formula. | | Difference between the theory and the experiments. |
|---|---|---|---|---|---|---|
| Inches. | Feet. | Min. | Sec. | Min. | Sec. | Seconds. |
| 1 | 4 | 7 | 25½ | 7 | 22.36 | 3.14 |
| 2 | 4 | 1 | 52 | 1 | 50.59 | 1.41 |
| 1 | 9 | 20 | 24½ | 20 | 16 | 8 50 |
| 2 | 9 | 5 | 6 | 5 | 4 | 2 00 |

The first column of the Table contains the diameter of the circular orifice; the second the depression of the upper surface of the fluid in feet; the third the time in which the surfaces descend through this height, according to experiment; the fourth contains the time as calculated from the formula in Chapter I. corrected by substituting 0.62 A instead of A, in order to make allowance for the effect of contraction. The numbers in column fourth always err in defect, probably from 0.62 being taken too great. If the orifices are vertical, the altitude of the fluid must be measured from their centre of gravity.

A few experiments on the partial exhaustion of vessels were made by M. Venturi. An orifice, 4.5 lines in diameter was made near the bottom of a cylindrical vessel 4.5 inches in diameter. The altitude of the water in the vessel was 8.3 inches above the centre of the orifice. The surface of the water was then depressed 7 inches in 27½ seconds. A cylindrical tube of the same diameter as the orifice, and 11 lines in length, was applied to the same orifice. The vessel was filled to the same height as formerly, and its surface descended 7 inches in 21 seconds of time. These experiments were afterwards repeated under the receiver of an air pump, in which the mercurial gauge stood only at the height of 10 lines, and the surface of the fluid was depressed 7 inches, whether the water flowed through the simple orifice, or the cylindrical tube.

SECT. VI. *Experiments of Bossut on the discharge of Water into a submerged Vessel.*

In order to examine the discharge of water into submerged vessels, M. Bossut employed a vessel ABCD, (Plate CCCXIX. Fig 1.) two feet in diameter, in which a white-iron cylinder VMNT, 1 foot high, and 20 lines in diameter, was immersed. This cylinder is supported on a tripod, so that it can be set in a vertical line, and is furnished with graduated scales for measuring the water which it receives. The orifice in the cylinder VMNT being shut, water is poured into the vessel till it reaches a certain height, and when the orifice is opened, the water rushes in and fills the cylinder. The following are the results of Bossut's experiments.

| Depth of immersion or HM. | Diameter of the orifice. | Time in which the water rises to H on a level with the water in the vessel. | Calculated time. |
|---|---|---|---|
| 11 inches | 1 line | 119 seconds. | 155.97 |
| 11 | 3 | 15 | 17.33 |

The fourth column contains the time, as calculated from theory, which differs very considerably in the first experiment from the observed time. M. Bossut accounts for this, by saying, that at the first entrance of the water a jet is formed, which penetrates the plate of water in the cylinder VMNT, till it stands at a certain height, when the surface of the water becomes level. Now as this jet will continue longer with small than with large orifices, a greater quantity of water, in proportion, ought to be discharged. Bossut also made the following experiments.

*Exp.* 1. When the water entered the cylinder by an orifice one inch in diameter, it was necessary to immerse the cylinder 8 inches and 11 lines in the water of the vessel, in order that the water might raise itself to the upper margin VT of the vessel.

*Exp.* 2. The bottom MN being wholly removed, the cylinder required to be immersed 7 inches and 7 lines, in order that the water might rise to the upper margin VT.

*Exp.* 3. When a large plate of white-iron was put round MN, it was necessary to sink the cylinder 6 inches 11½ lines, in order that the water might rise to the upper margin VT.

SECT. VII. *Bossut's Experiments on the Motion of Water in a Vessel crossed with Diaphragms.*

The experiments of Bossut on this subject were made with two vessels, ABCD, DCBA, Fig. 2. and Fig. 3. whose internal diameter is 6 inches, and height 3 inches. The length of ED was one foot, and EA two feet. The diaphragm EF was pierced with an aperture G, 6 lines in diameter; covers DC, AB with different orifices, were placed successively on the cylinder, and the cylinders were inverted as shewn in the two Figures. A narrow opening, 18 lines broad, was cut through the whole length of the cylinders, and covered up with glass, in order to see what was going on within, and near the diaphragm EF was perforated a small aperture *t*, which could be either opened to admit the air, or shut up with wax. The following results were then obtained.

*Exp.* 1. The cylinder Fig. 2. being completely filled, and the hole *t* shut, orifices of 6, 12, and 21 lines were successively applied. In all these cases the water in the lower compartment abandoned the diaphragm when the height EH of the water was about 6 or 7 lines. At the instant of separation a whistling noise was heard, arising from the passage of the air from the upper to the under compartment.

*Exp.* 2. By inverting the cylinder as in Fig. 3. and applying the same orifices, the very same effects were produced.

*Exp.* 3. The vessel having the position in Fig. 2. the hole *t* being now opened, and the orifice at M being 6 lines, the separation took place when EH was about 14 inches.

*Exp.* 4. When the diameter of the orifice at M was four lines, the separation took place when EH was six inches.

## Sect. VIII. *Experiments on the ascent of Water in Jets d'eau, either vertically or obliquely.*

The custom which formerly prevailed of decorating pleasure grounds and public squares with jets d'eau, rendered the subject of the present Section much more interesting than it is at present. The phenomena of Jets, however, are still of importance in a scientific point of view; and as the fashions of former times may again return, it would be inexcusable to omit altogether the consideration of this branch of Hydrodynamics.

According to the theory of vertical jets, which has already been explained under Chap. I. of Part II. they ought to rise to the same height as that of the surface of water in the reservoirs from which they flow. This, however, is not found to be the case in practice. The friction of the water on the sides of the tubes, the resistance of the air, and the obstruction of the descending drops, all conspire in diminishing the altitude to which water would otherwise be projected.

In the experiments made by Bossut, he employed a large reservoir ABCD, Fig. 4. and 5. to which he fitted horizontally two tubes BE of white iron, closed at the end E, and open at the end next the reservoir. Each of these was six feet long. The diameter of the first was 3 inches 8 lines, and that of the second from 9 to 10 lines, and on the upper surface of these tubes ajutages of different sizes were placed. Around the ends of each ajutage was soldered a tube of white iron, whose diameter was greater than that of the ajutage, in order to be able to stop the jet by means of cork, which goes into the white iron tubes. The following Table contains the results of the experiments.

Table XIII. *Shewing the Altitudes to which Jets rise through Ajutages of different forms, the Altitude of the Reservoir being Eleven Feet, reckoning from the upper surface of the horizontal Tubes* OE, OE. *Fig.* 4. *and* 5.

| Diameter of the horizontal tubes CE, CE, each being 6 feet long. | | Form of the Orifices. | References to Fig. 4. and 5. | Diameter of the Orifice. | Altitude of the Jet when rising vertically, reckoning from OF. | | | Altitude of the Jet when inclined a little to the vertical. | | | Description of the Jets. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Inch. | Lines. | | | Lines. | Feet. | Inch. | Lines. | Feet. | Inch. | Lines. | |
| 3 | 8 | Simple orifice, | F | 2 | 10 | 0 | 10 | 10 | 4 | 6 | The vertical jet very fine. |
| 3 | 8 | — | G | 4 | 10 | 5 | 10 | 10 | 7 | 6 | The vertical jet fine, and not much enlarged at the top. |
| 3 | 8 | — | H | 8 | 10 | 6 | 6 | 10 | 8 | 0 | All the jets occasionally rise to different heights. This is very perceptible in the present experiment. The vertical jet is much enlarged at top. The inclined one less so, and more beautiful. |
| 3 | 8 | Conical tube, | M | Length, 70; Lower diameter, 9; Upper diameter, 4 | 9 | 6 | 4 | 9 | 8 | 6 | The vertical jet fine. |
| 3 | 8 | Cylindrical tube, | N | Length, 70; Diameter, 4 | 9 | 1 | 6 | 7 | 3 | 6 | The vertical jet is very fine. |
| 0 | 9½ | Simple orifice, | M | 2 | 9 | 11 | 0 | — | — | — | The jet is here fine. |
| 0 | 9½ | — | L | 4 | 9 | 7 | 10 | — | — | — | The jet is much deformed, and very much enlarged at top. |
| 0 | 9½ | — | K | 8 | 7 | 10 | 0 | — | — | — | The column is much broken; and the successive jets are detached from each other. |

In comparing the three first experiments, it appears that great jets rise higher than small ones. This arises from the greater mass of the large jets; for, as both of them are projected with the same velocity, the large ones having a greater momentum, are more able to overcome the obstacles which are opposed to them. This, however, is true only of high jets. For when they do not exceed two or three feet in height, and when the ajutages are not below one line in diameter, small jets rise to the same height as large ones. This conclusion must also be limited to the case where the conduit pipe OE affords a sufficient supply of water; for it appears, from the three last experiments, when the conduit tube OE is very narrow, that the small jets rise to a greater height than large ones. Hence there is obviously a certain ratio which must exist between the diameter of the horizontal tube and that of the ajutage, to produce a maximum height in the jet.

In order to find this ratio, Bossut has given the following method. Let D be the diameter of the tube, $d$ that of the orifice, $v$ the velocity of the water in the tube, and $h$ the altitude of the fluid in the reservoir. Now $\sqrt{h}$ may be taken as the constant velocity at the ajutage. But by Hydraulics, Chap. I. Prop. 1. $\sqrt{h} : v = D^2 : d^2$, and $v = \frac{d^2}{D^2}\sqrt{h}$. In like manner, in any other tube, in which $D'$ $d'$, $h'$ and $v'$ represent the same quantities as before, we have $v' = \frac{d'^2}{D'^2}\sqrt{h'}$. But upon the hypothesis, which is conformable to experiment, that two jets will each rise to the greatest possible height when the velocities of the water in the two conduit tubes are equal, we have $v = v'$ and $\frac{d^2}{D^2}\sqrt{h} = \frac{d'^2}{D'^2}\sqrt{h'}$; consequently, $D^2 : D'^2 = d^2 \sqrt{h} : d'^2 \sqrt{h'}$; that is, *the squares of the diameters of the horizontal tubes ought to be to each other in the compound ratio of the squares of the diameters of the ajutages, and the square roots of the heights of water in the reservoir.*

Hence, if we know from one direct experiment the diameter which a tube ought to have to supply a given ajutage under a given height of fluid in the reservoir, we may find the diameter of every other tube which is necessary to supply any other ajutage under a given height of fluid in the reservoir.

With this view, M. Bossut made the following experiments. He applied a tin tube one inch in diameter to a reservoir. The point of the tube, bent upwards in order to project the water vertically, was made of lead, and was a little more than an inch long, and to the extremity of it seven different orifices were successively applied. The following were the results.

Table XIV. *Containing the Experiments of Bossut on the Height of Jets with different Orifices.*

| Diameter of the Ajutage. Lines. | Height of the Jet. Feet. | Inches. | lines. |
|---|---|---|---|
| 1 | 3 | 1 | 6 |
| 2 | 3 | 1 | 8 |
| 3 | 3 | 2 | 0 |
| 4 | 3 | 1 | 7 |
| 5 | 3 | 1 | 5 |
| 6 | 3 | 0 | 4 |
| 7 | 2 | 10 | 6 |

From these results it follows, that for a height of water in the reservoir of 3 feet 2 inches and 11 lines, and a conduit tube which has a diameter of 1 inch, the diameter of the orifice should be about $3\frac{3}{4}$ lines. Now Mariotte found, from experiment, that for a head of water of 52 feet, and an ajutage 6 lines in diameter, the diameter of the conduit tube should be 36 lines; whereas the preceding rule will give 38, agreeing very nearly with the experimental result.

It appears, from a comparison of the experiments of Bossut and Mariotte, that the *differences between the height of vertical jets and the height of the reservoir are nearly as the square of the heights of the jets themselves.* Hence, if we know this difference in one case, the difference in any other will be found by simple proportion. If the height of the reservoir of the second jet is given, and if it is required to determine the height of the jet, we must resolve a quadratic equation. Thus, let $a$ be the height of the reservoir of the experimental jet, $b$ the height of the same jet, $c$ the height of the reservoir of the proposed jet, $x$ the height of the proposed jet; then by the rule $a - b : c - x = b^2 : x^2$, we obtain

$$x^2 = \frac{b^2\,(c-x)}{a-b}, \text{ or } x = \frac{-b^2 + b\sqrt{(4ac - 4bc + b^2)}}{2(a-b)}$$

In order to facilitate the application of the preceding principles to practice, Bossut has computed the following Table:

Table XV. *Containing the Altitudes of Reservoirs, the Diameters of the Horizontal Tubes, &c. for Jets of different heights.*

| Altitude of the jet. | Altitude of the reservoir. | | Quantity of water discharged in a minute from an ajutage 6 lines in diameter. | Diameters of the horizontal tubes suited to the two preceding columns. |
|---|---|---|---|---|
| Paris Feet. | Feet. | Inch. | Paris Pints. | Lines. |
| 5 | 5 | 1 | 32 | 21 |
| 10 | 10 | 4 | 45 | 26 |
| 15 | 15 | 9 | 56 | 28 |
| 20 | 21 | 4 | 65 | 31 |
| 25 | 27 | 1 | 73 | 33 |
| 30 | 33 | 0 | 81 | 34 |
| 35 | 39 | 1 | 88 | 36 |
| 40 | 45 | 4 | 95 | 37 |
| 45 | 51 | 9 | 101 | 38 |
| 50 | 58 | 4 | 108 | 39 |
| 55 | 65 | 1 | 114 | 40 |
| 60 | 72 | 0 | 120 | 41 |
| 65 | 79 | 1 | 125 | 42 |
| 70 | 86 | 4 | 131 | 43 |
| 75 | 93 | 9 | 136 | 44 |
| 80 | 101 | 4 | 142 | 45 |
| 85 | 109 | 1 | 147 | 46 |
| 90 | 117 | 0 | 152 | 47 |
| 95 | 125 | 1 | 158 | 48 |
| 100 | 133 | 4 | 163 | 49 |

The two first columns, containing the heights of the jets and the corresponding altitudes of the reservoirs, are taken from Mariotte. The heights of the jets and of the reservoirs, not included in the Table, may be found from the preceding formula. The third column contains, in Paris pints, of which 36 form a cubic foot, the water discharged in a minute by an ajutage six lines in diameter; and the fourth column contains the diameter which ought to be given to the conduit tubes for an ajutage of six lines relatively to the altitudes in column 2. This column is computed on the hypothesis, that for an ajutage six lines in diameter, and an altitude of 16 feet of water in the reservoir, the conduit tube must be $28\frac{1}{2}$ lines in diameter, and upon the principle that the squares of the diameters of the conduit tubes are as the squares of the diameters of the ajutages multiplied by the square roots of the altitude of water in the reservoir.

It appears from a comparison of columns 5th and 6th of Table XIII. that the jets never reach the height of the reservoir, and that a small inclination of the jet causes it to rise higher than when it is projected vertically, a fact which was long ago observed by Wolfius. (See *Elementa Matheseos Universæ*, tom. i. p. 802. schol. 4.) The diminution of the height of the jet has been very properly ascribed by Wolfius principally to the gravity of the falling waters, which obstruct the ascent of the water which is rising. When the velocity of the foremost particles of water is spent, the particles immediately behind strike against them, and lose their velocity, and in consequence of this constant collision between the ascending and descending particles, the jet continues at an altitude less than that of the reservoir. This consideration also affords a reason why the height of the jet is increased, by giving it a slight inclination; for the descending fluid falling a little to one side, no longer opposes the ascent of the rising fluid. In proof of the opinion that the diminution of the jet is produced by the gravity of the falling water, Wolfius states that he has found that mercury rises to a still less altitude than water.* This, however, is not owing to the greater specific gravity of mercury; for though the particles of mercury are heavier than those of water, yet the momentum with which they ascend is proportionally greater, and therefore there is the same ratio between the momentum and the resistance which opposes their ascent, as there is in the case of water.

Toricellius† seems to have been the first who observed, that when the water is first projected from the orifice it generally springs higher than the height at which it permanently settles, which no doubt arises from there being at first no descending fluid to retard its vertical ascent. Another phenomenon, however, more remarkable, has been noticed by other authors. When the water first escapes from the orifice, it generally springs higher than the reservoir from which it flows, but the elevation is momentary, and the water speedily settles at a constant height. This fact has been ascribed to the elasticity of the air which follows the water in its passage through the orifice: but it is manifest that this would only diminish its specific gravity, as in the hydreoles of M. Mannoury Dectot, (see page 826,) and would never give an additional impulse to the ascending fluid. In order to explain this phenomenon, Bossut supposes the ajutage to be stopped, and that the air which follows the water accumulates near the orifice in a condensed state; as soon therefore as the orifice is opened, the elasticity of the included air causes it to escape with rapidity, and the water rushing into the space which it leaves, acquires by this short fall in the tube a certain velocity, which increases at the orifice in the ratio of the section of the orifice to the section of the tube.

In Chap. I. of Hydraulics, we have considered the theory of oblique jets. The following experiments were made by Bossut.

| Height of the water above the orifice. Feet. | Diameter of the ajutage. Lines. | Height of the ajutage above a horizontal plane. Ft. | in. | lin. | Amplitude of projection on a horizontal plane. Ft. | in. | lin. |
|---|---|---|---|---|---|---|---|
| 9 | 6 | 4 | 3 | 7 | 12 | 3 | 3 |
| 4 | 6 | 4 | 3 | 7 | 8 | 2 | 8 |

Hence it follows, that the real amplitudes, which are always less than those deduced from theory, are nearly as the square roots of the altitudes of the water in the reservoirs. In order to find the amplitude of any other jet, when the height of the water in the reservoir is 25 feet, we have $\sqrt{9} : \sqrt{25} =$ 11 feet 3 inches 3 lines : 18 feet 9 inches 5 lines.

The following experiments on oblique jets were made by M. Venturi and M. Michelotti.

| Height of the water in the reservoir. Inches. | Nature of the orifice. | Height of the ajutage above a horizontal plane. Inches. | Amplitude of projection. Inches. |
|---|---|---|---|
| 32.5 | A simple orifice | 54 | 81.5 |
| 32.5 | Additional tube | 54 | 69 |
| | Plate CCCXVIII. Fig. 5. | | |
| | A simple orifice | 19.33 | 23.2 |
| | Additional tube | 19.33 | 20 |

M. Bossut took a tube, and having filled it with water, he allowed it to empty itself by orifices of different sizes. When no orifice was added, but when the tube was allowed to empty itself, the water did not issue with the greatest velocity when the tube was fullest, but when a certain quantity of the water had run out. In the case of small ajutages, the greatest velocity, and the greatest amplitude of projection, is always that which is due to the corresponding height of water in the reservoir; but, in very large orifices, this relation does not exist.

## CHAP. IV.

### On the Motion of Water in Pipes and Open Canals.

There is perhaps no branch of science so highly important as that part of Hydrodynamics which relates to the conveyance of water in pipes and canals, and there is none in which theory affords the engineer so little assistance.

When it is required to supply a town with water, the first step of the engineer is to discover one or more springs situated above the level of that part of the town from which the water is to be distributed to private houses, and to the public fountains. The water discharged by the springs is then to be collected into one or more reservoirs; and conduit pipes of lead, or wood, or iron, are then to be laid to convey the water to the principal reservoirs in the town. The quantity of water which is necessary for the supply of the inhabitants having been previously ascertained, an additional allowance being made for the probable extension

* "Ego quidem multum tribuo gravitati aquæ ascendentis, quia observavi quod argentum vivum ad minorem altitudinem elevatur quam aqua. Nimirum guttarum anteriorum motus si languescit, posteriores in eas incurrentes retardantur: id quod ipsismet oculis suis videre poterit, qui aquas salientes attentius contemplare voluerit. Atque inde est quod si lumen angulo quantolibet exiguo inclinetur, ut aqua saliens a perpendiculo non admodum declinare videatur, saltus altitudo statim major evadat." Wolfii *Elementa Matheseos Universæ*, tom. i. p. 802. Schol. 4.

† *De Motu Projectorum*, lib. iii. or his *Opera Geometrica*, p. 192.

of the town, the engineer has next to consider what diameter of pipe is necessary to convey the quantity of water required. The quantity of water discharged will obviously depend upon the diameter of the conduit pipe, and on the velocity with which the water issues from it. Hence, if we can find the velocity of the water, the diameter will be easily ascertained.

The experiments of which we have already given a full account, enable us to determine, with very great accuracy, the velocity with which water will issue from an orifice of any form, or from short cylindrical or conical tubes, either simple or compound; and hence we can easily ascertain the velocity with which the water will enter the pipe, or its *initial velocity;* but these experiments afford us no assistance in ascertaining the various obstructions which the water suffers in its passage, so as to determine the velocity with which it issues from a pipe of a given length and diameter.

In order to obtain practical rules relative to this interesting subject, many valuable and laborious experiments have been made. The most celebrated individuals who have devoted their attention to this branch of hydrodynamics, are Bossut, Du Buat, M. Prony, and M. Girard, by whose labours the art of conducting water has been brought to a very high degree of perfection. It shall therefore be our principal object in the present Chapter to give an account of the experiments of these eminent individuals.

SECT. I. *Account of the Experiments of Bossut and Couplet on the Motion of Water in Conduit Pipes and Open Canals.*

THE experiments of Bossut were made upon an eminence near the springs by which the town of Mezieres is supplied with water. Two reservoirs were excavated, one of which furnishes water to the second, in which it stood at a constant height. The first of these reservoirs contained from 25 to 30 cubic toises of water, and the second was considerably less in magnitude, so as to contain only about six cubic toises of water when it stood at its greatest height, which was about $4\frac{1}{2}$ feet. A horizontal tube of white iron, about eight or nine inches in diameter, communicated with the bottom of the small reservoir, and terminated in a cubical box of white iron, about one foot broad, and shut up on all sides. To one of the vertical faces of this box were fitted perpendicularly two straight pipes of white iron, one of which had sixteen lines of interior diameter, and the other twenty-four lines. Various lengths of these pipes were employed, between 30 and 180 feet. At different distances, small holes were perforated, in order to facilitate the exit of the included air. These apertures were afterwards stopped up by a little wax. In this way M. Bossut obtained the results contained in the following Table.

TABLE I. *Containing the Quantities of Water discharged by Conduit Pipes of different lengths and diameters, compared with the Quantities discharged from additional tubes inserted in the same Reservoir.*

| Constant altitude of the water in the reservoir above the axis of the tube. | Length of the conduit pipes. | Quantity of water discharged in a minute by an additional tube. (Tube and Pipe 16 lines diam.) | Quantity of water discharged by the conduit pipe in a minute. (Tube and Pipe 16 lines diam.) | Ratio between the quantities of water furnished by the tube and the pipe of 16 lines diameter. | Quantity of water discharged by an additional tube in a minute. (Tube and Pipe 24 lines diam.) | Quantity of water discharged by the conduit pipe in a minute. (Tube and Pipe 24 lines diam.) | Ratio between the quantities of water furnished by the tube and the pipe of 24 lines diameter. |
|---|---|---|---|---|---|---|---|
| Feet. | Feet. | Cubic Inches. | Cubic Inches. | | Cubic Inches. | Cubic Inches. | |
| 1 | 30 | 6330 | 2778 | 100 to 43.89 | 14243 | 7680 | 100 to 53 92 |
| 1 | 60 | 6330 | 1957 | 100 to 30 91 | 14243 | 5564 | 100 to 39.06 |
| 1 | 90 | 6330 | 1587 | 100 to 25.07 | 14243 | 4534 | 100 to 31.83 |
| 1 | 120 | 6330 | 1351 | 100 to 21.34 | 14243 | 3944 | 100 to 27.69 |
| 1 | 150 | 6330 | 1178 | 100 to 18.61 | 14243 | 3486 | 100 to 24.48 |
| 1 | 180 | 6330 | 1052 | 100 to 16.62 | 14243 | 3119 | 100 to 21.90 |
| 2 | 30 | 8939 | 4066 | 100 to 45.48 | 20112 | 11219 | 100 to 55.78 |
| 2 | 60 | 8939 | 2888 | 100 to 32.31 | 20112 | 8190 | 100 to 40.72 |
| 2 | 90 | 8939 | 2352 | 100 to 26.31 | 20112 | 6812 | 100 to 33 87 |
| 2 | 120 | 8939 | 2011 | 100 to 22 50 | 20112 | 5885 | 100 to 29.26 |
| 2 | 150 | 8939 | 1762 | 100 to 19 71 | 20112 | 5232 | 100 to 26.01 |
| 2 | 180 | 8939 | 1583 | 100 to 17.70 | 20112 | 4710 | 100 to 23.41 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

This Table contains two sets of experiments, one set on the relative quantities of water discharged by an additional tube 16 lines in diameter, and a pipe of various lengths of the same diameter; and another set on the relative quantities discharged by an additional tube 24 lines in diameter, and a pipe of various lengths and of the same diameter. The fifth and eighth columns contain the ratios of these discharges, which are also the ratios of the velocities with which the water issues from the additional tube and the extremities of the pipes.

Even at the short length of 30 feet, the velocity with which the water issues from the pipe is nearly one half of that with which it issues from the tube, and when the pipe is 180 feet long, and its diameter 16 lines, the ratio of the velocities is only 100 to 16.6, so that the water has lost 5-6ths of its initial velocity by its friction on the sides of the pipe.

It is obvious, from a comparison of columns 5 and 8, that the diminution of the velocity is greatest in small pipes; a result which arises from the friction having a much greater effect on the fluid in the axis of the small tube, than on the fluid in the axis of the great one.

By comparing the six first experiments with the six last experiments, it will be seen that as the height of the fluid in the reservoir is increased, the diminution of discharge, and consequently of velocity, is also increased. This fact is analogous to what takes place in the friction of solid bodies, which in general increases with the velocity. Perhaps, however, it may yet be found, that when a very great velocity is given to the water, its velocity may be augmented, as Coulomb found it to be in some cases in solid bodies. From the above experiments, M. Bossut concludes in general, that the quantities of water discharged in equal times by a horizontal pipe under the same height of water in the reservoir, and for different lengths, *are to one another in the inverse ratio of the square roots of the lengths*, provided that these lengths are not very different from one another. Hence when we know by experiment the quantity of water discharged for a given length of pipe, we may find the quantity discharged for any other length. Since the diminution of velocity is greatest when the head of water is small, we may conceive the head of water to be reduced to such a degree, that the velocity with which the water enters the pipe is not sufficiently powerful to overcome the resistances arising from the friction upon the pipe, and the mutual cohesion of the particles of water. In order to examine this point experimentally, M. Bossut employed a head of water only 16 lines, from which the water flowed into the two preceding pipes, when their length was a hundred and eighty feet. In this case the water was discharged in the form of a narrow fillet, and the drops succeeded each other almost as if they were insulated bodies. Hence it follows, that in order to have a perceptible and continuous discharge from conduit pipes, there should be a head of water of about 20 lines in 180 feet. If the current of water, however, is very large, such a great declivity as this will not be necessary.

As the preceding experiments relate only to pipes placed horizontally, M. Bossut proceeds to the consideration of vertical and inclined pipes. In the case of a vertical pipe, it is obvious that its motion will be accelerated during its descent through the tube, as appears in the experiment of Venturi already described. When the pipe is inclined, a similar acceleration takes place when the inclination is considerable; for if the angle of inclination were only one degree, the resistances which the fluid experiences would more than counterbalance the acceleration of gravity.

The following Table contains Bossut's experiments with a pipe, which formed the hypothenuse of a right angled triangle, the hypothenuse being to the altitude of the triangle as 2124 to 241. Its diameter was sixteen lines.

TABLE. II. *On the Quantity of Water discharged by inclined Pipes of different lengths.*

| Head of water in inches. | Diameter of pipe. | Length of the pipe. | Number of cubic inches discharged in a minute. |
|---|---|---|---|
| 10 | 16 lines. | 59 feet. | 5808 |
| 10 | 16 | 118 | 5801 |
| 10 | 16 | 177 | 5795 |

Now, an additional tube of the same diameter, and with the same head of water, would have discharged 5779 cubic inches in a minute, which is less than that which is discharged by the preceding pipes. By diminishing, however, the inclination of the above pipes, they would be brought to give the same discharge as the additional tube. This equality of discharge will take place when the inclination of the pipe is 6° 31′, or when the depression of the lower extremity of the pipe is one-eighth or one-ninth of its length. In this case the velocity, arising from the relative gravity of the water, is exactly counterbalanced by the resistance which the water experiences in the pipe.

### *On the Motion of Water in Bent Pipes.*

In order to determine the effects of flexures or bendings in conduit pipes, M. Bossut made the following experiments. The pipes were perforated with small holes to facilitate the ascent of the air. At the end of each pipe was soldered a tube M, about two inches in diameter, which communicated with the smallest of the reservoirs already mentioned. This additional tube is furnished with a stopcock R, perforated with an aperture of more than 18 lines in diameter.

TABLE III. *Shewing the quantities of Water discharged by rectilineal and curvilineal leaden Pipes, 50 feet long, 1 inch in diameter, and 1 line thick.*

| Altitude of the Water in the Reservoir. | | Form and position of the Conduit Pipes. See Plate CCCXIX. Figs. 6, 7, 8. | Quantities of Water discharged in a Minute. |
|---|---|---|---|
| Feet. | Inch. | | Cub. Inch. |
| 0 | 4 | The rectilineal tube MN, placed horizontally, Fig. 6 . . | 576 |
| 1 | 0 | The same tube similarly placed, | 1050 |
| 0 | 4 | The same tube, bent into the curvilineal form ABC, Fig. 7. each flexure lying flat on a horizontal plane, ABC being a horizontal section, . . . | 540 |
| 1 | 0 | The same tube similarly placed, | 1030 |
| 0 | 4 | The same tube placed as in Fig. 8, where ABCD is a vertical section, the parts A, B, C, D, rising above a horizontal plane, and the parts *a*, *b*, *c*, lying upon it, . . . . . | 520 |
| 1 | 0 | The same tube similarly placed, | 1028 |

It appears from this Table, that a curvilineal pipe, in which the flexures lie horizontally, discharges less water than a rectilineal pipe of the same length, and that a still greater diminution takes place when the flexures are placed in a vertical plane. When there is a number of contrary flexures in a large pipe, the air sometimes lodges in the highest parts of the flexures, and greatly retards the motion of the water. This effect may be prevented by air holes, or by stop-cocks, which can be shut when the motion of the water is perfectly established.

As the pipes employed by M. Bossut were extremely short, he has endeavoured to supply this defect by combining them with the experiments made by M. Couplet at Versailles, with pipes, several of which were more than one mile, and one nearly three miles long. The results are shewn in the following Table.

TABLE IV. *Containing the results of the Experiments of Couplet and Bossut on Conduit Pipes differing in form, length, diameter, and in the materials of which they are composed,—under different Altitudes of water in the Reservoir.*

| Altitude of the water in the reservoir. | | | Length of the conduit pipes. | Diameter of the conduit pipes. | Nature, Position, and Form of the Conduit Pipes. | Ratio between the quantities which would be discharged if the fluid experienced no resistance in the pipes, and the quantities actually discharged;—or the ratio between the initial and the final velocities of the fluid. |
|---|---|---|---|---|---|---|
| Feet. | Inch. | Lines. | Feet. | Lines. | | |
| 0 | 4 | 0 | 50 | 12 | Rectilineal and horizontal pipes made of lead . . | 100 to 3.55 |
| 1 | 0 | 0 | 50 | 12 | The same pipe similarly placed . . . | 100 to 3.18 |
| 0 | 4 | 0 | 50 | 12 | The same pipe with several horizontal flexures . . | 100 to 3.78 |
| 1 | 0 | 0 | 50 | 12 | Same pipe . . . . . . | 100 to 3.43 |
| 0 | 4 | 0 | 50 | 12 | The same pipe with several vertical flexures . . | 100 to 3.93 |
| 1 | 0 | 0 | 50 | 12 | Same pipe . . . . . . . | 100 to 3.44 |
| 1 | 0 | 0 | 180 | 16 | Rectilineal and horizontal pipe made of white iron . | 100 to 6.01 |
| 2 | 0 | 0 | 180 | 16 | Same pipe . . . . . . . | 100 to 5.69 |
| 1 | 0 | 0 | 180 | 24 | Rectilineal and horizontal pipe made of white iron . | 100 to 4.57 |
| 2 | 0 | 0 | 180 | 24 | Same pipe . . . . . . . | 100 to 4.27 |
| 20 | 11 | 0 | 177 | 16 | Rectilineal pipe made of white iron, and inclined so that its length is to the depression as 2124 is to 241 . . | 100 to 5. |
| 13 | 4 | 8 | 118 | 16 | Rectilineal pipe made of white iron, and inclined like the last | 100 to 4. |
| 6 | 8 | 4 | 159 | 16 | Rectilineal pipe made of white iron, and inclined like the last | 100 to 2.82 |
| 0 | 9 | 0 | 1782 | 48 | Conduit pipe almost entirely of iron, with several flexures both horizontal and vertical . . . | 100 to 2.85 |
| 1 | 9 | 0 | 1782 | 48 | Same pipe . . . . . . . | 100 to 26.53 |
| 2 | 7 | 0 | 1782 | 48 | Same pipe . . . . . . . | 100 to 25.79 |
| 0 | 3 | 0 | 1710 | 72 | Conduit pipe almost entirely of iron, with several flexures both horizontal and vertical . . . . | 100 to 12.35 |
| 0 | 5 | 3 | 1710 | 72 | Same pipe . . . . . . . | 100 to 11.37 |
| 0 | 5 | 7 | 7020 | 60 | Conduit pipe, partly stone and partly lead, with several flexures both horizontal and vertical . . . | 100 to 23.10 |
| 0 | 11 | 4 | 7020 | 60 | Same pipe . . . . . . . | 100 to 20.98 |
| 1 | 4 | 9 | 7020 | 60 | Same pipe . . . . . . . | 100 to 19.49 |
| 1 | 9 | 1 | 7020 | 60 | Same pipe . . . . . . . | 100 to 18.78 |
| 2 | 1 | 0 | 7020 | 60 | Same pipe . . . . . . . | 100 to 18.40 |
| 12 | 1 | 3 | 3600 | 144 | Conduit pipe made of iron, with flexures both horizontal and vertical . . . . . . . | 100 to 10.8 |
| 12 | 1 | 1 | 3600 | 216 | Conduit pipe made of iron, with several flexures both horizontal and vertical . . . . . . | 100 to 6.05 |
| 4 | 7 | 6 | 4740 | 216 | Conduit pipe made of iron, with several flexures both horizontal and vertical . . . . . . | 100 to 10.11 |
| 20 | 3 | 0 | 14040 | 144 | Conduit pipe made of iron, with several flexures both horizontal and vertical . . . . . | 100 to 17.37 |

The application of the preceding Table is very simple. Let it be required, for example, to find the diameter of a pipe capable of discharging 40,000 cubic inches of water in a minute, at a point four feet below the level of the spring, and by a pipe 2400 feet long. Now, a short cylindrical tube, one inch in diameter, will furnish 7070 cubic inches in a minute, when the head of water is four feet. Hence, to find the diameter which will discharge 40,000 cubic inches, we have the analogy $\sqrt{70720} : \sqrt{40,000} = 12$ lines : 28.54 lines, the diameter required. But it appears from the preceding Table, that when the length of the pipe is about 2400 feet, it will discharge only about one-eighth of the water, or 5000 cubic inches. Hence, in order that it may discharge the whole 40,000 cubic inches, its diameter must be increased. This new diameter will be found thus, $\sqrt{5000} : \sqrt{40,000} = 28.54$ lines to 80.72, or six lines $8\frac{7}{10}$ lines, the diameter of the pipe which will discharge 40,000 cubic inches of water in a minute.

The following Table contains the remaining experiments made by M. Bossut.

TABLE. V. *Containing Bossut's Experiments on the Quantities of Water discharged by different Pipes of various Lengths and with different Ajutages.*

| Head of Water in Feet. | Length of Pipe. | Diameter of Pipe. | Size of Orifice. | Ratio of the Real to the Theoretical Discharges. | Ratio of the Height due to the Velocity to the Head of Water. | Cubic Inches of Water discharged in a Minute. |
|---|---|---|---|---|---|---|
| Feet In. | Feet. | Lines. | Lines. | | | |
| 24 7 | 161 | 12 | $7\frac{1}{2}$ | 0.045 | 0.002 | 242 |
| 23 9 | 192 | 12 | $5\frac{1}{2}$ | 0.075 | 0.006 | 230 |
| 19 3 | 193 | 12 | $6\frac{1}{4}$ | 0 068 | 0.005 | .222 |
| 19 9 | 188 | 12 | $6\frac{1}{2}$ | 0.061 | 0.004 | 237 |
| 19 10 | 146 | 12 | $2\frac{1}{2}$ by 7 | 0.089 | 0 008 | 168 |
| 29 1 | 187 | 15 | $7\frac{1}{2}$ by $5\frac{1}{2}$ | 0.105 | 0.011 | 588 |
| 8 0 | 1069 | 18 | Two ajutages, each 6 lines | 0.435 | 0.189 | 1686 |
| 24 7 | 278 | 15 | $3\frac{1}{2}$ | 0.396 | 0.157 | 458 |
| 32 7 | 314 | 15 | Two ajutages having each 5 lines | 0.227 | 0.052 | 1232 |
| 30 5 | 446 | 18 | 2 by $6\frac{1}{2}$ | 0.037 | 0.001 | 636 |
| 26 3 | 506 | 18 | 4 | 0 447 | 0.200 | 696 |
| 27 0 | 668 | 18 | $5\frac{1}{2}$ | 0.301 | 0.091 | 900 |
| 30 0 | 812 | 18 | 11 | 0.048 | 0.002 | 600 |
| 10 5 | 194 | 12 | 5 | 0.377 | 0.139 | 576 |
| 10 11 | 462 | 12 | $5\frac{1}{2}$ | 0.332 | 0.109 | 576 |
| 10 0 | 420 | 15 | 7 | 0.163 | 0.028 | 483 |

The preceding experiments were made at Mezieres, on the 8th and 9th October, 1779, upon the water discharged from the public and private fountains of that city.

*Bossut's Experiments on the Pressure exerted upon Pipes by the Water which they convey.*

In Chap. I. of this part of hydraulics, we have already considered theoretically the amount of the pressure exerted upon conduit pipes by the included water. When a tube placed horizontally discharges water without any additional aperture, it is obvious that the weight of the included water is the principal force which it has to bear. But if the water is discharged through a small ajutage, the velocity of the water in the pipe is diminished, and hence there results a pressure against the sides. In order to measure this pressure, Bossut perforated the pipes at different lengths or distances from the reservoir with small apertures exactly perpendicular to the axis of the pipe, and considered the quantity of water discharged in a given time as the exact measure of the lateral pressure which forced the fluid through the orifice. In this way he obtained the results in the three first columns of the following Table, which is suited to an orifice $3\frac{1}{4}$ lines in diameter.

TABLE VI. *Containing the Quantities of Water discharged by a Lateral Orifice, or the Pressures on the Sides of Pipes, according to Theory and Experiment.*

| Altitude of the Water in the Reservoir. | Length of the Conduit Pipe. | Quantities of Water discharged in 1 Minute, according to Experiment. | Quantities of Water discharged in 1 minute, computed from the Formula. |
|---|---|---|---|
| Feet. | Feet. | Cubic Inches. | Cubic Inches. |
| 1 | 30 | 171 | 176 |
| 1 | 60 | 186 | 186 |
| 1 | 90 | 190 | 190 |
| 1 | 120 | 191 | 191 |
| 1 | 150 | 193 | 192 |
| 1 | 180 | 194 | 193 |
| 2 | 30 | 240 | 244 |
| 2 | 60 | 256 | 259 |
| 2 | 90 | 261 | 264 |
| 2 | 120 | 264 | 267 |
| 2 | 150 | 265 | 268 |
| 2 | 180 | 266 | 269 |

The fourth column in the preceding Table is calculated from the formula $q = Q \times \frac{\sqrt{(D^4-d^4)}}{D^2}$, which is thus obtained. We have already seen in Chap. I. of Part II. that the pressure of the fluid on the pipe is measured by $h - \frac{d^4 h}{D^4}$. Then if Q is the quantity of water which would have been discharged in a given time under the head or pressure $h$, the quantity of water $q$ discharged in the same time under the head or pressure $h - \frac{d^4 h}{D^4}$, will be thus found Q: $q = \sqrt{h} : \sqrt{\left(h - \frac{d^4 h}{D^2}\right)}$, and

$$q = Q \times \frac{\sqrt{(D4-d4)}}{D^2}.$$

The agreement of the formula with the experiments is very striking. From this method of considering the subject, M. Bossut deduces a very simple method of determining the discharge from a long tube subject to friction from the expenditure of an orifice perforated in its sides. Let $x$ denote the ratio of the expenditure of the proposed pipe having regard to friction, to the expenditure upon the supposition that there is no friction; or, which is the same thing, let $x = \frac{d^2}{D^2}$. By substituting $x$ in place of $\frac{d^2}{D^2}$ in the preceding formula, we have $q = Q\sqrt{(1 - x^2)}$, and $x = \frac{\sqrt{(Q^2-q^2)}}{Q}$. Let us now suppose that the tube has two inches diameter, that the Q head of water is 3 feet, that the lateral orifice is 6 lines, and that it discharges at the orifice 1000 cubic inches in a minute. This orifice, as appears from former experiments, would give 1178 cubic inches in a minute, if the extremity of the pipe were stopped, that is, $Q = 1178$ cubic inches, whilst $q$ is only 1000 cubic inches. By putting these values in the equation $x = \frac{\sqrt{(Q^2-q^2)}}{Q}$, we have $x = 0.5289$. But by Table II. p. 839, this additional tube would give 24504 cubic inches in a minute, abstracting the effects of friction; hence the effects of friction being included, it will discharge $0.5289 \times 24504 = 12952$ cubic inches in a minute. The preceding observations are also applicable to inclined tubes, whether straight or curved.

In the formation of pipes, it is necessary to give them a much greater thickness than that which is necessary to resist the pressure indicated by the preceding Table, for the pipes are exposed to several forces which are not taken into consideration. The following Table contains the thickness of leaden and iron pipes, which were used in France in the time of Bossut.

| Leaden Pipes. | | Iron Pipes. | |
|---|---|---|---|
| Diameter in inches. | Thickness in lines. | Diameter in inches. | Thickness in lines. |
| 1 | 2½ | 1 | 1 |
| 1½ | 3 | 2 | 3 |
| 2 | 4 | 4 | 4 |
| 3 | 5 | 6 | 5 |
| 4½ | 6 | 8 | 6 |
| 6 | 7 | 10 | 7 |
| 7 | 8 | 12 | 8 |

The thickness of pipes ought to increase with the head of water, and the strain should always be calculated from the whole height of the reservoir, and upon the supposition that the pipe is stopped at one end.

*Bossut's Experiments on the Motion of Water in Canals.*

The experiments of Bossut on this subject were made upon an open canal, the bottom of which was on a level with the bottom of the reservoir from which the water flowed. The orifice by which the water issued into the canal from the reservoir had constantly a horizontal width of 5 inches, but the height of the orifice was made to vary by raising or depressing a slider so as to obtain a rectangular opening of various heights. In order to measure the velocity of the water in the canal, Bossut tried various ways; but he ultimately preferred the method of finding it by observing the time which elapsed between the opening of the orifice, and the arrival of the water at different parts of the canal. The velocity thus found is obviously less than the velocity of the water when the current is perfectly established. But there is a constant ratio between these two velocities, in consequence of which the one may be safely inferred from the other. The canal was 105 feet long, and was divided into five equal parts and also into three equal parts; so that each of the fifth parts was 21 feet, and each of the third parts 35 feet long. In order to ascertain the arrival of the water at these different parts of the canal, small wheels like those used by children were placed at each point of division; and the commencement of their motion, which indicated the arrival of the water at that point, was instantly perceived by the person who counted the oscillations of the pendulum. When the canal was horizontal, the following were the results.

TABLE VII. *Containing the Velocity of Water in different parts of a Rectangular Horizontal Canal* 105 *feet long, under different Altitudes of Fluid in the Reservoir.*

| Altitude of water in the reservoir. | *Ft. In.* 11 8 | *Ft. In.* 7 8 | *Ft. In.* 3 8 | *Ft. In.* 11 8 | *Ft. In.* 7 8 | *Ft. In.* 3 8 | Space run through by the water. |
|---|---|---|---|---|---|---|---|
| Vertical breadth of the orifice. | ½ an inch. | ½ an inch. | ½ an inch. | 1 inch. | 1 inch. | 1 inch. | *Feet.* |
| Time in which the number of feet in column 7th are run through by the water. | 2″ | 3″— | 3″+ | 2″ | 2″+ | 3″— | 21 |
| | 5— | 7 | 9 | 4 | 5 | 6+ | 42 |
| | 10— | 13— | 17+ | 7 | 9 | 11+ | 63 |
| | 16— | 20— | 27+ | 11 | 14 | 18+ | 84 |
| | 23+ | 28+ | 38+ | 16½ | 20 | 26 | 105 |

In the preceding Table the signs + and — indicate that the number of seconds is either a little too small or a little too great.

It appears from the above Table, that the time successively employed by the water in running through spaces of 21 feet each, are as the numbers 2, 3—, 5, 6, 7 +, which form nearly an increasing arithmetical progression, the difference of whose terms is nearly 1, so that the series may be continued, and the time determined in which the water will run through any number of feet. The two serieses of the times and spaces may also be continued for the other experiments in the Table, by means of the formula $t = 1'' \times \frac{4\,E}{5\sqrt{15\,H}}$, where E is the space described uniformly in the time $t$, with a velocity due to the height H. Bossut has calculated the times for the last line of the Table, or for the whole length of 105 feet. These times are,

| | | | | | | |
|---|---|---|---|---|---|---|
| Calculated by the formula, | 6″.350, | 7″.834, | 11″.330, | 6″.350, | 7″.184, | 11″.330 |
| Observed, | 23 | 28 | 38 | 16¼ | 20 | 26 |

from which it appears that the velocity of the water in the canal is very much retarded by the different resistances which it experiences; and that the retardation is less as the height of the orifice is increased.

The following experiments were made on the motion of water in inclined canals. The inclination of the canal is the depression of its lower extremity below a horizontal line which passes through its upper extremity.

TABLE VIII. *Containing the Velocity of Water in a Rectangular inclined Canal 105 Feet long, and under different Altitudes of Fluid in the Reservoir.*

| ALTITUDE OF WATER IN THE RESERVOIR . . | *Ft. In.* 11 8 | *Ft. In.* 7 8 | *Ft. In.* 3 8 | *Ft. In.* 11 8 | *Ft. In.* 7 8 | *Ft. In.* 3 8 | Space run through by the water. |
|---|---|---|---|---|---|---|---|
| *Inclination of the canal* | *Ft. In.* 0 3 | *Ft. In* 0 3 | *Ft. In.* 0 3 | *Ft. In.* 0 6 | *Ft. In.* 0 6 | *Ft. In.* 0 6 | *Feet.* |
| Time in which the number of feet in the last col. is run through by the water. | | | | | | | |
| Height of the orifice ½ an inch . . . . | 4″ | 4″+ | 6″+ | 3″½ | 4+ | 6 | 35 |
| | 11+ | 14+ | 18+ | 11½ | 14 | 18— | 70 |
| | 22 | 26 | 34+ | 21 | 25+ | 31+ | 105 |
| *Inclination of the canal* | *Ft. In.* 0 6 | *Ft. In.* 0 6 | *Ft. In.* 0 6 | *Ft. In.* 1 0 | *Ft. In.* 1 0 | *Ft. In.* 1 0 | |
| Height of the orifice 1 inch, | 3″ | 4″— | 5″— | 3″— | 4″— | 5— | 35 |
| | 8 | 9+ | 13— | 7½ | 9 | 12 | 70 |
| | 15 | 19— | 23— | 14 | 16 | 21 | 105 |
| *Inclination of the canal* | *Ft. In.* 2 0 | *Ft. In.* 2 0 | *Ft. In.* 2 0 | *Ft. In.* 4 0 | *Ft. In.* 4 0 | *Ft. In.* 4 0 | |
| Height of the orifice 1 inch | 2″+ | 4″— | 4″ | 2″+ | 3″+ | 4+ | 35 |
| | 7 | 9— | 10½ | 6½ | 8 | 9+ | 70 |
| | 13 | 15— | 17½ | 12 | 13 | 15+ | 105 |
| *Inclination of the canal* | *Ft. In.* 6 0 | *Ft. In.* 6 0 | *Ft. In.* 6 0 | *Ft. In.* 9 0 | *Ft. In.* 9 0 | *Ft. In.* 9 0 | |
| Height of the orifice 1 inch | 2″+ | 3″ | 4″ | 2″+ | 3″+ | 4″— | 35 |
| | 6 | 7+ | 9— | 6— | 6½ | 8— | 70 |
| | 10 | 12 | 14— | 9 | 10 | 12— | 105 |
| *Inclination of the canal* | *Feet.* 11 | *Feet.* 11 | *Feet.* 11 | *Feet.* 11 | *Feet.* 11 | *Feet.* 11 | |
| | *Half sec.* | *Half sec.* | *Half sec.* | *Half sec.* | *Half sec* | *Half sec.* | |
| In the three first columns the height of the orifice was ½ an inch, and in the three last 1 inch. | 2+ | 3+ | 4+ | | 3+ | 3— | 21 |
| | 7 | 8+ | 10 | 5 | 7 | 8 | 42 |
| | 12 | 13+ | 16 | 9 | 11 | 13 | 63 |
| | 17 | 18+ | 22 | 13 | 15 | 18— | 84 |
| | 21 | 23+ | 28 | 17 | 19 | 22 | 105 |
| *Inclination of the canal* | *Feet.* 11 | *Feet.* 11 | *Feet.* 11 | | | | |
| | *Half sec* | *Half sec* | *Half sec* | | | | |
| Height of the orifice 1½ inches . . . . . | 2 | 3— | 3+ | | | | 21 |
| | 5 | 6 | 7 | | | | 42 |
| | 8+ | 10— | 11+ | | | | 63 |
| | 12 | 13+ | 15 | | | | 84 |
| | 15+ | 17 | 20 | | | | 105 |

In the preceding experiments, Bossut only observed the velocity of the first portion of the water that issued from the reservoir. In order to compare this velocity with that of the current after it is completely established, he made the experiments in the following Table; the time in which the first portion of the water moved through the spaces in col. 6. was measured by means of the small wheels already mentioned; and the time in which the established current moved through the same spaces, was ascertained by placing gently upon the water four pieces of cork, which followed exactly the current. The first portion of the canal was always run through in less time than any of the other divisions, and the velocity did not become sensibly uniform till the declivity was about the 10th part of the length of the canal.

TABLE IX. *Containing a Comparison between the Velocity of the First Portion of Water, and that of the Established Current.*

| Altitude of the water in the reservoir. | Vertical breadth of the Orifice 1 inch. | | Vertical breadth of the Orifice 2 inches. | | Space run through by the water. |
|---|---|---|---|---|---|
| | Time in which the space in col. 6. was run through by the 1st portion of water. | Time in which the space in col. 6. was run through by the established current. | Time in which the space in col. 6. was run through by the 1st portion of water. | Time in which the space in col. 6. was run through by the established current. | |
| Feet. Inch. | Seconds. | Seconds. | Seconds. | Seconds. | Feet. |
| | 10 | 8 | 8 | 7 | 100 |
| | 20+ | 17 | 17 | $14\frac{1}{2}$ | 200 |
| 4 0 | 31— | 26 | 26 | 22 | 300 |
| | 42— | 35 | 35— | 29+ | 400 |
| | $52\frac{1}{2}$ | 43+ | 43+ | 37— | 500 |
| | 62+ | 52 | 52— | 44+ | 600 |
| | 11 | 10 | 9 | 8— | 100 |
| | 23 | 20 | 19 | 16 | 200 |
| 2 0 | 35 | 30 | 29 | 24 | 300 |
| | 46+ | 40 | 39 | 32 | 400 |
| | 58 | 49 | 49 | 40 | 500 |
| | 69 | 58 | 58 | 48 | 600 |
| | 12+ | 12 | 15 | 13 | 100 |
| 1 0 | $25\frac{1}{2}$ | 23+ | 31 | $26\frac{1}{2}$ | 200 |
| | 39 | 33 | 47 | $39\frac{1}{2}$ | 300 |
| | 11— | 9 | $13\frac{1}{2}$ | $11\frac{1}{2}$ | 100 |
| 0 6 | 22 | 18— | $26\frac{3}{4}$ | 23 | 200 |
| | $32\frac{1}{2}$ | 27 | $39\frac{1}{2}$ | $33\frac{1}{2}$ | 300 |

It will be seen from these results, that the velocity of the first portion of water is always less than that of the established current, and that the one has to the other a ratio which is nearly constant. The difference between these two velocities is obviously owing to friction, and to the viscidity of the fluid. The velocity of the water in contact with the bottom of the canal is not only retarded by friction, but the weight of the superincumbent fluid; and the fluid must obviously have the greatest velocity at the surface at a point equidistant from the sides.

## SECT. II. *Account of the Researches and Experiments of the Chevalier Du Buat.*

IN the preceding investigations of Bossut, no attempt is made to deduce any very general principle or formula from which the quantity of water discharged by pipes and canals could be obtained in cases which are not comprehended in the limits of his tables. His experiments, indeed, were neither sufficiently numerous nor varied to lay the foundation of any very general rule; and it is perhaps too much to expect that the same person should have the honour both of laying the foundation, and of bringing to perfection, one of the most difficult branches of physico-mathematical science.

In the historical part of this article, we have given a full account of the origin of the labours of the Chevalier Du Buat, and have stated the general formula which he obtained for expressing in all cases the velocity of water, whether it is conveyed in a pipe or canal, or rolls in the beds of rivers. We shall now proceed to give as succinct and perspicuous a view as possible of the principal steps by which this formula was obtained, and shall then point out the method of applying the formula in practice, by means of copious Tables, which have never before been published.

Considering an inch as the unity of length, and a second as the unity of time, we may express the declivity of a canal by $\frac{1}{s}$, on the supposition that upon the length of the pipe or canal $s$ there is a fall of 1 inch. But, in order to find the slope of a conduit pipe when the height of the reservoir and the place of discharge are known, we must subtract from the height of the reservoir, the height or head of water H due to the real velocity, which, in additional tubes, is $H = \frac{V^2}{505}$; for we have already seen in p. 502, col. 2, that $V = 22.47 \sqrt{H}$. Hence $H = \frac{V^2}{22.47^2} = \frac{V^2}{505}$. The remainder which arises after this subtraction must be considered as a declivity to be distributed over the whole length of the pipe.

In considering theoretically the change which the resistances will experience by an increase of velocity, it will appear that they will increase as the squares of the velocity; for while the impulses on all the little asperities are increased in the proportion of the velocity, the number of impelling particles is also increased in the same proportion. Du Buat therefore supposes the resistances equal to $\frac{V^2}{m}$, $m$ being a constant quantity to be determined by experiment. Now, if $g$ expresses the velocity acquired by a heavy body at the end of a second, $\frac{g}{s}$ will be the accelerating force relative to the slope $\frac{1}{s}$. But from the fundamental axiom, *that when a stream moves uniformly, the resistance is equal to the accelerating force*, we obtain $\frac{V^2}{m} = \frac{g}{s}$ and $V \sqrt{s} = \sqrt{mg}$, that is, in the same pipe or canal, the product of the velocity by the reciprocal of the square root of the slope is a constant quantity; and the leading formula for all the uniform velocities is $V = \frac{\sqrt{mg}}{\sqrt{s}}$.

M. Du Buat now proceeds to examine the preceding equation experimentally, in order to ascertain if $V \sqrt{s}$ is actually a constant quantity. After comparing together the results of many accurate experiments, he finds that the values of $V \sqrt{s}$, though taken in the same pipe or canal, are not exactly equal, but that they increase a little in proportion as the velocities increase; and hence he concludes, *that the resistances are in a less ratio than the square of the velocities*. Hence the term $\sqrt{s}$ ought to be diminished. The fraction of the slope which Du Buat found to make $\sqrt{mg}$ a constant quantity, is $\sqrt{s} - \text{Log.} \sqrt{s + 1.6}$ in employing the hyperbolic logarithms. Let X represent this fraction; then we shall have $VX = \sqrt{mg}$ for the same pipe or canal.

It is manifest from theoretical considerations, as well as from direct experiment, that the resistances must have a relation to the magnitude of the section of the pipe or canal. As the resistances all arise from the friction of the water upon the sides of the tube or canal, it is obvious that they must be least in those pipes and canals in which the section has the greatest ratio to the perimeter in contact with the water; that is, the resistance of every particle of water will be in the direct ratio of the perimeter of the section, and inversely as the area of the section.

In cylindrical pipes, the section is the area of a circle; and the perimeter of the section is the circumference of the circle; and the quotient arising from dividing the one by the other is always one half of the radius; or one half of the radius multiplied by the circumference is always equal to the area of the section. In rectangular and irregular channels, there is still some line, which, multiplied by the perimeter of the section, will give an area equal to the area of the section of the channel. This line, which may be called $d$, has been named the mean radius by Du Buat, and the hydraulic mean depth by Dr. Robison.

Since the resistances increase as the ratio of the perimeter of the section to the area of the section increase, so the quantity $m$ must be proportional to $d$; and consequently $\sqrt{mg}$ must be proportional to $\sqrt{d}$ for different channels; and $\frac{\sqrt{mg}}{\sqrt{d}}$ should in every case be a constant quantity.

In examining, by experiment, if this was actually the case, Du Buat found, that $\sqrt{mg}$ was neither proportional to $\sqrt{d}$, nor to any power of $d$, but that it increased less and less in proportion as $\sqrt{d}$ increased. In very wide channels $\sqrt{mg}$ becomes sensibly proportional to $\sqrt{r}$, but in small channels the velocity diminished much more than the values of $\sqrt{r}$. Du Buat ascribes this effect to the viscidity of the water, and he found, that his experiments were completely represented by diminishing $\sqrt{d}$ by one-tenth of an inch, that is, by using $\sqrt{d} - 0.1$ insead of $\sqrt{d}$; and hence $\frac{\sqrt{mg}}{\sqrt{d} - 0.1}$ is always a constant quantity, which Du Buat found, from many experiments, to be equal to 297.

Now, since $\frac{\sqrt{mg}}{\sqrt{d} - 0.1} = 297$, we have $m = \frac{\overline{297}^2}{g}$ $(\sqrt{d} - 0.1)^2 = \frac{88209}{362} (\sqrt{d} - 0.1)^2 = 243.7 (\sqrt{d} - 0.1)^2$ (or making $n = 243.7$) $= n (\sqrt{d} - 0.1)^2$. But the resistances were expressed by $\frac{V^2}{m}$, consequently they will now be expressed by $\frac{V^2}{n (\sqrt{d} - 0.1)^2}$.

We have also $\sqrt{mg} = \sqrt{ng} (\sqrt{d} - 0.1)$, and since $VX = \sqrt{mg}$, we obtain $V = \frac{\sqrt{ng} (\sqrt{d} - 0.1)}{X} = 297 \frac{(\sqrt{d} - 0.1)}{X}$, which is an expression of the velocity V for any channel, which, X being a variable quantity, M. Du Buat next proceeds to determine.

We do not think that our readers will be much instructed in following our author in his experimental determination of X. Upon the supposition that the value X must be sensibly proportional to $\sqrt{s}$ when $s$ is great; that it must always be less than $\sqrt{s}$; that it must deviate, from the proportion of $\sqrt{s}$, so much the more that $\sqrt{s}$ is smaller; that it must not vanish when the velocity is infinite; and that it must agree with a series of experiments for every variety of channel and slope, M. Du Buat found, that these conditions would be fulfilled if we take $X = \sqrt{s} - \text{Hyp. Log.} \sqrt{s + 1.6}$. Hence $V = \frac{297 (\sqrt{d} - 0.1)}{\sqrt{s} - \text{Log.} \sqrt{s + 1.6}}$.

M. Buat next supposes, that there is a constant portion of the accelerating force employed in overcoming the viscidity, and producing the mutual separation of the adjacent filaments; and he expresses that part of the accelerating force by a part $\frac{1}{S}$ of that slope which constitutes the whole of it. If this were not employed in overcoming a resistance, it would produce a velocity which is really lost; so that, in reasoning upon this as we did upon the real velocity, its value will be $\frac{\sqrt{ng} (\sqrt{d} - 0.1)}{\sqrt{S} - \text{Log.} \sqrt{S}}$, a quantity which must always be subtracted from the velocity already determined. Hence the value of V will be $V = \frac{\sqrt{ng}(\sqrt{d}-0.1)}{\sqrt{s}-\text{Log.}\sqrt{s+1.6}} - \frac{\sqrt{ng}(\sqrt{d}-0.1)}{\sqrt{S}-\text{Log.}\sqrt{S}} = (\sqrt{d}-0.1)\left(\frac{\sqrt{ng}}{\sqrt{s}-\text{Log.}\sqrt{s+1.6}} - \frac{\sqrt{ng}}{\sqrt{S}-\text{Log.}\sqrt{S}}\right)$. But since the term $\frac{\sqrt{ng}}{\sqrt{S}-\text{Log.}\sqrt{S}}$ is composed of constant quantities, it may be expressed in a single number. The value of it was determined by many experiments to be 0.3 inches. By substituting, therefore, this value, we obtain

$$V = \frac{\sqrt{ng}(\sqrt{d}-0.1)}{\sqrt{s}-\text{Log.}\sqrt{s+1.6}} - 0.3(\sqrt{s}-0.1), \text{or in numbers,}$$

$$V = \frac{297(\sqrt{d}-0.1)}{\sqrt{s}-\text{Log.}\sqrt{s+1.6}} - 0.3(\sqrt{d}-0.1) \text{ in Fr. measure,}$$

$$V = \frac{307(\sqrt{d}-0.1)}{\sqrt{s}-\text{Log.}\sqrt{s+1.6}} - 0.3(\sqrt{d}-0.1) \text{in Eng. measure.}$$

In these expressions the following are the values of the letters employed.

V represents the mean velocity in inches per second of any current moving in a channel of indefinite length, of which the sections of the declivity are constant.

$d$ is the mean radius or hydraulic mean depth, or a quantity, which, when multiplied by the perimeter of the section of the channel, gives an area equal to the area of the section. In circular pipes $d$ is equal to half the radius.

$n$ is an abstract and constant number, which is found by experiment to be equal to 243.7.

$g$ is the velocity in inches, acquired by a falling body at the end of a second of time, being always equal to 32.174.

$s$ is the denominator of a fraction which expresses the slope of the channel, the numerator being supposed unity.

*Log.* denotes the hyperbolic logarithm of the quantity to which it is prefixed, and may be obtained by multiplying the common logarithm by 2.302581.

In order to shew the agreement of the preceding formula with experiment, M. Du Buat drew up the following Table, which contains the observed velocities as deduced from the experiments of Bossut, and from many new experiments made by Du Buat himself, and also the velocities calculated from the formula.

In the first set of experiments on pipes, col. 1. contains the number of the experiment; col. 2. the length of the pipe; col. 3. the height of the reservoir; col. 4. the values of $s$ as deduced from col 2. and 3; col. 5. the observed velocities; and col. 6. the computed velocities.

In the second set of experiments on canals and rivers, col. 2. shows the area of the section of the channel; col. 3. the perimeter of the channel in contact with the water; col. 4. the square roots of $d$, or the mean radius or hydraulic mean depth; col. 5. the denominator $s$ of the slope; col. 6. the mean velocities observed; and col. 7. the mean velocities calculated.

TABLE X. *Containing a comparison of the Velocities calculated by Du Buat's Formula, with the Velocities observed in the Experiments of Couplet, Bossut, and Du Buat, on Pipes, Canals, and Rivers.*

### SECT I. EXPERIMENTS ON PIPES.

*Experiments by the Chevalier* DU BUAT.

*Pipe $\frac{2}{3}$ of a Line in Diameter, placed Vertically and* $\sqrt{d} = 0.117851$.

| No. | Length of Pipe. | Height of Reservoir. | Values of $s$. | Observed Velocities. | Calculated Velocities. |
|---|---|---|---|---|---|
| | Inches. | Inches. | Inches. | Inches. | Inches |
| 1 | 12 | 16.166 | 0.75636 | 11.704 | 12.006 |
| 2 | 12 | 13.125 | 0.9307 | 9.753 | 10.576 |

*Pipe 1½ Line Diameter, placed Vertically, and* $\sqrt{d} = 0.176776$ *Inch.*

| | | | | | |
|---|---|---|---|---|---|
| 3 | 34.166 | 42.166 | 0.9062 | 45.468 | 46.210 |
| 4 | Do. | 38.333 | 0.9951 | 43.156 | 43.721 |
| 5 | Do. | 36.666 | 1.0396 | 42.385 | 42.612 |
| 6 | Do. | 35.333 | 1.07805 | 41.614 | 41.714 |

*The same Pipe Horizontal.*

| | | | | | |
|---|---|---|---|---|---|
| 7 | 34.166 | 14.583 | 2.5838 | 26.202 | 25.523 |
| 8 | Do. | 9.292 | 4.0367 | 21.064 | 19.882 |
| 9 | Do. | 5.292 | 7.03597 | 14.642 | 14.447 |
| 10 | Do. | 2.083 | 17.6378 | 7.320 | 2.351 |

*Pipe 2 Lines Diameter, placed Vertically, and* $\sqrt{d} = 0.204124$.

| | | | | | |
|---|---|---|---|---|---|
| 11 | 36.25 | 51.250 | 0.854509 | 67.373 | 64.945 |
| 12 | Do. | 45.250 | 0.963382 | 59.605 | 60.428 |
| 13 | Do. | 41.916 | 1.038080 | 57.220 | 57.838 |
| 14 | Do. | 38.750 | 1.120473 | 54.186 | 55.321 |

*Same Pipe with a slope of* $\frac{1}{1.3024}$.

| | | | | | |
|---|---|---|---|---|---|
| 15 | 36.25 | 33.500 | 1.291741 | 51.151 | 50.983 |

*Same Pipe Horizontal.*

| | | | | | |
|---|---|---|---|---|---|
| 16 | 36.25 | 15.292 | 2.79005 | 33.378 | 33.167 |
| 17 | Do. | 8.875 | 4.76076 | 25.430 | 24.553 |
| 18 | Do. | 5.292 | 7.89587 | 19.940 | 18.318 |
| 19 | Do. | 2.042 | 20.016366 | 10.620 | 10.492 |

*Pipe* $2\frac{9}{10}$ *Lines Diameter, placed Vertically, and* $\sqrt{d} = 0.245798$.

| No. | Length of Pipe. | Height of Reservoir. | Values of *s*. | Observed Velocities. | Calculated Velocities. |
|---|---|---|---|---|---|
| | Inches. | Inches. | Inches. | Inches. | Inches. |
| 20 | 36 25 | 53.250 | 0.952348 | 85.769 | 85.201 |
| 21 | Do. | 50.250 | 1.006424 | 82.471 | 82.461 |
| 22 | Do. | 48.333 | 1.044400 | 81.646 | 80.698 |
| 23 | Do. | 48.333 | 1.044400 | 79.948 | |
| 24 | Do. | 47 916 | 1.052952 | 81.027 | 80 318 |
| 25 | Do. | 44.750 | 1.124052 | 76.079 | 77.318 |
| 26 | Do. | 41.250 | 1.215688 | 73.811 | 73.904 |

*Same Pipe with the Slope* $\frac{1}{1.3024}$.

| No. | Length of Pipe. | Height of Reservoir. | Values of *s*. | Observed Velocities. | Calculated Velocities. |
|---|---|---|---|---|---|
| 27 | 36.25 | 37 500 | 1.332332 | 70.822 | 70.138 |

*Same Pipe Horizontal.*

| No. | Length of Pipe. | Height of Reservoir. | Values of *s*. | Observed Velocities. | Calculated Velocities. |
|---|---|---|---|---|---|
| 28 | 36.25 | 20.166 | 2.43034 | 51.956 | 50.140 |
| 29 | Do. | 9.083 | 5.26858 | 33.577 | 32.442 |
| 30 | Do. | 7.361 | 6.45035 | 28.658 | 28.801 |
| 31 | Do. | 5 000 | 9.35730 | 23.401 | 23.195 |
| 32 | Do. | 4.916 | 9.50972 | 22.989 | 22.974 |
| 33 | Do. | 4.833 | 9.66522 | 25.679 | 22.754 |
| 34 | Do. | 3.708 | 12.4624 | 19.587 | 19.550 |
| 35 | Do. | 2 713 | 16 3135 | 16.631 | 16.324 |
| 36 | Do. | 2.083 | 21.6639 | 14.295 | 14.003 |
| 37 | Do. | 1.625 | 27.5102 | 12.680 | 12.115 |
| 38 | Do. | 0.833 | 52.3427 | 7.577 | 8.215 |

*Pipes sensibly Horizontal* $\sqrt{d} = 0.5$, *or* 1 *Inch Diameter.*

| No. | Length of Pipe. | Height of Reservoir. | Values of *s*. | Observed Velocities. | Calculated Velocities. |
|---|---|---|---|---|---|
| 39 | 117 | 36.000 | 5 65026 | 84.945 | 85 524 |
| 40 | 117 | 26.666 | 7.48002 | 71.301 | 72.617 |
| 41* | 138.5 | 20 950 | 10.32149 | 58.808 | 60 034 |
| 42 | 117 | 18.000 | 10.78798 | 58.310 | 58.472 |
| 43* | 138.5 | 6.000 | 33.19623 | 29.341 | 29 663 |
| 44* | 737 | 23.700 | 33.66578 | 28.669 | 29 412 |
| 45 | Do. | 14.600 | 54.26340 | 21.856 | 22.056 |
| 46 | Do. | 13.700 | 57.77718 | 20.970 | 21.240 |
| 47 | Do. | 12 320 | 64.15725 | 19.991 | 19.950 |
| 48 | Do. | 8.96 | 87.86790 | 16.625 | 16.543 |
| 49* | Do. | 8 96 | | 16.284 | |
| 50* | Do. | 7.780 | 101.0309 | 15.112 | 15.232 |
| 51* | Do. | 5.930 | 132.1617 | 13 315 | 13.005 |
| 52* | Do. | 4 20 | 186.0037 | 10.671 | 10.656 |
| 53* | Do. | 4 20 | | 10.441 | |
| 54* | 138.5 | 0.700 | 257.8663 | 8 689 | 8 824 |
| 55* | 737 | 0.500 | 1540.76 | 3.623 | 3.218 |
| 56 | 737 | 0.150 | 5113.42 | 1.589 | 1.647 |

*Experiments of the Abbé* Bossut.

*Horizontal Pipe* 1 *Inch Diameter* $\sqrt{d} = 0.5$.

| No. | Length of Pipe. | Height of Reservoir. | Values of *s*. | Observed Velocities. | Calculated Velocities. |
|---|---|---|---|---|---|
| | Inches. | Inches. | Inches. | Inches. | Inches. |
| 57 | 600 | 12 | 54.5966 | 22.282 | 21.975 |
| 58 | 600 | 4 | 161 3120 | 12.223 | 11.756 |

*Horizontal Pipe* $1\frac{1}{3}$ *Inch Diameter* $\sqrt{d} = 0.57735$.

| No. | Length of Pipe. | Height of Reservoir. | Values of *s*. | Observed Velocities. | Calculated Velocities. |
|---|---|---|---|---|---|
| 59 | 360 | 24 | 19 0781 | 48.534 | 49.515 |
| 60 | 720 | 24 | 33.6166 | 34.473 | 35.130 |
| 61 | 360 | 12 | 37.0828 | 33.160 | 33.106 |
| 62 | 1080 | 24 | 48.35416 | 28.075 | 28.211 |
| 63 | 1440 | 24 | 64.1806 | 24.004 | 24.023 |
| 64 | 720 | 12 | 66 3020 | 23.360 | 23.345 |
| 65 | 1800 | 24 | 78.05318 | 21.032 | 21.182 |
| 66 | 2160 | 24 | 92.9474 | 18.896 | 19.096 |
| 67 | 1080 | 12 | 95.87567 | 18 943 | 18.749 |
| 68 | 1440 | 12 | 125 6007 | 16 128 | 15.991 |
| 69 | 1800 | 12 | 155.4015 | 14.066 | 14.119 |
| 70 | 2160 | 12 | 185 2487 | 12.560 | 12.750 |

*Horizontal Pipe* 2.01 *Inch Diameter* $\sqrt{d} = 0.7089458$.

| No. | Length of Pipe. | Height of Reservoir. | Values of *s*. | Observed Velocities. | Calculated Velocities. |
|---|---|---|---|---|---|
| 71 | 360 | 24 | 21.47087 | 58.903 | 58.803 |
| 72 | 720 | 24 | 35.80824 | 43. | 43.136 |
| 73 | 366 | 12 | 41.27586 | 40.322 | 39.587 |
| 74 | 1080 | 24 | 50.41193 | 35.765 | 35 096 |
| 75 | 1440 | 24 | 65.1448 | 30.896 | 30.096 |
| 76 | 720 | 12 | 70.14263 | 29.215 | 28.796 |
| 77 | 1800 | 24 | 79.84866 | 27.470 | 26.639 |
| 78 | 2160 | 24 | 94.79006 | 27.731 | 24.079 |
| 79 | 1080 | 12 | 99.4979 | 23.806 | 23.400 |
| 80 | 1440 | 12 | 129.0727 | 20.707 | 20.076 |
| 81 | 1800 | 12 | 158.75116 | 18.304 | 17.788 |
| 82 | 2160 | 12 | 188.5179 | 16.377 | 16.097 |

Couplet's *Experiments at Versailles.*

*Pipe* 5 *Inches Diameter* $\sqrt{d} = 1.118034$.

| No. | Length of Pipe. | Height of Reservoir. | Values of *s*. | Observed Velocities. | Calculated Velocities. |
|---|---|---|---|---|---|
| 83 | 84.240 | 25 | 3378 26 | 5.323 | 5.287 |
| 84 | Do. | 24 | 3518.98 | 5.213 | 5.168 |
| 85 | Do. | 21.083 | 4005.66 | 4.806 | 4.887 |
| 86 | Do. | 16 750 | 5041.61 | 4.127 | 4.225 |
| 87 | Do. | 11.333 | 7450.42 | 3.154 | 3.388 |
| 88 | Do. | 5.583 | 15119 96 | 2 0107 | 2.254 |

*Pipe* 18 *Inches Diameter* $\sqrt{d} = 2.12132$.

| No. | Length of Pipe. | Height of Reservoir. | Values of *s*. | Observed Velocities. | Calculated Velocities. |
|---|---|---|---|---|---|
| 89 | 43.200 | 145.083 | 304.9734 | 39.159 | 40.510 |

* In the experiments marked with an asterisk, the pipe discharged itself into water. In all the other experiments it discharged itself in the air.

## Sect. II. Experiments with a Wooden Canal.

*Trapezium Canal.*

| No. | Area of the Section of Canal. | Perimeter of Canal in contact with the Water. | Values of $\sqrt{d}$. | Values of $s$. | Mean Velocity observed. | Mean Velocity calculated. |
|---|---|---|---|---|---|---|
| | Inches. | Inches. | Inches. | Inch. | Inches. | Inches. |
| 90 | 18.84 | 13.06 | 1.20107 | 212 | 27.51 | 27.19 |
| 91 | 50.60 | 29.50 | 1.3096 | 212 | 28.92 | 29.88 |
| 92 | 83.43 | 26. | 1.7913 | 412 | 27.14 | 28.55 |
| 93 | 27.20 | 15.31 | 1.33290 | 427 | 18.28 | 20.39 |
| 94 | 39.36 | 18.13 | 1.47342 | 427 | 20.30 | 22.71 |
| 95 | 50.44 | 20.37 | 1.57359 | 427 | 22.37 | 24.37 |
| 96 | 56.43 | 21.50 | 1.62007 | 427 | 23.54 | 25.14 |
| 97 | 98.74 | 28.25 | 1.86955 | 432 | 28.29 | 29.06 |
| 98 | 100.74 | 28.53 | 1.87910 | 432 | 28.52 | 29.23 |
| 99 | 119.58 | 31.06 | 1.96219 | 432 | 30.16 | 30 60 |
| 100 | 126.20 | 31.91 | 1.98868 | 432 | 31.58 | 31.03 |
| 101 | 130.71 | 32.47 | 1.00637 | 432 | 31.89 | 32.32 |
| 102 | 135.32 | 33.03 | 1.02407 | 432 | 32.32 | 31.61 |
| 103 | 20.83 | 13 62 | 1.23667 | 1728 | 8.94 | 8.58 |
| 104 | 34.37 | 17. | 1.42188 | 1728 | 9.71 | 9.98 |
| 105 | 36.77 | 17.56 | 1.44708 | 1728 | 11 45 | 10.17 |
| 106 | 42.01 | 18 69 | 1.49924 | 1728 | 12.34 | 10.53 |

*Rectangular Canal.*

| No. | Area of the Section of Canal. | Perimeter of Canal in contact with the Water. | Values of $\sqrt{d}$. | Values of $s$. | Mean Velocity observed. | Mean Velocity calculated. |
|---|---|---|---|---|---|---|
| 107 | 34.50 | 21.25 | 1.27418 | 458 | 20.24 | 18.66 |
| 108 | 86.25 | 27.25 | 1.77908 | 458 | 28.29 | 26.69 |
| 109 | 34.50 | 21.25 | 1.27418 | 929 | 13.56 | 11.53 |
| 110 | 35.22 | 21.33 | 1.28499 | 1412 | 9.20 | 10.01 |
| 111 | 51.75 | 23.25 | 1.49191 | 1412 | 12.10 | 11.76 |
| 112 | 76.19 | 26.08 | 1.70921 | 1412 | 14.17 | 13.59 |
| 113 | 105.78 | 29.17 | 1.90427 | 1412 | 15.55 | 15.24 |
| 114 | 69. | 25.25 | 1.65308 | 9288 | 4 59 | 4.56 |
| 115 | 155.25 | 35.25 | 2.09868 | 9288 | 5.70 | 5 86 |

## Sect. III. Experiments on the Canal of Jard.

| No. | Area of the Section of Canal. | Perimeter of Canal in contact with the Water. | Values of $\sqrt{d}$. | Values of $s$. | Velocity observed at Surface. | Velocity calculated. |
|---|---|---|---|---|---|---|
| 116 | 16252 | 402 | 6.3583 | 8919 | 17.42 | 18 77 |
| 117 | 11905 | 366 | 5.7032 | 11520 | 12.17 | 14.52 |
| 118 | 10475 | 360 | 5.3942 | 15360 | 15.74 | 11.61 |
| 119 | 7858 | 340 | 4.8074 | 21827 | 9.61 | 8 38 |
| 200 | 7376 | 337 | 4 6784 | 27648 | 7.79 | 7.07 |
| 211 | 6125 | 324 | 4.3475 | 27648 | 7.27 | 6.55 |

*Experiments on the River Hayne.*

| No. | Area of the Section of River. | Perimeter of River in contact with the Water. | Values of $\sqrt{d}$. | Values of $s$. | Velocity at Surface. | Velocity (mean) calculated. |
|---|---|---|---|---|---|---|
| 122 | 31498 | 569 | 7 43974 | 6048 | 35 11 | 27.62 |
| 123 | 38838 | 601 | 8 03879 | 6413 | 31.77 | 28 76 |
| 124 | 36905 | 568 | 7 37632 | 32951 | 13.61 | 10 08 |
| 125 | 39639 | 604 | 8 10108 | 35723 | 15.96 | 10.53 |

The slightest inspection of the preceding Table will show the reader how much the science of hydrodynamics is indebted to the labours of M. Buat. The coincidence of the calculated with the observed velocities is extremely striking.

*New Tables for Facilitating the Application of Du Buat's Formula.*

In order to facilitate the application of the formula in practice, Dr Robison, in his dissertation on Water-works, published in his *System of Mechanical Philosophy*, has computed two tables, one of which contains calculated values of the numerator of the fractional formula, or value of V, also the value of the negative quantity 0.3 ($\sqrt{d}$—0.1) corresponding to the different values of $d$ from 0.1 to 100; while the other contains the value of the denominator of the formula for different values of $s$ from 1.0 to 24000.

As these Tables were neither sufficiently correct, nor extensive, we have inserted the following tables, which were calculated with great care and trouble by Mr John Lourie of Glasgow, who has permitted us to publish them for the first time.

The column of natural numbers has been added in this Table, which will enable the engineer to calculate the velocity V without having recourse to logarithms. The logarithmic differences are likewise added.

*Explanation of the Tables.*

Table I. contains values of the denominator of the fractional formula. Col. 1. contains the values of $s$ or the length of the pipe; and col. 2, 3, 4. the natural numbers, the hyperbolic logarithm, and the logarithmic difference from the denominator 307 ($\sqrt{d}$—0.1), all of which are computed from 1.0 to 2400.

Table II. which has not been calculated in any shape by Dr Robison, has been computed by Mr Lourie, and contains the values of the numerator 307 ($\sqrt{d}$—0.1), and the negative quantity 0.3 ($\sqrt{d}$—0.1) suited to conduit pipes of all diameters, from $\frac{1}{4}$ of an inch to 18 inches in diameter.

Table III. contains the values of the numerator of the fractional formula, and also the values of the negative quantity 0.3 ($\sqrt{d}$—0.1.) The first column contains the values of $d$, the mean radius or the hydraulic mean depth; col. 2 and 3. contain the natural numbers, and also the hyperbolic logarithms, and the logarithmic difference for the numerator 307 ($\sqrt{d}$—0.1); and col. 5. contains the values of the negative quantity 0.3 ($\sqrt{d}$—0.1), all of which are computed from 0.1 to 100.

## TABLE I.

*Containing values of* $\sqrt{s}$—Hyp. Log. $\sqrt{s+1.6}$, *the Denominator of the Fraction* $\dfrac{307(\sqrt{d}-0.1}{\sqrt{s}-\text{Hyp. Log.}\sqrt{s+1.6}}$ *for every Value of the Slope s.*

| Slope of the Pipe, or s. | $\sqrt{s}$—Hyp. Log $\sqrt{s+1.6}$ | | Log. Differ. | Slope of the Pipe, or s. | $\sqrt{s}$—Hyp. Log $\sqrt{s+1.6}$ | | Log. Differ. | Slope of the Pipe, or s. | $\sqrt{s}$—Hyp. Log. $\sqrt{s+1.6}$ | | Log. Differ. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Numbers. | Logarithms. | | | Numbers. | Logarithms. | | | Numbers. | Logarithms. | |
| 1.0 | 0.52224 | 9.71787 | | 6.0 | 1.43542 | 0.15698 | 422 | 20 | 2.93519 | 0.46772 | 1345 |
| 1.1 | 0.55218 | 9.74208 | 2421 | 6.1 | 1.44921 | 0.16113 | 415 | 21 | 3.02360 | 0.48052 | 1280 |
| 1.2 | 0.58063 | 9.76390 | 2182 | 6.2 | 1.46292 | 0.16522 | 409 | 22 | 3.10979 | 0.49273 | 1221 |
| 1.3 | 0.60782 | 9.78378 | 1988 | 6.3 | 1.47655 | 0.16925 | 403 | 23 | 3.19446 | 0.50440 | 1167 |
| 1.4 | 0.63391 | 9.80203 | 1825 | 6.4 | 1.49008 | 0.17321 | 396 | 24 | 3.27768 | 0.51557 | 1117 |
| 1.5 | 0.65904 | 9.81891 | 1688 | 6.5 | 1.50358 | 0.17713 | 392 | 25 | 3.35954 | 0.52628 | 1071 |
| 1.6 | 0.68334 | 9.83463 | 1572 | 6.6 | 1.51698 | 0.18098 | 385 | 26 | 3.44011 | 0.53657 | 1029 |
| 1.7 | 0.70688 | 9.84935 | 1472 | 6.7 | 1.53031 | 0.18478 | 380 | 27 | 3.51945 | 0.54647 | 990 |
| 1.8 | 0.72975 | 9.86318 | 1383 | 6.8 | 1.54356 | 0.18852 | 374 | 28 | 3.59762 | 0.55601 | 954 |
| 1.9 | 0.75202 | 9.87623 | 1305 | 6.9 | 1.55675 | 0.19222 | 370 | 29 | 3.67466 | 0.56522 | 921 |
| 2.0 | 0.77375 | 9.88860 | 1237 | 7.0 | 1.56987 | 0.19586 | 364 | 30 | 3.75064 | 0.57411 | 889 |
| 2.1 | 0.79497 | 9.90035 | 1175 | 7.1 | 1.58292 | 0.19946 | 360 | 31 | 3.82561 | 0.58270 | 859 |
| 2.2 | 0.81574 | 9.91155 | 1120 | 7.2 | 1.59591 | 0.20302 | 356 | 32 | 3.89959 | 0.59102 | 832 |
| 2.3 | 0.83609 | 9.92225 | 1070 | 7.3 | 1.60883 | 0.20651 | 349 | 33 | 3.97263 | 0.59908 | 806 |
| 2.4 | 0.85605 | 9.93250 | 1025 | 7.4 | 1.62168 | 0.20997 | 346 | 34 | 4.04478 | 0.60689 | 781 |
| 2.5 | 0.87565 | 9.94233 | 983 | 7.5 | 1.63448 | 0.21338 | 341 | 35 | 4.11606 | 0.61448 | 759 |
| 2.6 | 0.89491 | 9.95178 | 945 | 7.6 | 1.64721 | 0.21675 | 337 | 36 | 4.18650 | 0.62185 | 737 |
| 2.7 | 0.91386 | 9.96088 | 910 | 7.7 | 1.65988 | 0.22008 | 333 | 37 | 4.25614 | 0.62902 | 717 |
| 2.8 | 0.93252 | 9.96966 | 878 | 7.8 | 1.67250 | 0.22336 | 328 | 38 | 4.32500 | 0.63599 | 697 |
| 2.9 | 0.95090 | 9.97813 | 847 | 7.9 | 1.68505 | 0.22661 | 325 | 39 | 4.39311 | 0.64277 | 678 |
| 3.0 | 0.96902 | 9.98633 | 820 | 8.0 | 1.69755 | 0.22982 | 321 | 40 | 4.46050 | 0.64938 | 661 |
| 3.1 | 0.98690 | 9.99427 | 794 | 8.1 | 1.70999 | 0.23299 | 317 | 41 | 4.52720 | 0.65583 | 645 |
| 3.2 | 1.00455 | 0.00197 | 770 | 8.2 | 1.72237 | 0.23613 | 314 | 42 | 4.59321 | 0.66212 | 629 |
| 3.3 | 1.02197 | 0.00944 | 747 | 8.3 | 1.73470 | 0.23923 | 310 | 43 | 4.65857 | 0.66825 | 613 |
| 3.4 | 1.03919 | 0.01669 | 725 | 8.4 | 1.74699 | 0.24229 | 306 | 44 | 4.72330 | 0.67424 | 599 |
| 3.5 | 1.05621 | 0.02375 | 706 | 8.5 | 1.75921 | 0.24532 | 303 | 45 | 4.78740 | 0.68010 | 586 |
| 3.6 | 1.07304 | 0.03061 | 686 | 8.6 | 1.77139 | 0.24831 | 299 | 46 | 4.85091 | 0.68582 | 572 |
| 3.7 | 1.08968 | 0.03730 | 669 | 8.7 | 1.78353 | 0.25128 | 297 | 47 | 4.91384 | 0.69142 | 560 |
| 3.8 | 1.10616 | 0.04382 | 652 | 8.8 | 1.79558 | 0.25420 | 292 | 48 | 4.97621 | 0.69690 | 548 |
| 3.9 | 1.12247 | 0.05017 | 635 | 8.9 | 1.80760 | 0.25710 | 290 | 49 | 5.03802 | 0.70226 | 536 |
| 4.0 | 1.13862 | 0.05638 | 621 | 9.0 | 1.81957 | 0.25997 | 287 | 50 | 5.09931 | 0.70751 | 525 |
| 4.1 | 1.15461 | 0.06244 | 606 | 9.1 | 1.83150 | 0.26281 | 284 | 51 | 5.16[illegible]07 | 0.71266 | 515 |
| 4.2 | 1.17046 | 0.06836 | 592 | 9.2 | 1.84338 | 0.26561 | 280 | 52 | 5.22033 | 0.71770 | 504 |
| 4.3 | 1.18617 | 0.07415 | 579 | 9.3 | 1.85521 | 0.26839 | 278 | 53 | 5.28009 | 0.72264 | 494 |
| 4.4 | 1.20174 | 0.07981 | 566 | 9.4 | 1.86699 | 0.27114 | 275 | 54 | 5.33938 | 0.72749 | 485 |
| 4.5 | 1.21781 | 0.08535 | 554 | 9.5 | 1.87873 | 0.27387 | 273 | 55 | 5.39820 | 0.73225 | 467 |
| 4.6 | 1.23249 | 0.09078 | 543 | 9.6 | 1.89043 | 0.27656 | 269 | 56 | 5.45655 | 0.73692 | 467 |
| 4.7 | 1.24767 | 0.09610 | 532 | 9.7 | 1.90208 | 0.27923 | 267 | 57 | 5.51145 | 0.74150 | 458 |
| 4.8 | 1.26274 | 0.10131 | 521 | 9.8 | 1.91369 | 0.28187 | 264 | 58 | 5.57194 | 0.74601 | 451 |
| 4.9 | 1.27769 | 0.10643 | 512 | 9.9 | 1.92525 | 0.28449 | 262 | 59 | 5.62900 | 0.75043 | 442 |
| 5.0 | 1.29253 | 0.11144 | 501 | 10.0 | 1.93677 | 0.28708 | 259 | 60 | 5.68564 | 0.75478 | 435 |
| 5.1 | 1.30726 | 0.11636 | 492 | 11.0 | 2.04978 | 0.31171 | 2463 | 61 | 5.74187 | 0.65905 | 427 |
| 5.2 | 1.32190 | 0.12120 | 484 | 12.0 | 2.15907 | 0.33427 | 2256 | 62 | 5.79970 | 0.76326 | 421 |
| 5.3 | 1.33641 | 0.12594 | 474 | 13.0 | 2.26504 | 0.35508 | 2081 | 63 | 5.85315 | 0.76739 | 413 |
| 5.4 | 1.35084 | 0.13060 | 466 | 14.0 | 2.36802 | 0.37439 | 1931 | 64 | 5.90821 | 0.77146 | 407 |
| 5.5 | 1.36516 | 0.13518 | 458 | 15.0 | 2.46828 | 0.39239 | 1800 | 65 | 5.96290 | 0.77546 | 400 |
| 5.6 | 1.37939 | 0.13960 | 451 | 16.0 | 2.56605 | 0.40927 | 1688 | 66 | 6.01723 | 0.77940 | 394 |
| 5.7 | 1.39353 | 0.14412 | 443 | 17.0 | 2.66152 | 0.42513 | 1586 | 67 | 6.07120 | 0.78327 | 387 |
| 5.8 | 1.40758 | 0.14847 | 435 | 18.0 | 2.75488 | 0.44010 | 1497 | 68 | 6.12483 | 0.78709 | 382 |
| 5.9 | 1.42154 | 0.15276 | 429 | 19.0 | 2.84625 | 0.45427 | 1417 | 69 | 6.17811 | 0.79086 | 377 |

TABLE I. *continued.*—*Values of* $\sqrt{s}$ —Hyp. Log. $\sqrt{s+1.6}$, *the Denominator of the Fraction* $\dfrac{307(\sqrt{d}-0.1)}{\sqrt{s}-\text{Hyp. Log. }\sqrt{s+1.6}}$ *for every Value of the Slope s.*

| Slope of the Pipe, or s. | $\sqrt{s}$—Hyp. Log. $\sqrt{s+1.6}$ Numbers. | Logarithms. | Log. Differ. | Slope of the Pipe, or s. | $\sqrt{s}$—Hyp. Log. $\sqrt{s+1.6}$ Numbers. | Logarithms. | Log. Differ. | Slope of the Pipe, or s. | $\sqrt{s}$—Hyp. Log. $\sqrt{s+1.6}$ Numbers. | Logarithms. | Log. Differ. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 6.23105 | 0.79456 | 370 | 410 | 17.23843 | 1.23650 | 599 | 1200 | 31.09531 | 1.49269 | 2046 |
| 71 | 6.28367 | 0.79821 | 365 | 420 | 17.47187 | 1.24234 | 584 | 1300 | 32.46984 | 1.51148 | 1879 |
| 72 | 6.33596 | 0.80181 | 360 | 430 | 17.70269 | 1.24804 | 570 | 1400 | 33.79888 | 1.52884 | 1736 |
| 73 | 6.38794 | 0.80536 | 355 | 440 | 17.93097 | 1.25360 | 556 | 1500 | 35.07269 | 1.54497 | 1613 |
| 74 | 6.43963 | 0.80886 | 350 | 450 | 18.15680 | 1.25904 | 544 | 1600 | 36.31062 | 1.56003 | 1506 |
| 75 | 6.49096 | 0.81231 | 345 | 460 | 18.38026 | 1.26435 | 531 | 1700 | 37 51139 | 1.57416 | 1413 |
| 76 | 6.65420 | 0.81571 | 340 | 470 | 18 60142 | 1.26955 | 520 | 1800 | 38.67820 | 1.58747 | 1331 |
| 77 | 6.59270 | 0.81907 | 336 | 480 | 18.82034 | 1.27463 | 508 | 1900 | 39.81376 | 1 60004 | 1257 |
| 78 | 6.64325 | 0.82238 | 331 | 490 | 19.03711 | 1.27960 | 497 | 2000 | 40.92165 | 1.61195 | 1191 |
| 79 | 6.69345 | 0.82565 | 327 | 500 | 19.25178 | 1.28447 | 487 | 2100 | 42.00052 | 1.62325 | 1130 |
| 80 | 6.74336 | 0.82888 | 323 | 510 | 19.46441 | 1.28924 | 477 | 2200 | 43.05569 | 1.63403 | 1078 |
| 81 | 6.79294 | 0.83206 | 318 | 520 | 19.67506 | 1.29392 | 468 | 2300 | 44.08763 | 1.64432 | 1029 |
| 82 | 6.84327 | 0.83521 | 315 | 530 | 19.88378 | 1.29850 | 458 | 2400 | 45.09784 | 1.65416 | 984 |
| 83 | 6.89147 | 0.83831 | 310 | 540 | 20.09064 | 1.30299 | 449 | 2500 | 46.08761 | 1.66358 | 942 |
| 84 | 6.94031 | 0.84138 | 307 | 550 | 20.29567 | 1.30740 | 441 | 2600 | 47.05826 | 1.67264 | 906 |
| 85 | 6.98889 | 0.84441 | 303 | 560 | 20.49892 | 1.31173 | 433 | 2700 | 48.01072 | 1.68134 | 870 |
| 86 | 7.03723 | 0.84740 | 299 | 570 | 20.70045 | 1 31598 | 425 | 2800 | 48 84605 | 1.68972 | 838 |
| 87 | 7.08531 | 0.85036 | 296 | 580 | 20.90030 | 1.32015 | 417 | 2900 | 49.86514 | 1 69780 | 808 |
| 88 | 7.13315. | 0.85328 | 292 | 590 | 21.09858 | 1.32425 | 410 | 3000 | 50 76880 | 1.70560 | 780 |
| 89 | 7.18075 | 0.85617 | 289 | 600 | 21.29510 | 1.32828 | 403 | 3100 | 51.65781 | 1.71313 | 753 |
| 90 | 7.22812 | 0.85903 | 286 | 610 | 21.49014 | 1.33224 | 396 | 3200 | 52 53284 | 1.72043 | 730 |
| 91 | 7.27525 | 0.86185 | 282 | 620 | 21.68365 | 1.33613 | 389 | 3300 | 53.39454 | 1.72750 | 707 |
| 92 | 7.32215 | 0.86464 | 279 | 630 | 21 87567 | 1.33996 | 383 | 3400 | 54.24352 | 1.73435 | 685 |
| 93 | 7.36882 | 0.86740 | 276 | 640 | 22.06634 | 1.34373 | 377 | 3500 | 55.08031 | 1.74100 | 665 |
| 94 | 7.41527 | 0.87013 | 273 | 650 | 22.25538 | 1.34743 | 370 | 3600 | 55.90543 | 1.74745 | 645 |
| 95 | 7.46150 | 0.87283 | 270 | 660 | 22.44313 | 1.35108 | 365 | 3700 | 56.71937 | 1.75373 | 628 |
| 96 | 7.50752 | 0.87550 | 267 | 670 | 22.62953 | 1.35467 | 359 | 3800 | 57.52267 | 1.75984 | 611 |
| 97 | 7.55332 | 0.87814 | 264 | 680 | 22 81459 | 1.35821 | 354 | 3900 | 58.31540 | 1.76578 | 594 |
| 98 | 7.59891 | 0.88075 | 261 | 690 | 22.99835 | 1 36170 | 349 | 4000 | 59.09832 | 1.77157 | 579 |
| 99 | 7.64430 | 0.88334 | 259 | 700 | 23.18083 | 1.36513 | 343 | 4100 | 59 87168 | 1.77722 | 565 |
| 100 | 7.68948 | 0.88590 | 256 | 710 | 23.36207 | 1.36851 | 338 | 4200 | 60.63580 | 1.78273 | 551 |
| 110 | 8.13063 | 0.91012 | 2422 | 720 | 23.54208 | 1.37184 | 333 | 4300 | 61.39103 | 1.78810 | 537 |
| 120 | 8.55408 | 0.93217 | 2205 | 730 | 23.72089 | 1.37513 | 329 | 4400 | 62.13754 | 1.79335 | 525 |
| 130 | 8.96187 | 0.95240 | 2023 | 740 | 23 89854 | 1.37837 | 324 | 4500 | 62.87595 | 1.79848 | 513 |
| 140 | 9.35566 | 0.97107 | 1867 | 750 | 24.07502 | 1.37157 | 320 | 4600 | 63 60622 | 1.80350 | 502 |
| 150 | 9.73683 | 0.98842 | 1735 | 760 | 24.25038 | 1.38472 | 315 | 4700 | 64.32872 | 1.80840 | 490 |
| 160 | 10.10655 | 1.00460 | 1618 | 770 | 24 42464 | 1.38783 | 311 | 4800 | 65.04368 | 1.81320 | 480 |
| 170 | 10.46582 | 1 01977 | 1517 | 780 | 24 59781 | 1.39090 | 307 | 4900 | 65.75134 | 1.81790 | 470 |
| 180 | 10.81550 | 1.03405 | 1428 | 790 | 24 76991 | 1.39392 | 302 | 5000 | 66.45192 | 1.82251 | 461 |
| 190 | 11.15634 | 1.04752 | 1347 | 800 | 24.94097 | 1.39691 | 299 | 5100 | 67.14563 | 1.82702 | 451 |
| 200 | 11.48899 | 1.06028 | 1276 | 810 | 25.11099 | 1.39986 | 295 | 5200 | 67.83267 | 1.83144 | 442 |
| 210 | 11.81403 | 1.07240 | 1212 | 820 | 25.28001 | 1.40278 | 292 | 5300 | 68.51323 | 1.83577 | 433 |
| 220 | 12.13196 | 1.08393 | 1153 | 830 | 25.44804 | 1.40565 | 287 | 5400 | 69.18747 | 1.84003 | 426 |
| 230 | 12.44324 | 1.09493 | 1100 | 840 | 25.61510 | 1.40849 | 284 | 5500 | 69.85560 | 1 84420 | 417 |
| 240 | 12.74829 | 1.10545 | 1052 | 850 | 25.78120 | 1.41130 | 281 | 5600 | 70.51773 | 1.84830 | 410 |
| 250 | 13.04737 | 1.11553 | 1008 | 860 | 25.94636 | 1.41408 | 278 | 5700 | 71.17412 | 1.85232 | 402 |
| 260 | 13.34111 | 1 12519 | 966 | 870 | 26 11060 | 1.41682 | 274 | 5800 | 71.82479 | 1.85627 | 395 |
| 270 | 13.62951 | 1 13448 | 929 | 880 | 26 27392 | 1 41952 | 270 | 5900 | 72.46996 | 1.86016 | 389 |
| 280 | 13.91296 | 1.14342 | 894 | 890 | 26 43636 | 1.42220 | 268 | 6000 | 73.10978 | 1.86398 | 382 |
| 290 | 14.19169 | 1.15203 | 861 | 900 | 26.59791 | 1.42485 | 265 | 6100 | 73 74434 | 1.86773 | 375 |
| 300 | 14.46596 | 1.16035 | 832 | 910 | 26.75859 | 1.42746 | 261 | 6200 | 74.37381 | 1.87142 | 369 |
| 310 | 14.73596 | 1.16838 | 803 | 920 | 26.91845 | 1.43005 | 259 | 6300 | 74.99826 | 1.87505 | 363 |
| 320 | 15.00189 | 1.17615 | 777 | 930 | 27.07745 | 1.43261 | 256 | 6400 | 75.61785 | 1.87862 | 357 |
| 330 | 15.26394 | 1 18367 | 752 | 940 | 27.23563 | 1.43514 | 253 | 6500 | 76.23267 | 1.88214 | 352 |
| 340 | 15.52227 | 1 19096 | 729 | 950 | 27.39301 | 1 43764 | 250 | 6600 | 76.84286 | 1.88560 | 346 |
| 350 | 15.77704 | 1 19803 | 707 | 960 | 27.54957 | 1.44011 | 247 | 6700 | 77.44847 | 1 88901 | 341 |
| 360 | 16.02840 | 1 20489 | 686 | 970 | 27 70535 | 1 44256 | 245 | 6800 | 78.04966 | 1.89237 | 336 |
| 370 | 16.27647 | 1.21156 | 667 | 980 | 27 86036 | 1.44499 | 243 | 6900 | 78.64650 | 1.89568 | 331 |
| 380 | 16.52146 | 1 21805 | 649 | 990 | 28.01460 | 1.44738 | 236 | 7000 | 79.23905 | 1.89894 | 326 |
| 390 | 16.76330 | 1.22436 | 631 | 1000 | 28 16180 | 1 44976 | 238 | 7100 | 79 82746 | 1.90215 | 321 |
| 400 | 17 00227 | 1.23051 | 615 | 1100 | 29.66399 | 1 47223 | 2247 | 7200 | 80.41179 | 1 90532 | 317 |

TABLE I. *continued.—Values of* $\sqrt{s}$ — Hyp. Log. $\sqrt{s+1.6}$ *the Denominator of the Fraction* $\frac{307\,(\sqrt{d}-0.1)}{\sqrt{s}-\text{Hyp. Log.}\sqrt{s+1.6}}$ *for every Value of the Slope s.*

| Slope of the Pipe, or *s*. | $\sqrt{s}$— Hyp. Log. $\sqrt{s+1.6}$ Numbers. | Logarithms. | Log. Differ. | Slope of the Pipe, or *s*. | $\sqrt{s}$— Hyp. Log. $\sqrt{s+1.6}$ Numbers. | Logarithms. | Log. Differ. | Slope of the Pipe, or *s*. | $\sqrt{s}$— Hyp. Log. $\sqrt{s+1.6}$ Numbers. | Logarithms. | Log. Differ. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7300 | 80.99213 | 1.90844 | 312 | 8700 | 88.73817 | 1.94811 | 261 | 11000 | 100.22798 | 2.00099 | 2147 |
| 7400 | 81.56887 | 1.91152 | 308 | 8800 | 89.26698 | 1.95069 | 258 | 12000 | 104.84811 | 2.02056 | 1957 |
| 7500 | 82.14112 | 1.91456 | 304 | 8900 | 89.79281 | 1.95324 | 255 | 13000 | 109.28109 | 2.03854 | 1798 |
| 7600 | 82.70992 | 1.91756 | 300 | 9000 | 90.31576 | 1.95576 | 252 | 14000 | 113.54812 | 2.05518 | 1664 |
| 7700 | 83.27505 | 1.92051 | 295 | 9100 | 90.83582 | 1.95826 | 250 | 15000 | 117.66652 | 2.07065 | 1547 |
| 7800 | 83.83658 | 1.92343 | 292 | 9200 | 91.35306 | 1.96072 | 246 | 16000 | 121.65088 | 2.08511 | 1446 |
| 7900 | 84.39455 | 1.92631 | 288 | 9300 | 91.86753 | 1.96316 | 244 | 17000 | 125.51374 | 2.09869 | 1358 |
| 8000 | 84.94902 | 1.92916 | 285 | 9400 | 92.37930 | 1.96557 | 241 | 18000 | 129.26496 | 2.11148 | 1279 |
| 8100 | 85.50009 | 1.93197 | 281 | 9500 | 92.88831 | 1.96796 | 239 | 19000 | 132.91434 | 2.12357 | 1209 |
| 8200 | 86.04784 | 1.93474 | 277 | 9600 | 93.39476 | 1.97032 | 236 | 20000 | 136.46956 | 2.13504 | 1147 |
| 8300 | 86.59226 | 1.93748 | 274 | 9700 | 93.89858 | 1.97266 | 234 | 21000 | 139.93758 | 2.14593 | 1089 |
| 8400 | 87.13343 | 1.94018 | 270 | 9800 | 94.39982 | 1.97497 | 231 | 22000 | 143.32475 | 2.15632 | 1039 |
| 8500 | 87.67144 | 1.94286 | 268 | 9900 | 94.89852 | 1.97726 | 229 | 23000 | 146.63584 | 2.16624 | 992 |
| 8600 | 88.20645 | 1.94550 | 264 | 10000 | 95.39475 | 1.97952 | 226 | 24000 | 149.87637 | 2.17573 | 949 |

## TABLE II.

*Values of the Numerator* 307 ($\sqrt{d}$—0.1) *for every Value of the Hydraulic Mean Depth d, calculated for Pipes, from ¼ of an inch to* 18 *Inches Diameter; also the Value of the Factor* 0.3 ($\sqrt{d}$—0.1.)

| Diameters. | Mean Radius, or Hydraulic mean depth or values of *d*. | 307 ($\sqrt{d}$—0.1) Numbers. | Logarithms. | Log. Differ. | 0.3 × $\sqrt{d}$—0.1 | Diameters. | Mean Radius, or Hydraulic mean depth or values of *d*. | 307 ($\sqrt{d}$—0.1) Numbers. | Logarithms. | Log. Differ. | 0.3 × $\sqrt{d}$—0.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0¼ | 0.0625 | 46.050 | 1.66323 | | 0.045 | 9¼ | 2.3125 | 436.152 | 2.63964 | 637 | 0.426 |
| 0½ | 0.125 | 77.841 | 1.89121 | 22798 | 0.076 | 9½ | 2.375 | 442.419 | 2.64583 | 619 | 0.432 |
| 0¾ | 0.1875 | 102.235 | 2.00960 | 11839 | 0.100 | 9¾ | 2.4375 | 448.604 | 2.65186 | 603 | 0.438 |
| 1 | 0.25 | 122.800 | 2.08920 | 7960 | 0.120 | 10 | 2.5 | 454.710 | 2.65773 | 587 | 0.444 |
| 1¼ | 0.3125 | 140.918 | 2.14897 | 5977 | 0.138 | 10¼ | 2.5625 | 460.740 | 2.66346 | 573 | 0.450 |
| 1½ | 0.375 | 157.298 | 2.19672 | 4775 | 0.154 | 10½ | 2.625 | 466.697 | 2.66903 | 557 | 0.456 |
| 1¾ | 0.4375 | 172.561 | 2.23644 | 3972 | 0.168 | 10¾ | 2.6875 | 472.583 | 2.67448 | 545 | 0.462 |
| 2 | 0.5 | 186.382 | 2.27040 | 3396 | 0.182 | 11 | 2.75 | 478.402 | 2.67979 | 531 | 0.467 |
| 2¼ | 0.5625 | 199.550 | 2.30005 | 2965 | 0.195 | 11¼ | 2.8125 | 484.155 | 2.68498 | 519 | 0.473 |
| 2½ | 0.625 | 212.005 | 2.32635 | 2630 | 0.207 | 11½ | 2.875 | 489.844 | 2.69006 | 508 | 0.479 |
| 2¾ | 0.6875 | 223.851 | 2.34996 | 2361 | 0.219 | 11¾ | 2.9375 | 495.471 | 2.69502 | 496 | 0.484 |
| 3 | 0.75 | 235.170 | 2.37138 | 2142 | 0.230 | 12 | 3. | 501.040 | 2.69987 | 485 | 0.490 |
| 3¼ | 0.8125 | 246.026 | 2.39098 | 1960 | 0.240 | 12¼ | 3.0625 | 506.550 | 2.70462 | 475 | 0.495 |
| 3½ | 0.875 | 256.472 | 2.40904 | 1806 | 0.251 | 12½ | 3.125 | 512.004 | 2.70927 | 465 | 0.500 |
| 3¾ | 0.9375 | 266.551 | 2.42578 | 1674 | 0.260 | 12¾ | 3.1875 | 517.405 | 2.71383 | 456 | 0.506 |
| 4 | 1. | 276.300 | 2.44138 | 1560 | 0.270 | 13 | 3.25 | 522.752 | 2.71830 | 447 | 0.511 |
| 4¼ | 1.0625 | 285.748 | 2.45598 | 1460 | 0.279 | 13¼ | 3.3125 | 528.049 | 2.72267 | 437 | 0.516 |
| 4½ | 1.125 | 294.923 | 2.46971 | 1373 | 0.288 | 13½ | 3.375 | 533.295 | 2.72697 | 430 | 0.521 |
| 4¾ | 1.1875 | 303.846 | 2.48265 | 1294 | 0.297 | 13¾ | 3.4375 | 538.493 | 2.73118 | 421 | 0.526 |
| 5 | 1.25 | 312.536 | 2.49490 | 1225 | 0.305 | 14 | 3.5 | 543.644 | 2.73531 | 413 | 0.531 |
| 5¼ | 1.3125 | 321.013 | 2.50652 | 1162 | 0.314 | 14¼ | 3.5625 | 548.750 | 2.73937 | 406 | 0.536 |
| 5½ | 1.375 | 329.289 | 2.51758 | 1106 | 0.322 | 14½ | 3.625 | 553.811 | 2.74336 | 399 | 0.541 |
| 5¾ | 1.4375 | 337.380 | 2.52812 | 1054 | 0.330 | 14¾ | 3.6875 | 558.828 | 2.74728 | 392 | 0.546 |
| 6 | 1.5 | 345.297 | 2.53819 | 1007 | 0.337 | 15 | 3.75 | 563.803 | 2.75113 | 385 | 0.551 |
| 6¼ | 1.5625 | 353.050 | 2.54784 | 965 | 0.345 | 15¼ | 3.8125 | 568.737 | 2.75491 | 378 | 0.556 |
| 6½ | 1.625 | 360.650 | 2.55709 | 925 | 0.352 | 15½ | 3.875 | 573.630 | 2.75863 | 372 | 0.561 |
| 6¾ | 1.6875 | 368.105 | 2.56597 | 888 | 0.360 | 15¾ | 3.9375 | 578.484 | 2.76229 | 366 | 0.565 |
| 7 | 1.75 | 375.423 | 2.57452 | 855 | 0.367 | 16 | 4. | 583.300 | 2.76589 | 360 | 0.570 |
| 7¼ | 1.8125 | 382.611 | 2.58276 | 824 | 0.374 | 16¼ | 4.0625 | 588.078 | 2.76943 | 254 | 0.575 |
| 7½ | 1.875 | 389.677 | 2.59070 | 794 | 0.381 | 16½ | 4.125 | 592.820 | 2.77292 | 349 | 0.579 |
| 7¾ | 1.9375 | 396.626 | 2.59838 | 768 | 0.388 | 16¾ | 4.1875 | 597.526 | 2.77636 | 344 | 0.584 |
| 8 | 2. | 403.464 | 2.60580 | 742 | 0.394 | 17 | 4.25 | 602.197 | 2.77974 | 338 | 0.588 |
| 8¼ | 2.0625 | 410.195 | 2.61299 | 719 | 0.401 | 17¼ | 4.3125 | 606.833 | 2.78307 | 333 | 0.593 |
| 8½ | 2.125 | 416.826 | 2.61995 | 696 | 0.407 | 17½ | 4.375 | 611.437 | 2.78635 | 328 | 0.597 |
| 8¾ | 2.1875 | 423.359 | 2.62671 | 676 | 0.414 | 17¾ | 4.4375 | 616.007 | 2.78958 | 323 | 0.602 |
| 9 | 2.25 | 529.800 | 2.63327 | 656 | 0.420 | 18 | 4.5 | 620.545 | 2.79277 | 319 | 0.606 |

## TABLE III.

*Values of the Numerator* 307 $(\sqrt{d}-0.1)$ *for every Value of the Hydraulic Mean Depth d; also the Values of the Factor* 0.3 $(\sqrt{d}-0.1)$.

| Mean Radius, or Hydraulic mean depth or values of *d*. | 307 $(\sqrt{d}-0.1)$ Numbers. | Logarithms. | Log. Differ. | 0.3 × $\sqrt{d}-0.1$ | Mean Radius or Hydraulic mean depth or values of *d*. | 307 $(\sqrt{d}-0.1)$ Numbers. | Logarithms. | Log. Differ. | 0.3 × $\sqrt{d}-0.1$ |
|---|---|---|---|---|---|---|---|---|---|
| 0.1 | 66.382 | 1.82205 | | 0.065 | 5.5 | 689.279 | 2.83839 | 416 | 0.674 |
| 0.2 | 106.595 | 2.02774 | 20569 | 0.104 | 5.6 | 695.795 | 2.84248 | 409 | 0.680 |
| 0.3 | 137.451 | 2.13815 | 11041 | 0.134 | 5.7 | 702.253 | 2.84649 | 401 | 0.686 |
| 0.4 | 163.464 | 2.21342 | 7527 | 0.160 | 5.8 | 708.654 | 2.85043 | 394 | 0.692 |
| 0.5 | 186.382 | 2.27040 | 5698 | 0.182 | 5.9 | 715.000 | 2.85431 | 388 | 0.699 |
| 0.6 | 207.101 | 2.31618 | 4578 | 0.202 | 6.0 | 721.293 | 2.85811 | 380 | 0.705 |
| 0.7 | 226.155 | 2.35441 | 3823 | 0.221 | 6.1 | 727.534 | 2.86185 | 374 | 0.711 |
| 0.8 | 243.889 | 2.38719 | 3278 | 0.238 | 6.2 | 733.724 | 2.86553 | 368 | 0.717 |
| 0.9 | 260.458 | 2.41588 | 2869 | 0.255 | 6.3 | 739.864 | 2.86915 | 362 | 0.723 |
| 1.0 | 276.300 | 2.44138 | 2550 | 0.270 | 6.4 | 745.955 | 2.87271 | 356 | 0.729 |
| 1.1 | 291.285 | 2.46432 | 2294 | 0.285 | 6.5 | 752.000 | 2.87622 | 351 | 0.735 |
| 1.2 | 305.602 | 2.48516 | 2084 | 0.299 | 6.6 | 757.997 | 2.87967 | 345 | 0.741 |
| 1.3 | 319.334 | 2.50425 | 1909 | 0.312 | 6.7 | 763.950 | 2.88306 | 339 | 0.747 |
| 1.4 | 332.548 | 2.52185 | 1760 | 0.325 | 6.8 | 769.858 | 2.88641 | 335 | 0.752 |
| 1.5 | 345.297 | 2.53819 | 1634 | 0.337 | 6.9 | 775.723 | 2.88971 | 330 | 0.758 |
| 1.6 | 357.628 | 2.55343 | 1524 | 0.349 | 7.0 | 781.545 | 2.89295 | 324 | 0.764 |
| 1.7 | 369.679 | 2.56771 | 1428 | 0.361 | 7.1 | 787.327 | 2.89615 | 320 | 0.769 |
| 1.8 | 381.184 | 2.58113 | 1342 | 0.372 | 7.2 | 793.068 | 2.89931 | 316 | 0.775 |
| 1.9 | 392.470 | 2.59381 | 1268 | 0.384 | 7.3 | 798.768 | 2.90242 | 311 | 0.781 |
| 2.0 | 403.464 | 2.60580 | 1199 | 0.394 | 7.4 | 804.430 | 2.90549 | 307 | 0.786 |
| 2.1 | 414.185 | 2.61719 | 1139 | 0.405 | 7.5 | 810.054 | 2.90851 | 302 | 0.792 |
| 2.2 | 424.655 | 2.62804 | 1085 | 0.415 | 7.6 | 815.641 | 2.91150 | 299 | 0.797 |
| 2.3 | 434.888 | 2.63838 | 1034 | 0.425 | 7.7 | 821.190 | 2.91444 | 294 | 0.802 |
| 2.4 | 444.902 | 2.64826 | 988 | 0.435 | 7.8 | 826.704 | 2.91725 | 291 | 0.808 |
| 2.5 | 454.710 | 2.65773 | 947 | 0.444 | 7.9 | 832.183 | 2.92022 | 287 | 0.813 |
| 2.6 | 464.323 | 2.66681 | 908 | 0.454 | 8.0 | 837.627 | 2.92305 | 283 | 0.819 |
| 2.7 | 473.753 | 2.67555 | 874 | 0.463 | 8.1 | 843.037 | 2.92585 | 280 | 0.824 |
| 2.8 | 483.003 | 2.68395 | 840 | 0.472 | 8.2 | 848.414 | 2.92861 | 276 | 0.829 |
| 2.9 | 492.102 | 2.69205 | 810 | 0.481 | 8.3 | 853.758 | 2.93133 | 272 | 0.834 |
| 3.0 | 501.040 | 2.69987 | 782 | 0.490 | 8.4 | 859.070 | 2.93403 | 270 | 0.839 |
| 3.1 | 509.829 | 2.70743 | 756 | 0.498 | 8.5 | 864.351 | 2.93669 | 266 | 0.845 |
| 3.2 | 518.478 | 2.71473 | 730 | 0.507 | 8.6 | 869.601 | 2.93932 | 263 | 0.850 |
| 3.3 | 526.993 | 2.72180 | 707 | 0.515 | 8.7 | 874.820 | 2.94192 | 260 | 0.855 |
| 3.4 | 535.380 | 2.72866 | 686 | 0.523 | 8.8 | 880.009 | 2.94449 | 257 | 0.860 |
| 3.5 | 543.644 | 2.73531 | 665 | 0.531 | 8.9 | 785.169 | 2.94703 | 254 | 0.865 |
| 3.6 | 551.792 | 2.74177 | 646 | 0.539 | 9.0 | 890.300 | 2.94954 | 251 | 0.870 |
| 3.7 | 559.826 | 2.74805 | 628 | 0.547 | 9.1 | 895.403 | 2.95202 | 248 | 0.875 |
| 3.8 | 567.753 | 2.75416 | 611 | 0.555 | 9.2 | 900.447 | 2.95447 | 245 | 0.880 |
| 3.9 | 575.576 | 2.76010 | 594 | 0.562 | 9.3 | 905.424 | 2.95690 | 243 | 0.885 |
| 4.0 | 583.300 | 2.76589 | 579 | 0.570 | 9.4 | 910.544 | 2.95930 | 240 | 0.890 |
| 4.1 | 590.928 | 2.77153 | 564 | 0.577 | 9.5 | 915.537 | 2.96168 | 238 | 0.895 |
| 4.2 | 598.463 | 2.77704 | 551 | 0.585 | 9.6 | 920.505 | 2.96403 | 235 | 0.900 |
| 4.3 | 605.909 | 2.78241 | 537 | 0.592 | 9.7 | 925.446 | 2.96635 | 232 | 0.904 |
| 4.4 | 613.269 | 2.78765 | 524 | 0.599 | 9.8 | 930.362 | 2.96865 | 230 | 0.909 |
| 4.5 | 620.545 | 2.79277 | 512 | 0.606 | 9.9 | 935.253 | 2.97093 | 228 | 0.914 |
| 4.6 | 627.742 | 2.79778 | 501 | 0.613 | 10.0 | 940.119 | 2.97318 | 225 | 0.919 |
| 4.7 | 634.860 | 2.80268 | 490 | 0.620 | | | | | |
| 4.8 | 641.903 | 2.80747 | 479 | 0.627 | 11 | 987.504 | 2.99454 | 2136 | 0.965 |
| 4.9 | 648.773 | 2.81216 | 469 | 0.634 | 12 | 1032.779 | 3.01401 | 1947 | 1.009 |
| 5.0 | 655.673 | 2.81675 | 459 | 0.641 | 13 | 1076.204 | 3.03189 | 1788 | 1.051 |
| 5.1 | 662.604 | 2.82125 | 450 | 0.647 | 14 | 1117.989 | 3.04844 | 1655 | 1.092 |
| 5.2 | 669.368 | 2.82566 | 441 | 0.654 | 15 | 1158.306 | 3.06382 | 1538 | 1.131 |
| 5.3 | 665.067 | 2.82999 | 433 | 0.661 | 16 | 1197.500 | 3.07820 | 1438 | 1.170 |
| 5.4 | 682.704 | 2.83423 | 424 | 0.667 | 17 | 1235.093 | 3.09170 | 1350 | 1.207 |

### TABLE III. *Continued.*

*Values of the Numerator* 307 ($\sqrt{d}$—0.1) *for every Value of the Hydraulic Mean Depth* d ; *also the Value of the Factor* 0.3 ($\sqrt{d}$—0.1.)

| Mean Radius, or Hydraulic mean depth or values of *d*. | 307 ($\sqrt{d}$—0.1) Numbers. | Logarithms. | Log. Differ. | 0.3 × $\sqrt{d}$—0.1 | Mean Radius, or Hyraulic mean depth or values of *d*. | 307 ($\sqrt{d}$—0.1). Numbers. | Logarithms. | Log Differ. | 0.3 × $\sqrt{d}$—0.1 |
|---|---|---|---|---|---|---|---|---|---|
| 18 | 1271.791 | 3.10442 | 1272 | 1.243 | 60 | 2347.312 | 3.37057 | 370 | 2.293 |
| 19 | 1307.482 | 3.11644 | 1202 | 1.278 | 61 | 2367.046 | 3.37421 | 364 | 2.313 |
| 20 | 1342.246 | 3.12783 | 1139 | 1.312 | 62 | 2386.621 | 3.37778 | 357 | 2.332 |
| 21 | 1376.150 | 3.13866 | 1083 | 1.345 | 63 | 2406.037 | 3.38130 | 352 | 2.351 |
| 22 | 1409.258 | 3.14899 | 1033 | 1.377 | 64 | 2425.300 | 3.38477 | 347 | 2.370 |
| 23 | 1441.620 | 3.15885 | 986 | 1.409 | 65 | 2444.413 | 3.38817 | 340 | 2.389 |
| 24 | 1473.286 | 3.16829 | 944 | 1.440 | 66 | 2463.380 | 3.39153 | 336 | 2.407 |
| 25 | 1504.300 | 3.17733 | 904 | 1.470 | 67 | 2482.203 | 3.39484 | 331 | 2.426 |
| 26 | 1534.699 | 3.18602 | 869 | 1.500 | 68 | 2500.887 | 3.39809 | 325 | 2.[illegible]44 |
| 27 | 1564.519 | 3.19438 | 836 | 1.529 | 69 | 2519.434 | 3.40130 | 321 | 2.462 |
| 28 | 1593.791 | 3.20243 | 805 | 1.557 | 70 | 2537.846 | 3.40446 | 316 | 2.480 |
| 29 | 1622.546 | 3.21020 | 777 | 1.586 | 71 | 2556.128 | 3.40758 | 312 | 2.498 |
| 30 | 1650.808 | 3.21770 | 750 | 1.613 | 72 | 2574.282 | 3.41066 | 308 | 2.516 |
| 31 | 1678.604 | 3.22496 | 726 | 1.640 | 73 | 2592.310 | 3.41369 | 303 | 2.533 |
| 32 | 1705.954 | 3.23197 | 701 | 1.667 | 74 | 2610.224 | 3.41668 | 299 | 2.551 |
| 33 | 1732.881 | 3.23877 | 680 | 1.693 | 75 | 2627.998 | 3.41962 | 294 | 2.568 |
| 34 | 1759.402 | 3.24536 | 659 | 1.719 | 76 | 2645.664 | 3.42253 | 291 | 2.585 |
| 35 | 1785.536 | 3.25177 | 641 | 1.745 | 77 | 2663.214 | 3.42541 | 288 | 2.602 |
| 36 | 1811.300 | 3.25799 | 622 | 1.770 | 78 | 2680.651 | 3.42824 | 283 | 2.619 |
| 37 | 1836.708 | 3.26404 | 605 | 1.795 | 79 | 2697.976 | 3.43104 | 280 | 2.636 |
| 38 | 1861.775 | 3.26993 | 589 | 1.819 | 80 | 2715.191 | 3.43380 | 276 | 2.653 |
| 39 | 1886.514 | 3.27566 | 573 | 1.843 | 81 | 2732.300 | 3.43653 | 273 | 2.670 |
| 40 | 1910.938 | 3.28125 | 559 | 1.867 | 82 | 2749.304 | 3.43922 | 269 | 2.687 |
| 41 | 1935.059 | 3.28669 | 544 | 1.891 | 83 | 2766.204 | 3.44188 | 266 | 2.703 |
| 42 | 1958.887 | 3.39201 | 532 | 1.914 | 84 | 2783.002 | 3.44451 | 263 | 2.720 |
| 43 | 1982.434 | 3.29720 | 519 | 1.937 | 85 | 2799.700 | 3.44711 | 260 | 2.736 |
| 44 | 2005.708 | 3.30227 | 507 | 1.960 | 86 | 2816.301 | 3.44968 | 257 | 2.752 |
| 45 | 2028.719 | 3.30722 | 495 | 1.982 | 87 | 2832.906 | 3.45223 | 255 | 2.768 |
| 46 | 2051.475 | 3.31207 | 485 | 2.005 | 88 | 2849.215 | 3.45473 | 250 | 2.784 |
| 47 | 2073.986 | 3.31681 | 474 | 2.027 | 89 | 2865.532 | 3.45721 | 248 | 2.800 |
| 48 | 2096.258 | 3.32144 | 463 | 2.048 | 90 | 2881.758 | 3.45966 | 245 | 2.816 |
| 49 | 2118.300 | 3.32599 | 455 | 2.070 | 91 | 2897.893 | 3.46208 | 242 | 2.832 |
| 50 | 2140.118 | 3.33044 | 445 | 2.091 | 92 | 2913.940 | 3.46448 | 240 | 2.847 |
| 51 | 2161.718 | 3.33480 | 436 | 2.112 | 93 | 2929.900 | 3.46685 | 237 | 2.863 |
| 52 | 2183.109 | 3.33908 | 428 | 2.133 | 94 | 2945.776 | 3.46920 | 235 | 2.879 |
| 53 | 2204.204 | 3.34328 | 420 | 2.154 | 95 | 2961.565 | 3.47152 | 232 | 2.894 |
| 54 | 2225.280 | 3.34738 | 410 | 2.175 | 96 | 2977.274 | 3.47382 | 230 | 2.909 |
| 55 | 2246.073 | 3.35142 | 404 | 2.195 | 97 | 2992.900 | 3.47609 | 227 | 2.925 |
| 56 | 2266.678 | 3.35539 | 397 | 2.215 | 98 | 3008.445 | 3.47834 | 225 | 2.940 |
| 57 | 2287.100 | 3.35928 | 389 | 2.235 | 99 | 3023.912 | 3.48057 | 223 | 2.955 |
| 58 | 2307.343 | 3.36311 | 383 | 2.255 | 100 | 3039.300 | 3.48277 | 220 | 2.970 |
| 59 | 2327.411 | 3.36687 | 376 | 2.274 | | | | | |

*Method of Using the preceding Tables.*

Example I. Water is brought into Edinburgh by several pipes, one of which is 5 inches in diameter. This pipe is 14,367* feet long, and the reservoir at Comiston is 44 feet higher than the reservoir on the Castle-hill into which the water is delivered. It is required to know how many Scots pints the pipe should deliver in a minute.

1. In this case we have $d = \frac{5}{4} = 1.25$ inches.

2. We have $s = \frac{14,367}{44} = 326.36$.

Now, by entering Table III. with 1.25 as the value of $d$, and Table I. with 326 as the value of $s$, we obtain

2.49490 as the logarithm for the *numerator*, and
1.18065 as the logarithm corresponding to 326.36.
——— the difference of which logarithms is
1.31425 the logarithm of 20.618, or the value of

$$\frac{307(\sqrt{d}-01)}{\sqrt{s} - \text{Hyp. Log.} \sqrt{s+1.6}}$$

In order to find the value of the negative quantity 0.3 ($\sqrt{d}$—0.1) enter Table III. col. 1. with 1.25, and in col. 5. will be found, by taking proportional parts, 0.305 ; hence we have the velocity V=20.618—0.305=20.313, the velocity of the water in inches per second.

The whole of the preceding operation may be saved by Table II.; for, by entering col. 1. of this Table with five inches as the diameter of the pipe, we obtain at once 2.49490, and 0.305 as the values of the numerator and the negative quantity. In order to obtain the number of Scotch pints per minute, each of which contains 103.4 cubic inches, we must multiply the velocity by 60″, and this product by $5^2$ or 25, and then by 0.7854, the area of a circle whose diameter is 1, and then divide by 103.4. Thus,

| | | |
|---|---|---|
| Log. of | 20.313 | 1.3077741 |
| Log. of | 60″ | 1.7781513 |
| Log. of | $5^2$ or 25 | 1.3979400 |
| Log. of | 0.7854 | 9.8950909 |
| | From | 4 3789563 |
| Subtract Log. of | 103.4 | 2.0145205 |
| Remains Log. of | 231.44 | 2.3644358 |

Scots pints which should be delivered by the pipe.

Now, the pipe, when in its best order, yielded 250 pints in a minute, as we have learned from a MS. note of Dr. Robison.

Since the logarithm of 60, of .7854, and of 103.4 is constant, we may take 1.7781513+9.8950909— 2.0145205 =9.6587217, and the operation will stand thus :

| | |
|---|---|
| Log. of 20.313 | 1.3077741 |
| Log. of $5^2$ | 1.3979400 |
| Log. for reducing to Scotch pints | 9.6587217 |
| Log. of 231.44 as before. | 2.3644358 |

Hence we have the following Rule: Add together the logai. hm of the velocity in inches per second, as found by the formula, the logarithm of the square of the diameter of the pipe, and the constant logarithm 9.6587213, and the sum is the logarithm of the Scotch pints discharged in a minute.

The facts in the preceding example respecting the supply of Edinburgh with water was taken from Dr Robison's article on Waterworks already quoted. We are informed, however, by James Jardine, Esq. civil engineer, that the facts are wholly erroneous, and we have been indebted to the kindness of this gentleman for the following state of the Edinburgh water pipes, to which we shall apply the formula of Du Buat.

Example II. An excellent cast leaden pipe was laid from the fountain head at Comiston to the reservoir on the Castlehill of Edinburgh in the year 1720. The interior diameter of the pipe was $4\frac{1}{2}$ inches, the fountain-head was 51 feet above the point of delivery, and the length of the pipe was 14,930 feet. Its maximum discharge during the years 1738, 1739, 1740, 1741, and 1742, was $11\frac{1}{3}$ cubic feet, or 189.4 Scotch pints per minute.

In this example we have $d = \frac{4\frac{1}{2}}{4} = 1.125$

$$s = \frac{14930}{51} = 292.745$$

| | | |
|---|---|---|
| Log. of numerator | | 2.46971 |
| Log. of denominator | | 1.15431 |
| Log. of | 20.673 | 1.31540 |
| Subtract negative quantity | .288 | |
| Remains | 20.385 the velocity per second. | |
| Hence | | |
| Log. of 20.385 | | 1.3093107 |
| Log. of $\overline{4\frac{1}{2}}^2$ or 20.25 | | 1.3064250 |
| Log. for reducing to Scotch pints | | 9.6587217 |
| Log. of 188.13 Scotch pints | | 2.2744574 |

A result which agrees in a very wonderful manner with 189.4, the quantity actually delivered by the pipe.

Example III. A flanch cast iron pipe is laid from Swanston cistern to the reservoir on the Castlehill, Edinburgh. Its diameter is seven inches ; the cistern at Swanston is 222 feet higher than the point of delivery, the length of the pipe is 21,350 feet, and in its best state it delivers $3\frac{1}{2}$ cubic feet, or 593.3 Scotch pints in a minute.

In this case we have $d = \frac{7}{4} = 1.75$

$$s = \frac{21350}{222} = 96.17.$$

| | | |
|---|---|---|
| Log. of numerator | | 2.57452 |
| Log. of denominator | | 0.87595 |
| Log. of | 49.964 | 1.69857 |
| Subtract negative quantity | .367 | |
| Remains | 49.597 the velocity per second. | |
| Log. of | 49.597 | 1.695447 |
| Log. of | $7^2$ or 49 | 1.690196 |
| Log. for reducing to Scotch pints | | 9.658721 |
| Log. of 1107.5 | | 3.044364 |

* Dr Robison, who applied his tables to this example, makes the length of the pipe 14,637 by mistake, and has corrected it to 14,367 in his MS. notes.

Hence the discharge is 1107.5 Scotch pints, which differs so widely from 593.3, the quantity actually delivered, that there must have been some unknown obstruction in the pipe.

The cast iron main, five inches in diameter, which is laid from Comiston to Edinburgh, was always very defective in its delivery. Though its length is only 13.518 feet, and the height of the fountain above the point of delivery 88 feet, yet it yields only ten cubic feet, or 167.7 Scotch pints per minute.

Example IV. Mr Watt found, from very careful measurements, that a canal in his neighbourhood, which was 18 feet wide at the surface, 7 feet wide at the bottom, 4 feet deep, and had a declivity of 4 inches in a mile, moved with a velocity of 17 inches per second at the surface, 14 inches in the middle, and 10 at the bottom: the mean velocity being 13.3.

Now, since the sloping side of a canal corresponding to 4 feet deep, and $\frac{18-7}{2}=5\frac{1}{2}$ of projection, is 6.8 feet, we have for the perimeter of the section in contact with the water, $6.8+7+6.8=20.6$. The area of the section will therefore be $4\times\frac{18+7}{2}=50$ square feet. Hence $d=\frac{50}{20.6}=2.4272$, or 29.126. The logarithm corresponding to this in Table III. is 3.21117, and the value of the negative quantity in col. 5. is 1.589.

Now, since the slope is 4 inches, or $\frac{1}{3}$ of a foot in a mile, we have $s=15.840$, and the corresponding logarithm in the table 2.08280. Hence

| | |
|---|---|
| From | 3.21117 |
| Subtract | 2.08280 |

| | | |
|---|---|---|
| And there remains | 1.12837 = Log. of 13.439 inches | |
| Subtract the negative quantity | | 1.589 |
| And there remains | | 11.850 inches, |

the velocity of the canal per second required, which differs considerably from 13.33, the mean velocity observed by Mr Watt.

In the two first examples, the reader will observe that the formula errs in defect. Dr Robison considers it as most correct in small canals, where it is most needed, such as in mill courses and other derivations for working machinery. From several comparisons with direct observation, he proposes to substitute in place of the expression Hyp. Log. $\sqrt{s+1.6}$ the expression $2\frac{1}{4}$ Com. Log. $\sqrt{s}+1.6$, which he considers both as more simple and more accurate.

Instead of the part of the numerator Hyp. Log. $\sqrt{s}+1.6$, Dr Young proposes to substitute $0.85\ s^{\frac{11}{60}}$, which is nearly the same for moderate velocities. He proposes also $V=307\ (\sqrt{d}-1).\left(\frac{1}{\sqrt{s}}+\frac{1.6}{s^{.88}}-.001\right)$ and since $s^{0.875}$, may be substituted without much inaccuracy in place of $s^{0.88}$, the term $\frac{1.6}{s^{0.88}}$ will become $\frac{1.6s^{\frac{1}{8}}}{l}$ which may be determined without logarithms. Hence the whole formula will become

$$V=153\ (\sqrt{d}-0.2).\sqrt{\left(\frac{h}{l+45\,d}\right)}+1.6\left(\frac{h}{l+45\,d}\right)^{\frac{7}{8}}-.001$$

$l$ being the length of the pipe, $h$ the height of the whole head of water, and $d$ the diameter of the pipe. In this formula $s=\frac{l+45d}{h}$. The formula may be applied to rivers, by taking $\frac{1}{s}$ as the sine of their inclination.

M. Langsdorf has proposed to substitute 482 in place of the number 478 used by Du Buat in his formula $V^2=\sqrt{478\ h}$ in French inches, which gives $V=\sqrt{509\ h}$ in English inches.

When the pipe is bent in one or more places, the effect of the bending may be found by adding into one sum $\sigma$ the squares of the sines thus,

$$s=\frac{l}{h-\left(\frac{V^2}{509}+\frac{V^2\sigma}{3000}\right)}$$

Or more simply,

$$V=\sqrt{\left(\frac{509\ d\ h}{d+\frac{1}{45}l+0.16\ d\ \sigma}\right)},$$

which is Langsdorf's formula reduced to English measure.

M. Eytelwein conceives the head of water to be divided into two parts, one of which is employed in producing velocity, while the other is employed in overcoming the resistances to which it is exposed. He considers the height employed in overcoming the resistances to be directly as the length of pipe, and as the circumference of the section, or as the diameter of the pipe, and inversely as the area of the section, or as the square of the diameter, that is, on the whole inversely as the diameter. This height too, must, like the resistance arising from friction, vary as the square of the velocity. Hence if $f$ denote the height due to the friction, $\delta$ the diameter of the pipe, and $a$ a constant quantity, we shall have

$$f=V^2\frac{a\ l}{\delta},\ \text{and}\ V^2=\frac{f\ \delta}{a\ l}.$$

But the height employed in overcoming the friction corresponds to the difference between the actual velocity and the actual height, that is, $f=h-\frac{V^2}{b^2}$ where $b$ is the coefficient for finding the velocity from the height. Hence we have

$$V^2=\frac{b^2\ \delta h-\delta V^2}{a\ b^2\ l}\ \text{and}\ V=\sqrt{\frac{b^2\ \delta h}{a\ b^2\ l+\delta}}.$$

Now Buat found $b$ to be 6 6, and $a\,b^2$ was found to be 0.0211, particularly when the velocity is between 6 and 24 inches per second. Hence we have

$$V^2=\frac{43.6\ \delta h}{0.0211\,l+\delta},\ \text{or}\ V=45.5\sqrt{\left(\frac{\delta\ h}{l+47\ \delta}\right)}.$$

Or, what is considered more accurate,

$$V=50\sqrt{\left(\frac{\delta\ h}{l+50\ \delta}\right)}.$$

If the pipe is bent, the velocity thus found must be diminished by taking the product of its square, multiplied by the sum of the sines of the several angles of flexure, and then by 0.0038. This will give the degree of pressure employed in overcoming the resistance occasioned by the angles; and subtracting this height from the height corresponding to the velocity, we may thence find the corrected velocity.

In applying this formula to *Example* 2. in p. 867, relative to the $4\frac{1}{2}$ inch pipe, which supplies Edinburgh with water, we have $h=51$ feet, $\delta=0.375$ of a foot, $=14930$, hence we shall obtain 1.7136 for the velocity in feet per second, or 20.5632 for the velocity in inches, which, by the rule already explained, gives 189.77 Scotch pints per minute.

| | |
|---|---|
| Quantity of water delivered by the pipe, . . . . . | 189.4 Scotch pints per minute. |
| Ditto determined by Eytelwein's formula, . . . . . . . | 189.77 |
| Ditto by Du Buat's formula, | 188.13 |

From which it appears, that in this case Eytelwein's formula is the most correct of the two, the error being only 0.37, while in Du Buat's it is 1.27 Scotch pints. The accuracy of both the formulæ is very remarkable.

In order to obtain a rule for determining the velocity of water in canals and rivers, M. Eytelwein considers the friction as nearly proportional to the square of the velocity, not because a number of particles proportional to the velocity is torn asunder in a time proportionally short, but because, when a body is moving in lines of a given curvature, the deflecting forces are as the squares of the velocities; for it is obvious, that the particles of water which touch the sides and bottom of the canal must be deflected, in consequence of the elevations and depressions on the surface upon which they slide nearly into the same curvilineal path, whatever be the velocity with which they move. We may therefore consider the friction as nearly proportional to the square of the velocity, and as nearly the same at all depths. It will, however, vary according to the surface of the fluid which is in contact with the solid, in proportion to the whole quantity of fluid; that is, the friction for a given quantity of water will be directly as the surface of the bottom and sides of a canal, or as the perimeter of the section in contact with the water; or, supposing the whole quantity of water to be spread upon a horizontal plane equal to the bottom and sides, the friction will be inversely as the height at which the water would stand, which is the mean radius, or hydraulic mean depth.

But in a river flowing uniformly, and neither accelerated nor retarded by gravity, the whole weight of the water must be employed in overcoming this friction; and if the inclination of the plane varies, the relative weight, or the force that urges the particles along the inclined plane, will vary as the height of the plane when its length is given, or as the fall in any given distance. Hence it follows, that the friction, which is equal to the relative weight, must vary as the fall; and the velocity, which is as the square root of the friction, must be as the square root of the fall; and supposing the hydraulic mean depth to increase or diminish while the inclination remains the same, the friction would be diminished or increased in the same ratio, and therefore, in order to preserve its equality with the relative weight, it must be proportionally increased or diminished, by increasing the square of the velocity, in the ratio of the hydraulic mean depth, or the velocity in the ratio of its square root. We may expect, therefore, that the velocities will be conjointly as the square root of the hydraulic mean depth, and of the fall in a given distance, or as a mean proportional between these two lines. If we take two English miles for a given length, we must find a mean proportional between the hydraulic mean depth and the fall in two English miles; and having ascertained the relation which this bears to the velocity in a particular case, we may easily determine it in all other cases. According to M. Eytelwein's formula, this mean proportional is $\frac{11}{10}$ of the velocity, or 0.91 times the velocity in a second. Making $d$ the hydraulic mean depth in inches, $f$ the fall in two English miles in inches, $\sqrt{fd}$ being the mean proportional, we have

$$V = 0.91 \sqrt{fd}$$

In applying this formula to Example II. in p. 867, relative to the velocity in a canal as measured by Mr Watt, we have $d = 29.126$ and $f = 8$ inches.

$$\text{Hence } V = 0.91 \sqrt{8 \times 29.126} = 0.91 \times 15.264 = 13.890,$$

a result which agrees very nearly with the mean velocity as ascertained by Mr Watt.

The preceding formula is applicable only to a canal, or to a straight river flowing through an equable channel. M. Eytelwein has shewn that the velocity is in general a little greater when the bottom is horizontal, than when it is parallel to the surface, and that the velocity in curved channels is always greater on the convex than on the concave side. It is not easy to give a rule for the decrease of the velocity from the surface to the bottom of a stream of water, as it is sometimes found to be a maximum below the surface.

The following are the velocities in the Arno and the Rhine.

| Arno. Depth in feet. | Velocity in inches per second. | Rhine. Depth in feet. | Velocity in inches per second. |
|---|---|---|---|
| 2 | $39\frac{1}{2}$ | 1 | 58 |
| 4 | $38\frac{1}{2}$ | 5 | 56 |
| 8 | 37 | 10 | 52 |
| 16 | $33\frac{1}{2}$ | 15 | 43 |
| 17 | 31 | | |

M. Eytelwein considers that an approximate value of the mean velocity may be obtained by deducting $\frac{1}{130}$ for every foot of the whole depth.

## Sect. III. *Account of the Investigations of M. Prony, respecting the velocity of Water in Conduit Pipes and open Canals.*

In our history of Hydrodynamics, we have already given a general view of the labours of Chezy, Girard, and Prony, in the composition of formulæ for determining the velocity of water in conduit pipes and open canals. As the formulæ obtained by these eminent engineers have all the same character, both from their extreme simplicity, and from their containing only algebraical quantities, we have thought it proper to give an account of them in the same Section. In doing this, we shall adopt the notation of M. Prony, and retain the coefficients as he has given them in French metres.

The following are the symbols which he employs:

$\lambda$ = the length of the pipe or canal.
$\zeta$ = the difference of level between the two extremities of the pipe.
$\omega$ = the area of the section of the pipe or canal.
$\chi$ = the perimeter of the section in contact with the water.
$g$ = the accelerating force of gravity, or 32.174.
D = the diameter of the tube.
$R = \frac{\omega}{\chi}$ = the mean radius, or the hydraulic mean depth.
I = the sine of the inclination of the pipe or canal.
U = the mean velocity in the section $\omega$.
V = the velocity of the surface } In open canals, &c.
W = the velocity at the bottom }

According to this notation, the formula of Du Buat, in English inches, is

$$U = \frac{\sqrt{307\,g}\left(\sqrt{\frac{\omega}{\chi}} - 0.1\right)}{\sqrt{\frac{\lambda}{\zeta}} - \text{Hyp. Log.}\sqrt{\frac{\lambda}{\zeta} + 1.6}} - 0.3\left(\sqrt{\frac{\omega}{\chi}} - 0.1\right)$$

Or when reduced to French metres,

$$U = \left(\frac{\sqrt{243.79}}{\sqrt{\frac{\lambda}{\zeta}} - \text{Hyp. Log.}\sqrt{\frac{\lambda}{\zeta} + 1.6}} - 0{,}049359\right)\left(\sqrt{\frac{\omega}{\chi}} - 0{,}016453\right)$$

About eleven years before the publication of the second edition of Du Buat's work, M. Chezy obtained an expression of the velocity much more simple than the preceding. He assimilates the resistance of the sides of the pipe or canal to known resistances, which follow the law of the square of the velocity; and he supposes that the ratio of $\chi U^2 : \frac{\zeta\,\omega}{\lambda}$ is constant for all currents of the same fluid. Upon this hypothesis, it is sufficient to determine, by experiment, the values of U, $\chi$, $\zeta$ and $\lambda$ for any known current of water, and to deduce from it the general value of U in terms of $\chi$, $\zeta$ and $\lambda$ belonging to any other current. The formula of Chezy, deduced from these principles, is

$$U = \sqrt{\frac{g\,\omega\,\zeta}{\beta\,\lambda\,\chi}}.$$

A single experiment only is necessary for determining $\beta$, which is an abstract number, or $\frac{g}{\beta}$, which is a linear quantity.

The fine researches of Coulomb respecting the resistance of fluids, were first applied by M. Girard to the discovery of a correct formula for expressing the velocity of water. He proposed to adopt for the value of the resistance, the product of a contant quantity, by the sum of the first and second powers of the velocity; and having determined this constant quantity after 12 experiments of Chezy and Du Buat, he obtained a formula, which, as we shall presently see, represents the experimental velocities as accurately as the more complicated one of Du Buat. He expresses the resistance due to the cohesion by $R'\chi U$; $R'$ being a quantity to be obtained from experiment; and supposing that the adhesion to the *paroi mouillée*, or the film which adheres to the sides of the pipe, of the asperities which are there disseminated, is the same as that which retains the fluid molecules to one another, he makes the resistance due to these asperities equal to $R'\chi U^2$, so that the sum of the two resistances is $R'\chi(U+U^2)$, which leads to the formula $\frac{g\,\omega\,\zeta}{\lambda\,\chi} = R'(U+U^2)$.

M. Girard assigns, from the experiments of Du Buat, 0.0012181 as the value of R, and his formula becomes $U = -0.5 + \sqrt{\left(0.25 + 8052{,}54\,\frac{\omega\,\zeta}{\lambda\,\chi}\right)}$ or making $\frac{\zeta}{\lambda} = \frac{1}{b} = I$, and $\frac{\omega}{\chi} = R$, the formula becomes $U = -0.5 + \sqrt{(0.25 + 8052.54\,RI)}$.

In order to obtain a formula for the mean velocity of fluids, M. Prony found, that an expression of the mean velocity, deduced from the theory of fluids, and composed of terms relative to gravity, to the dimensions or figure of the pipe or canal, ought to be equal to a certain function of this mean velocity; and in determining this function, he observed, that in all the hypotheses respecting the unknown function of the velocity to which the resistance is proportional that makes the motion uniform, it may always be developed in a series, arranged according to the whole powers of the mean velocity, or the variable quantity. That is,

$$\frac{g\,\omega\,\zeta}{\lambda\,\chi} = c + \alpha U + \beta U^2 + \gamma U^3, \text{ \&c.}$$

in which $c$ is a function independent of U, and which, along with the co-efficients $\alpha$, $\beta$, $\gamma$, &c. must be determined by experiment.

The first term $c$ of this series is related on the one hand to the inclination which the canal or tube ought to have, in order that the motion may be ready to commence; and on the other hand, to the form and dimensions which must be given to the transverse section, in order that the whole fluid which is contained in the canal or pipe may adhere to it. The determination of this first term depends on very delicate experiments, which have not been made; but it is quite certain that, from its extreme smallness, it may be safely neglected.

The second term $\alpha U$ is naturally related to very small velocities; and as it is known from good experiments, that the first and second powers of the velocity satisfy all the phenomena included within certain limits, it is requisite first to examine if these limits contain the greatest velocities, which are necessary to be considered in practice. M. Prony therefore takes the equation

$$\frac{g\,\omega\,\zeta}{\lambda\,\chi} = \alpha U + \beta U^2,$$

and he then endeavours to determine the values of the constant quantities $\alpha$ and $\beta$, which may be conformable with the best experiments which have been made on the motion of water in canals.

In the execution of this task, M. Prony has availed himself of the fine methods for the correction of anomalies, which M. La Place has applied in his *Mecanique Celeste*,* for determining the figure of the earth. La Place has given no fewer than three of these methods, the last of which Prony considers as the best.

If we have obtained, for example, a series of experimental values of any variable quantity, these values may be connected together by a law, by applying small corrections to each of the experimental results. The equation which expresses this law may be put under the form

$$Z = \alpha + \beta X,$$

where Z and X are functions of one or more variable quantities, of which we have a certain number of values either directly observed, or calculated from observations. It is then required to assign to the unknown constant quantities $\alpha$ and $\beta$ such values, that the phenomena may be represented in the best possible manner by the preceding equation.

The explanation of these methods does not belong to the present article; but in some part of our work, probably under the article Physics, we shall lay them before our readers.

* See *Mecanique Celeste,* Part I. Lib. iii. Sect. 39. and 40.

If we divide by U both sides of the equation, $\frac{g\,\omega\,\zeta}{\lambda\,\chi} = \alpha\,U + \beta\,U^2$, we obtain $\frac{g\,\omega\,\zeta}{\lambda\,\chi\,U} = \alpha + \beta U$, and putting $\frac{g\,\omega\,\zeta}{\lambda\,\chi\,U} = y$, we have an equation of the first order $y = \alpha + \beta U$, in which all the quantities are linear except $\beta$, which is an abstract number.

By calculating as many values of $y$ corresponding to the determined values of U, as we have experiments on the velocity observed in canals, where $\zeta$, $\lambda$, $\omega$, and $\chi$ have been measured, and by finding $\alpha$ and $\beta$ by the methods already mentioned, we obtain an expression of the velocity.

M. Prony has applied these methods to the twelve experiments, from which Girard deduced the value of the coefficient R in his formula, chiefly with the view of comparing the results obtained by Du Buat's formula, Girard's formula, and his own formula. Two of these twelve experiments were made by M. Chezy upon the Rigole of Courpalet, and upon the Seine. The other ten are taken from Du Buat's work, and are those which Girard employed. From these experiments, Prony finds $\alpha = 0.00093$, and $\beta = 0.00266$. Hence we obtain

$$\frac{g\,\omega\,\zeta}{\lambda\,\chi} = 0.00093\,U + 0.00266\,U^2,$$

which, when reduced, gives

$$U = -0{,}174812 + \sqrt{\left(0.0305592 + \frac{3687.52\,\omega\,\zeta}{\lambda\,\chi}\right)}$$

The particulars of the twelve experiments are given in the following Table, in columns 1, 2, 3, 4, 5, 6. Column 7 is calculated from Du Buat's formula already given, column 8 from Girard's, and column 9 from the preceding formula of Prony's. The four experiments marked with an asterisk are rejected as anomalous.

## TABLE I.

*Containing the mean Velocities of Currents of Water deduced from eight Experiments, compared with the Velocities as calculated by the Formulæ of Du Buat, Girard, and Prony.*

| No. of Experiment. | Names of the Currents. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Velocities observed, directly deduced from Observation. | | Total length of the Current or values of $\lambda$ | Total declivity on the length $\lambda$, or values of $\zeta$ | Area of the Section of the Current, or values of $\omega$ | Perimeter of the Section, or values of $\chi$ | Mean Velocities calculated, or values of U. | | |
| | | Superficial Velocity. | Mean Velocity. | | | | | By the Formula of Du Buat. | By the Formula of Girard. | By the Formula of Prony. |
| 1 | Rigole of Courpalet. | 0,142659 | 0,094051 | 31379,5 | 1,11438 | 0.674492 | 2,33863 | 0,130759 | 0,076449 | 0,086587 |
| 2 | Canal of Jard. | 0,196799 | 0,137345 | 467,769 | 0.016355 | 4 4883 | 8.77066 | 0.177309 | 0.131695 | 0,135891 |
| 3 | Canal of Jard. | 0,210875 | 0,148857 | 467,769 | 0.016919 | 5.4050 | 9,12257 | 0,191385 | 0,071647 | 0,156218 |
| 4 | Canal of Jard. | 0,260143 | 0,189760 | 467,769 | 0,021430 | 5,7582 | 9.20378 | 0,226847 | 0.1934 | 0.194314 |
| 5* | Canal of Jard. | 0,329414 | 0,248518 | 467,769 | 0,040605 | 8.72377 | 9,9076 | 0.393055 | 0,429232 | 0,384124 |
| 6 | River Hayne. | 0,368423 | 0.282091 | 359,272 | 0,010896 | 22 6466 | 15,3757 | 0,272865 | 0.280515 | 0,267086 |
| 7 | Canal of Jard. | 0,426081 | 0,332219 | 477.769 | 0,030454 | 7,6759 | 9,74518 | 0.314282 | 0,428938 | 0.293862 |
| 8 | River Hayne. | 0,432036 | 0,337349 | 359.272 | 0,010061 | 29,0468 | 16.3503 | 0.285046 | 0,317697 | 0.287803 |
| 9* | Canal of Jard. | 0,461532 | 0,372087 | 476,769 | 0.052448 | 11,9092 | 10,8821 | 0,508103 | 0,661130 | 0,520199 |
| 10* | River Seine. | 0,785029 | 0,652790 | 2592.22 | 0,297770 | 284.9 | 103.299 | 0,824497 | 1,17367 | 0,92010 |
| 11* | River Hayne. | 0,860012 | 0,720968 | 359,272 | 0,056012 | 28.4598 | 16.269 | 0.778532 | 1,0541 | 0,843152 |
| 12 | River Hayne. | 0,950426 | 0,803563 | 359.272 | 0,059596 | 23,0812 | 15.4082 | 0,747672 | 0,994162 | 0,796834 |

In the preceding Table, the mean velocities in column 2 were not directly observed, but were deduced from the superficial velocities by a formula of Du Buat, viz.

$$U = (\sqrt{V} - 0.08227)^2 + 0.0067675.$$

In this formula, which is reduced to metres, U is the mean velocity, and V the superficial velocity. Girard also calculated his mean velocities by an equivalent formula.

The relative accuracies of the three formulæ will be seen from the following Table of differences.

| | Absolute differences between the calculated and observed mean velocity. Positive difference. | Negative difference. |
|---|---|---|
| Formula of Du Buat | 0.0338 | 0.0391 |
| Formula of Girard | 0.0238 | 0.0970 |
| Formula of Prony | 0.0198 | 0 0060 |

In Du Buat's formula, the errors are between $\frac{3}{100}$ and $\frac{29}{100}$ of the observed results; in Girard's, they are between $\frac{16}{100}$ and $\frac{18}{100}$; and in Prony's between $\frac{7}{100}$ and $\frac{4}{100}$. The great superiority of Prony's formula is therefore manifest.

As the preceding formula of Prony was drawn only from a few observations, for the purpose of comparing it with the other formula, he has deduced more correct values of $\alpha$ and $\beta$ from 31 experiments, including the eight experiments of Du Buat in Table I. The 23 new experiments were performed with very great accuracy upon artificial canals, and have the advantage of giving the mean velocity from direct observation.

These experiments, which are contained in Table II. give the following values of $\alpha$ and $\beta$, viz.

$\alpha = 0\,000436$. $\beta = 0.003034$, from which we obtain

$$U = -0.0718523 + \sqrt{\left(0.00516275 + \frac{3232.96\,\omega\,\zeta}{\lambda\,\chi}\right)}.$$

Or more simply,

$$U = -0.07 + \sqrt{\left(0.005 + \frac{3233\,\omega\,\zeta}{\lambda\,\chi}\right)},$$ which will be sufficiently exact. With the first of these formulæ, the numbers in column 8 of Table II. were calculated.

### TABLE II.

*Containing the Velocities of Water in Canals, as observed in thirty one Experiments, compared with the Velocities calculated by Prony's Formula.*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| Number of Experiment. | Perimeters of the Sections or values of $\chi$ | Areas of the Sections, or values of $\omega$ | Inclination of the Canal, or values of $\frac{\zeta}{\lambda}$ | Values of the Functions. $\frac{g\omega\zeta}{\lambda\chi U}$ | Mean Velocities, or values of U | | Velocities, or values of U calculated. |
| | | | | | By direct Experiment. | Deduced from the superficial Velocity. | |
| | Metres. | Metres. | Metres. | Metres. | Metres. | Metres. | Metres. |
| 1 | 2,33863 | 0 674492 | 0,00003551 | 0,0008623 | | 0,116509 | 0,123793 |
| 2 | 0,683516 | 0.050562 | 0,0001077 | 0,0006287 | 0,124241 | | 0,103964 |
| 3 | 0.954216 | 0,0113764 | *Id.* | 0.0008160 | 0,154299 | | 0,144161 |
| 4 | 8,77066 | 4,4883 | 0,00003496 | 0,0010922 | | 0,160679 | 0.179161 |
| 5 | 9,12257 | 5.4050 | 0,00003617 | 0,0012213 | | 0,172109 | 0.200992 |
| 6 | 9,20378 | 5,7582 | 0,00004581 | 0,0013239 | | 0,212361 | 0,240924 |
| 7 | 0,368693 | 0,0152639 | 0,0005787 | 0,00097107 | 0.242005 | | 0,215583 |
| 8 | 0,577402 | 0,0258071 | 0,0007082 | 0.0012481 | 0,248773 | | 0,256018 |
| 9 | 0,460189 | 0.0251857 | 0,0005787 | 0,0011819 | 0,262849 | | 0,256107 |
| 10 | 15,3757 | 22.6466 | 0,00003033 | 0,0014567 | | 0,300783 | 0,314896 |
| 11 | 0.629377 | 0,0379215 | 0,0007082 | 0,0012779 | 0,327546 | | 0,306459 |
| 12 | 0.505937 | 0,0307842 | 0,0005717 | 0,0010339 | 0,334043 | | 0.273113 |
| 13 | 9,74518 | 7,6759 | 0,00006510 | 0,0014458 | | 0,347893 | 0.341608 |
| 14 | 16,3503 | 29,0468 | 0,00002800 | 0,0013832 | | 0,352792 | 0,33558 |
| 15 | 0,575237 | 0.025281 | 0,0010764 | 0.0012641 | 0,367069 | | 0,325775 |
| 16 | 0.705984 | 0,0558285 | 0,0007082 | 0,0014321 | 0,383581 | | 0,359686 |
| 17 | 0,789630 | 0.0753154 | *Id.* | 0,0015741 | 0,420938 | | 0,400958 |
| 18 | 0.414442 | 0,0199317 | 0,0023419 | 0 0022326 | 0,494839 | | 0.535840 |
| 19 | 0,575237 | 0,025281 | 0,0021834 | 0.0017179 | 0,547896 | | 0 489747 |
| 20 | 0,490778 | 0,0288423 | 0,0023419 | 0.0024567 | 0,549520 | | 0,599057 |
| 21 | 0 551415 | 0 0369616 | *Id.* | 0.0025427 | 0,605555 | | 0,644159 |
| 22 | 0,582004 | 0,0413509 | *Id.* | 0.0025612 | 0,637227 | | 0,665101 |
| 23 | 0,703819 | 0.061136 | 0,0024272 | 0,0028149 | 0,734678 | | 0,756869 |
| 24 | 0.353534 | 0.0138156 | 0,0047170 | 0.0024262 | 0,744694 | | 0.703180 |
| 25 | 0,737656 | 0,0632025 | 0.0021834 | 0,0023961 | 0,765809 | | 0.709152 |
| 26 | 0,772306 | 0.0738205 | 0,0023148 | 0,0028111 | 0,772035 | | 0,776964 |
| 27 | 15,4028 | 23,0812 | 0.00016532 | 0.0031313 | | 0,776043 | 0,825972 |
| 28 | 0,708563 | 0,0370788 | 0,004717 | 0.0027442 | 0,782863 | | 0,772683 |
| 29 | 0,840793 | 0.0876261 | 0,0023148 | 0.0028984 | 0,816430 | | 0,814208 |
| 30 | 0,878961 | 0 095782 | *Id.* | 0,0028662 | 0.863261 | | 0.834050 |
| 31 | 0,894121 | 0,0991601 | *Id.* | 0 0028604 | 0 880315 | | 0 841999 |

In comparing the calculated with the observed results in the preceding Table, it appears that the absolute positive differences are 0.0272, and that the absolute negative differences 0,0260, which shews the anomalies have been divided with great equality, and that the calculated results hold a just medium between those which were observed. The preceding formula may therefore be adopted in practice with much confidence.

M. Prony next proceeds to the investigation of a formula for the motion of water in conduit pipes. In this case we have $\frac{\omega}{\chi} = \frac{1}{4}$ D, D being the diameter of the tube; and if Z is the difference of level between the surface of water, in the superior reservoir, and that of the water in the lower basin, or the height of the head of water the equation will be

$$\frac{\frac{1}{4} g\, ZD}{\lambda} = \alpha\, U + \beta\, U^2.$$

In order to find $\alpha$ and $\beta$, M. Prony selected fifty-one of the best experiments made by Couplet, Bossut, and Du Buat, and by the application of the methods of correction, he obtained

$$\alpha = 0.00017,\ \beta = 0{,}003416.$$

From which we obtain

$$\frac{\frac{1}{4} g\, RD}{\lambda} = 0\ 00017\ U + 0.003416 U^2,$$

which, after reduction, gives

$$U = -0{,}0248829 + \sqrt{\left(0.000619159 + \frac{717.857\ DZ}{\lambda}\right)}.$$

By means of this formula, the numbers in column 8 of the following Table have been calculuted, which agree most surprisingly with the observed results. This agreement is the more remarkable, as the experiments were made by different observers, and with different apparatus, and upon pipes whose lengths varied from $11\frac{1}{2}$ feet to 7020, and their diameters from 1 inch to 18 inches.

The difference between the calculated and observed results amount only to $\frac{1}{40}$ or $\frac{1}{25}$.

The preceding formula should always be used in its present state when the velocities are very small; but when the velocities are considerable, we may in ordinary cases use the following very simple formula,

$$U = 26.79 \sqrt{\frac{DZ}{\lambda}}.$$

From which it appears, that the velocity is directly in the compound ratio of the square roots of the diameter of the pipe and the head of water, and inversely as the square roots of the length of the pipe; a result, which agrees with that which the Abbé Bossut obtained from his experiments; that is, for any given head of water and diameter of pipe, the velocity in a horizontal pipe is inversely as the square root of the length of the pipe. See page 511, col. 1.

In Table IV. we have given the observed measures in French inches, for the sake of those who may wish to compare them with the other experiments of Du Buat or Bossut.

TABLE III.

*Comparison of Prony's Formula with the results of Fifty-one Experiments by different Observers.*

| No. of experiments. | Names of Observers. | Head of water above the lower end of the Pipe. | Diameter of the Pipe. | Length of the Pipe. | Values of $\frac{g\,DZ}{4\,\lambda\,U}$ | Velocities, or values of U. | |
|---|---|---|---|---|---|---|---|
| | | | | | | Observed velocities. | Calculated velocities. |
| | | Metres. | Metres. | Metres. | Metres. | Metres. | Metres. |
| 1 | Du Buat. | 0,0040605 | 0,0270699 | 19,9506 | 0,00031409 | 0,0430142 | 0,04275 |
| 2 | Couplet. | 0,151132 | 0,135350 | 2280,37 | 0,00040412 | 0,0544296 | 0,059132 |
| 3 | Couplet. | 0,306784 | *Id.* | *Id.* | 0,00052299 | 0,0853786 | 0,092124 |
| 4 | Du Buat. | 0,013535 | 0,0270699 | 19,9506 | 0,00045929 | 0,0980744 | 0,092602 |
| 5 | Couplet. | 0,453422 | 0,135350 | 2280,37 | 0,00059072 | 0,111718 | 0,126321 |
| 6 | *Id.* | 0,570716 | *Id.* | *Id.* | 0,00063849 | 0,130098 | 0,133029 |
| 7 | *Id.* | 0,649678 | *Id.* | *Id.* | 0,00167009 | 0,141116 | 0,143345 |
| 8 | *Id.* | 0,676749 | *Id.* | *Id.* | 0,00168358 | 0,144093 | 0,146739 |
| 9 | Du Buat. | 0,0189489 | 0,0270699 | 3,74919 | 0,00142651 | 0,235211 | 0,289495 |
| 10 | *Id.* | 0,113694 | *Id.* | *Id.* | 0,00133843 | 0,282637 | 0,308824 |
| 11 | *Id.* | *Id.* | *Id.* | *Id.* | 0,00130958 | 0,288863 | *Id.* |
| 12 | Bossut. | 0,1082800 | *Id.* | 16,2419 | 0,00133748 | 0,330876 | 0,335905 |
| 13 | *Id.* | 0,324839 | 0,0360933 | 58,47108 | 0,00144598 | 0,340053 | 0,355330 |
| 14 | Du Buat. | 0,160525 | 0,0270699 | 19,9506 | 0,00148184 | 0 360437 | 0,371316 |
| 15 | Bossut. | 0,324839 | 0,0360933 | 48,7258 | 0,00154965 | 0,380766 | 0.391471 |
| 16 | Du Buat. | 0,210604 | 0,0270699 | 19,9506 | 0,00171296 | 0,409081 | 0,428717 |
| 17 | Bossut. | 0,324839 | 0,0360933 | 38,98072 | 0,00168746 | 0,436584 | 0,440183 |
| 18 | Du Buat. | 0,242547 | 0,0270699 | 19.9506 | 0,0018308 | 0,440807 | 0,461806 |
| 19 | Bossut | 0,324839 | 0,0544106 | 58,47108 | 0,00167204 | 0,443325 | 0,441608 |
| 20 | Du Buat. | 0,242547 | 0,0270699 | 19.9506 | 0,0017932 | 0,450038 | 0,461806 |
| 21 | Bossut. | 0,324839 | 0,0544106 | 48.7258 | 0,00179521 | 0,495488 | 0,486011 |
| 22 | *Id.* | 0,649678 | 0,0360933 | 58,47108 | 0,00192257 | 0.511514 | 0,512245 |
| 23 | *Id.* | 0,324839 | *Id.* | 29,2355 | 0,00191780 | 0,512786 | *Id.* |
| 24 | Du Buat. | 0,333502 | 0,0270699 | 19,9506 | 0.00205052 | 0,541155 | 0,545006 |
| 25 | Bossut. | 0,324839 | 0,0544106 | 38,98072 | 0.001981315 | 0,560537 | 0,545851 |
| 26 | Du Buat. | 0,370858 | 0,0270699 | 19,9506 | 0,00217375 | 0,567657 | 0,676653 |
| 27 | Bossut. | 0,649678 | 0,0360933 | 48,7258 | 0,00207278 | 0.569335 | 0,563405 |
| 28 | Du Buat. | 0,395221 | 0,0270699 | 19,9506 | 0,00222265 | 0,591641 | 0,596064 |
| 29 | Bossut. | 0,324839 | *Id.* | 16 2419 | 0,00220106 | 0,603173 | 0,599029 |
| 30 | *Id.* | *Id.* | 0.0360933 | 19 49036 | 0,00233276 | 0.632354 | 0,632726 |
| 31 | *Id.* | *Id.* | 0,0544106 | 29,2355 | 0,002300502 | 0,644427 | 0,634365 |
| 32 | *Id.* | 0,649678 | 0,0360933 | 38.98072 | 0,00226756 | 0,649787 | 0,632347 |
| 33 | *Id.* | *Id.* | 0,0544106 | 58,47108 | 0 00221446 | 0,669467 | 0,634366 |
| 34 | *Id.* | *Id.* | *Id.* | 48,7258 | 0.00239239 | 0.743615 | 0,697201 |
| 35 | *Id.* | *Id.* | 0,0360933 | 29,2355 | 0.00258798 | 0.759989 | 0.734322 |
| 36 | Du Buat. | 0,641558 | 0,0270699 | 19,9506 | 0,0027506 | 0,776068 | 0,766011 |
| 37 | Bossut. | 0.324839 | 0,0544106 | 19.49036 | 0,0028119 | 0,790849 | 0,782336 |
| 38 | Du Buat. | 0,162419 | 0,0270699 | 3.74919 | 0,0036206 | 0.794259 | 0,892970 |
| 39 | Bossut. | 0,649678 | 0,0544106 | 38.98072 | 0,0026558 | 0.836353 | 0,781872 |
| 40 | *Id.* | 0,324339 | 0,0360933 | 9,74518 | 0,0032867 | 0,897639 | 0,904784 |
| 41 | *Id.* | 0,649678 | *Id.* | 19,49036 | 0,0031615 | 0,933183 | *Id.* |
| 42 | *Id.* | *Id.* | 0,0544106 | 29,2355 | 0.0030625 | 0,968157 | 0,907103 |
| 43 | Couplet. | 3,92739 | 0,487259 | 1169.42 | 0,0037855 | 1,06003 | 1.059247 |
| 44 | Bossut. | 0 324839 | 0,0544106 | 9,74518 | 0,0040737 | 1,09151 | 1,116427 |
| 45 | *Id.* | 0,649678 | *Id.* | 19,49034 | 0,0038209 | 1,16401 | *Id.* |
| 46 | *Id.* | *Id.* | 0,0360933 | 9.74518 | 0,0044911 | 1,31381 | 1,289627 |
| 47 | Du Buat. | 0,487259 | 0,0270699 | 3.16718 | 0.0064699 | 1,57845 | 1,704337 |
| 48 | *Id.* | 0.567116 | *Id.* | 3,74919 | 0,0063075 | 1,59193 | 1,689767 |
| 49 | Bossut. | 0,649678 | 0,0544106 | 9,74518 | 0,0055786 | 1,5945 | 1.588977 |
| 50 | Du Buat. | 0,721864 | 0,0270699 | 3,16718 | 0,0078386 | 1,93011 | 2,079787 |
| 51 | *Id.* | 0,974518 | *Id.* | *Id.* | 0.0088825 | 2,29946 | 2.420487 |

TABLE IV.

*Containing the observed Measures in* TABLE III. *in French Inches.*

| No. of Experiment. | Names of Authors. | Head of Water above the lower end | Diameter of the Pipe. | Length of the Pipe. | | Observed Velocities or values of U. |
|---|---|---|---|---|---|---|
| | | Inches. | Inches. | Inches. | Feet. | Inches. |
| 1 | Du Buat. | 0,15 | 1 | 737 | 61,417 | 1,589 |
| 2 | Couplet. | 5,583 | 5 | 84240 | 7020 | 2,0107 |
| 3 | Couplet. | 11,333 | *Id.* | *Id.* | *Id.* | 3,154 |
| 4 | Du Buat. | 0,5 | 1 | 737 | 61,417 | 3,623 |
| 5 | Couplet. | 16,75 | 5 | 84240 | 7020 | 4,127 |
| 6 | *Id.* | 21,083 | *Id.* | *Id.* | *Id.* | 4,806 |
| 7 | *Id.* | 24 | *Id.* | *Id* | *Id.* | 5,213 |
| 8 | *Id.* | 25 | *Id.* | *Id.* | *Id.* | 5,323 |
| 9 | Du Buat. | 0,7 | 1 | 138,5 | 11,542 | 8,689 |
| 10 | *Id.* | 4,2 | *Id.* | *Id.* | *Id.* | 10,441 |
| 11 | *Id.* | *Id.* | *Id.* | *Id.* | *Id.* | 10,671 |
| 12 | Bossut. | 4 | *Id.* | 600 | 50 | 12,225 |
| 13 | *Id.* | 12 | 1,333 | 2160 | 180 | 12,562 |
| 14 | Du Buat. | 5,93 | 1 | 737 | 61,417 | 13,315 |
| 15 | Bossut. | 12 | 1,3333 | 1800 | 150 | 14,066 |
| 16 | Du Buat. | 7,78 | 1 | 737 | 61,417 | 15,112 |
| 17 | Bossut. | 12 | 1,3333 | 1440 | 120 | 16,128 |
| 18 | Du Buat. | 8,96 | 1 | 737 | 61,417 | 16,284 |
| 19 | Bossut. | 12 | 2,01 | 2160 | 180 | 16,377 |
| 20 | Du Buat. | 8,96 | 1 | 737 | 61,417 | 16,625 |
| 21 | Bossut. | 12 | 2,01 | 1800 | 150 | 18,304 |
| 22 | *Id.* | 24 | 1,3333 | 2160 | 180 | 18,896 |
| 23 | *Id.* | 12 | *Id.* | 1080 | 90 | 18,943 |
| 24 | Du Buat. | 12,32 | 1 | 737 | 61,417 | 19,991 |
| 25 | Bossut. | 12 | 2,01 | 1440 | 120 | 20,707 |
| 26 | Du Buat. | 13,7 | 1 | 737 | 61,417 | 20,97 |
| 27 | Bossut. | 24 | 1,3333 | 1800 | 150 | 21,032 |
| 28 | Du Buat. | 14,6 | 1 | 737 | 61,417 | 21,856 |
| 29 | Bossut. | 12 | *Id.* | 600 | 50 | 22,282 |
| 30 | *Id.* | *Id.* | 1,3333 | 720 | 60 | 23,360 |
| 31 | *Id.* | *Id.* | 2,01 | 1080 | 90 | 23,806 |
| 32 | *Id.* | 24 | 1,3333 | 1440 | 120 | 24,004 |
| 33 | *Id.* | *Id.* | 2,01 | 2160 | 180 | 24,731 |
| 34 | *Id.* | *Id.* | *Id.* | 1800 | 150 | 27,470 |
| 35 | *Id.* | *Id.* | 1,333 | 1080 | 90 | 28,075 |
| 36 | Du Buat. | 23,7 | 1 | 737 | 61,417 | 28,669 |
| 37 | Bossut. | 12 | 2,01 | 720 | 60 | 29,215 |
| 38 | Du Buat. | 6 | 1 | 138,5 | 11,542 | 29,341 |
| 39 | Bossut. | 24 | 2,01 | 1440 | 120 | 30,896 |
| 40 | *Id.* | 12 | 1,333 | 360 | 30 | 33,160 |
| 41 | *Id.* | 24 | *Id.* | 720 | 60 | 34,473 |
| 42 | *Id.* | *Id.* | 2,01 | 1080 | 90 | 35,765 |
| 43 | Couplet. | 145,083 | 18 | 43200 | 3600 | 39,159 |
| 44 | Bossut. | 12 | 2,01 | 360 | 30 | 40,322 |
| 45 | *Id.* | 24 | *Id.* | 720 | 60 | 43, |
| 46 | *Id.* | *Id.* | 1,333 | 360 | 30 | 48 534 |
| 47 | Du Buat. | 18 | 1 | 117 | 9,75 | 58,310 |
| 48 | *Id.* | 20,95 | *Id.* | 138,5 | 11,542 | 58,808 |
| 49 | Bossut. | 24 | 2,01 | 360 | 30 | 58,903 |
| 50 | Du Buat. | 26,666 | 1 | 117 | 9,75 | 71,301 |
| 51 | *Id.* | 36 | *Id.* | *Id.* | *Id.* | 84.945 |

M. Prony next proceeds to investigate a single formula which will serve both for canals and pipes. The resulting formula is

$$U = -0.0469734 + \sqrt{(0.0022065 + 3041.47\,G)}.$$

When this formula is applied to canals, we must take

$$G = RI\,;\ I = \frac{\zeta}{\lambda}\,;\ \text{and } R = \frac{\omega}{\chi}.$$

When it is to be applied to pipes, we must take

$G = \frac{1}{4}DJ$, $D =$ diameter of pipe, and $J = \frac{H' + \zeta - H''}{\lambda}$, when the pipe discharges itself in water, or $J = \frac{H' + \zeta}{\lambda}$, when the pipe discharges itself in air; as in this case, $H'' = 0$, $H'$ being the height of the head of water above the superior orifice of the pipe, and $H''$ the height of the head of water above the lower orifice of the pipe.

The formula in English feet is,

$$U = -0.1541131 + \sqrt{(0{,}023751 + 32806.6\,G.)}$$

*On the Relation between the Superficial Velocity and the Mean Velocity.*

The formula given by Du Buat for deducing the mean from the superficial velocity was, when reduced to the metre,

$$U = (\sqrt{V} - 0.08227)^2 + 0.0067675,$$

which is deduced from the equation

$$U = (\sqrt{V} - \sqrt{\tfrac{1}{2}W})^2 + \tfrac{1}{4}W,$$

where $W$ is a constant velocity $= 0.0270699 = 1$ inch of the old measure, and $\sqrt{W} = 0.16453$.

Although this formula is sufficiently simple, and harmonizes with many of Du Buat's experiments, it is nevertheless incompatible with observation, as it makes the mean velocity U have a finite value, when the superficial velocity V is nothing. Now, as Prony has observed, every formula, which does not make both these velocities vanish at the same time, is evidently erroneous; and, as it follows from the examination of the experiments, that the ratio between these velocities approaches to equality as they increase, so that at one limit we have $V = 0$, $U = 0$, and at another limit $V = \infty$, $U = \infty$; and $V = U$.

In order to obtain a formula which should satisfy these conditions, and at the same time be simple, and suited to the nature of the phenomena, M. Prony gives it the form

$$U = \frac{V(V + a)}{V + b},$$

which may be put under the form,

$\frac{V}{V - U} = \frac{b}{b - a} + \frac{V}{b - a}$, and making $\frac{b}{b - a} = \alpha$, and $\frac{1}{b - a} = \beta$, and using the values of V and U, given in col. 2. and 3. of the following Table, he obtained, by the methods already mentioned,

$\alpha = 4.036$; $\beta = 1.280$, from which we have
$a = 2.37187$; $b = 3.15312$, and

$$U = \frac{V(V + 2\,37187)}{V + 3.15312},$$

a formula, which is not only more commodious, and more easily calculated, but also more conformable with experiments than that of Du Buat. This formula may be put under the form

$$U = V - 0.78125 + \frac{2.46338}{V + 3.15312},$$

from which we obtain,

$$V = \tfrac{1}{2}\left(U - 2.37187 + \sqrt{(U - 2.37187)^2 + 3.15312\,U}\right)$$

The numbers in column 5 of the following Table have been computed from the formula

$$U = 0,816458\ V,$$

which gives a precision of between $\frac{1}{25}$ and $\frac{1}{18}$, and is a simplification of the preceding formula.

TABLE V.

*Containing the observed mean Velocities of Water, compared with those deduced from the superficial Velocities by the Formulæ of Du Buat and Prony.*

| 1. | 2. | 3. | 4. | 5. | 6. | 7. |
|---|---|---|---|---|---|---|
| | Velocities. | | | | | |
| Number of Experiments. | Observed. | | Calculated. | | Values of $\frac{V}{V-U}$. | Mean Velocities deduced by Prony's best Formula. |
| | Velocities of the surface, or values of V. | Mean velocities, or values of U. | By Du Buat's Formula. | By Prony's Formula. | | |
| 1 | 0,1638 | 0,1242 | 0,11124 | 0,13374 | 4,1363 | 0,12522 |
| 2 | 0,2954 | 0,2421 | 0,21951 | 0,24118 | 5,5422 | 0,22848 |
| 3 | 0,3118 | 0,2487 | 0,23346 | 0,25457 | 4,9414 | 0,24151 |
| 4 | 0,4331 | 0 3275 | 0,33837 | 0,35361 | 4,1014 | 0,33876 |
| 5 | 0,4640 | 0,3836 | 0,32526 | 0,37884 | 5,7711 | 0,36379 |
| 6 | 0,5197 | 0,4210 | 0,41462 | 0,42431 | 5,2654 | 0,40916 |
| 7 | 0,6186 | 0,4949 | 0,50273 | 0,50506 | 5,0008 | 0,49047 |
| 8 | 0,6719 | 0,5479 | 0,55057 | 0,54857 | 5,4185 | 0,53467 |
| 9 | 0,7797 | 0,7447 | 0,64795 | 0,63660 | 22,2770 | 0,61060 |
| 10 | 0 8121 | 0,6055 | 0,67737 | 0,66305 | 3,9308 | 0,65210 |
| 11 | 0,8473 | 0,6372 | 0,70939 | 0,69179 | 4,0328 | 0,68184 |
| 12 | 0,9280 | 0,7720 | 0,78304 | 0,75767 | 5,9488 | 0,75036 |
| 13 | 0,9745 | 0,7658 | 0,82562 | 0,79564 | 4,6694 | 0,79006 |
| 14 | 1,0257 | 0,8633 | 0,87246 | 0,83744 | 6,3158 | 0,83395 |
| 15 | 1,1461 | 1,0893 | 0,99346 | 0,93574 | 20,1780 | 0,93784 |
| 16 | 1,2994 | 1,0555 | 1,12538 | 1,0609 | 5,3264 | 1,0714 |
| 17 | 1,2994 | 1,1099 | 1,12538 | 1,0609 | 6,8569 | 1,0714 |

The agreement of the numbers in column 7, with those in column 3, is very striking; and it is remarkable that the numbers in column 5, calculated from Prony's simple formula, viz. $U = 0,816458\ V$, are more accordant with experiment than those in column 4, computed from Du Buat's formula. This formula may be reduced to

$$U = 0.82\ V, \text{ or even } U = 0.8\ V,$$

from which it follows, that the mean velocity is four-fifths of the superficial velocity.

In order to introduce into the equation which expresses the velocity, the value of the volume of water which flows through any section in a given time, Prony calls Q the volume of water, and $3.1416 = \pi$; and hence $U = \frac{4\,Q}{\pi D^2}$, and these being introduced into the equation $\frac{1}{4}\,g j\,D = \alpha\,U + \beta\,U^2$, where $\alpha = 0.00017$, and $\beta = 0.003416$, gives $\alpha + \frac{4\,\beta Q}{\pi D^2} = \frac{\pi g j D^3}{16\,Q}$, which making $\frac{16\,\alpha}{\pi\,g} = \alpha'$, and $\frac{64\beta}{\pi^2 g} = \beta'$ gives

$$j\,D^5 - \alpha'\,Q\,D^2 - \beta'\,Q^2 = 0, \text{ or since}$$

$$\alpha' = 0.000088268 \text{ and } \beta'\ 0.002258305, \text{ we have}$$

$$j\,D^5 - 0.000088268\ Q\,D^2 - 0.00225830\ Q^2 = 0,$$

which expresses the relation between the diameter of a pipe, the quantity of water which it discharges in a second, when its length, its declivity, and the heads of water above its upper and lower orifices, are known.

$$\text{In this equation } j = \frac{H + \zeta - H'}{\lambda}.$$

In order to facilitate the application of this formula, Prony has computed the following Table, which gives the relations between D, Q and $j$, as deduced from the above equation.

TABLE VI. *Containing the Declivity of the Pipe and its Diameter for different Quantities of Water discharged in a Second.*

| Diameter of the Pipe in hundred parts of a Metre. | Quantities of Water discharged in a Second in ten thousand parts of a Cubic Metre. | | | | |
|---|---|---|---|---|---|
| | Q = 0,0001 | Q = 0,0002 | Q = 0,0003 | Q = 0,0004 | Q = 0,0005 |
| | Values of *j*. | Values of *j*. | Values of *j*. | Values of *j*. | Values of *j*. |
| 0.01 | 0.2346568 | 0.9209736 | 2.0589504 | 3.648[illegible]872 | 5.6898840 |
| 0.02 | 0.0081604 | 0.0304354 | 0.0668247 | 0.1173284 | 0.1819463 |
| 0.03 | 0.0012563 | 0.0043712 | 0.0093445 | 0.0161763 | 0.0248665 |
| 0.04 | 0.0003585 | 0.0011580 | 0.0023986 | 0.0040803 | 0.0062031 |
| 0.05 | 0.0001429 | 0.0004303 | 0.0008622 | 0.0014387 | 0.0021597 |
| 0.06 | 0.0000699 | 0.0001979 | 0.0003840 | 0.0006281 | 0.0009304 |
| 0.07 | 0.0000392 | 0.0001052 | 0.0001981 | 0.0003179 | 0.0004645 |
| 0.08 | 0.0000241 | 0.0000620 | 0.0001137 | 0.0001792 | 0.0002585 |
| 0.09 | 0.0000159 | 0.0000395 | 0.0000707 | 0.0001097 | 0.0001562 |
| 0.10 | 0.0000111 | 0.0000267 | 0.0000468 | 0.0000714 | 0.0001006 |

| Diameter of the Pipe in 10th parts of a Metre. | Quantities of Water discharged in a Second in thousand parts of a Cubic Metre. | | | | |
|---|---|---|---|---|---|
| | Q = 0,001 | Q = 0,002 | Q = 0,003. | Q = 0,004. | Q = 0,005 |
| 0.10 | 0.0031410 | 0.0107986 | 0.0229728 | 0.0396636 | 0.0608709 |
| 0.11 | 0.0020654 | 0.0069353 | 0.0146096 | 0.0250884 | 0.0383716 |
| 0.12 | 0.0014184 | 0.0046519 | 0.0097005 | 0.0165642 | 0.0252431 |
| 0.13 | 0.0010100 | 0.0032364 | 0.0066793 | 0.0113387 | 0.0172145 |
| 0.14 | 0.0007416 | 0.0023230 | 0.0047441 | 0.0080051 | 0.0121058 |
| 0.15 | 0.0005589 | 0.0017126 | 0.0034611 | 0.0058044 | 0.0087424 |
| 0.16 | 0.0004309 | 0.0012925 | 0.0025848 | 0.0043079 | 0.0064617 |
| 0.17 | 0.0003387 | 0.0009955 | 0.0019705 | 0.0032636 | 0.0048748 |
| 0.18 | 0.0002709 | 0.0007808 | 0.0015297 | 0.0025176 | 0.0037446 |
| 0.19 | 0.0002199 | 0.0006222 | 0.0012069 | 0.0019740 | 0.0029236 |
| 0.20 | 0.0001809 | 0.0005030 | 0.0009662 | 0.0015705 | 0.0023160 |
| 0.21 | 0.0001506 | 0.0004118 | 0.0007836 | 0.0012660 | 0.0018589 |
| 0.22 | 0.0001267 | 0.0003411 | 0.0006431 | 0.0010327 | 0.0015100 |
| 0.23 | 0.0001076 | 0.0002854 | 0.0005334 | 0.0008516 | 0.0012399 |
| 0.24 | 0.0000922 | 0.0002411 | 0.0004468 | 0.0007092 | 0.0010283 |
| 0.25 | 0.0000796 | 0.0002055 | 0.0003776 | 0.0005960 | 0.0008606 |
| 0.26 | 0.0000692 | 0.0001765 | 0.0003217 | 0.0005050 | 0.0007263 |
| 0.27 | 0.0000606 | 0.0001526 | 0.0002762 | 0.0004312 | 0.0006177 |
| 0.28 | 0.0000533 | 0.0001329 | 0.0002387 | 0.0003708 | 0.0005291 |
| 0.29 | 0.0000472 | 0.0091164 | 0.0002077 | 0.0003209 | 0.0004562 |
| 0.30 | 0.0000420 | 0.0001026 | 0.0001817 | 0.0002795 | 0.0003958 |
| 0.31 | 0.0000375 | 0.0000908 | 0.0001599 | 0.0002447 | 0.0003453 |
| 0.32 | 0.0000337 | 0.0000808 | 0.0001414 | 0.0002154 | 0.0003029 |
| 0.33 | 0.0000303 | 0.0000722 | 0.0001256 | 0.0001906 | 0.0002671 |
| 0.34 | 0.0000274 | 0.0000648 | 0.0001121 | 0.0001694 | 0.0002366 |
| 0.35 | 0.0000249 | 0.0000584 | 0.0001005 | 0.0001511 | 0.0002104 |
| 0.36 | 0.0000227 | 0.0000528 | 0.0000904 | 0.0001354 | 0.0001880 |
| 0.37 | 0.0000207 | 0.0000479 | 0.0000816 | 0.0001218 | 0.0001685 |
| 0.38 | 0.0000189 | 0.0000436 | 0.0000739 | 0.0001099 | 0.0001517 |
| 0.39 | 0.0000174 | 0.0000398 | 0.0000672 | 0.0000996 | 0.0001370 |
| 0.40 | 0.0000160 | 0.0000364 | 0.0000612 | 0.0000905 | 0.0001241 |
| 0.41 | 0.0000148 | 6.0000334 | 0.0000560 | 0.0000824 | 0.0001128 |
| 0.42 | 0.0000136 | 0.0000307 | 0.0000513 | 0.0000753 | 0.0001028 |
| 0.43 | 0.0000126 | 0.0000283 | 0.0000471 | 0.0000690 | 0.0000939 |
| 0.44 | 0.0000117 | 0.0000262 | 0.0000434 | 0.0000634 | 0.0000860 |
| 0.45 | 0.0000109 | 0.0000243 | 0.0000401 | 0.0000583 | 0.0000790 |
| 0.46 | 0.0000102 | 0.0000225 | 0.0000371 | 0.0000538 | 0.0000728 |
| 0.47 | 0.0000095 | 0.0000209 | 0.0000344 | 0.0000498 | 0.0000671 |
| 0.48 | 0.0000089 | 0.0000195 | 0.0000319 | 0.0000461 | 0.0000621 |
| 0.49 | 0.0000083 | 0.0000182 | 0.0000297 | 0.0000428 | 0.0000575 |
| 0.50 | 0.0000078 | 0.0000170 | 0.0000277 | 0.0000398 | 0.0000534 |

TABLE VI. *Continued.—Containing the Declivity of the Pipe and its Diameter for different quantities of Water discharged in a Second.*

| Diameter of the Pipe in hundred parts of a Metre. | Quantities of Water discharged in a Second in ten thousand parts of a Cubic Metre. | | | | |
|---|---|---|---|---|---|
| | Q = 0,0006 | Q = 0,0007 | Q = 0,0008 | Q = 0,0009 | Q = 0,0010 |
| | Values of *j*. | Values of *j*. | Values of *j*. | Values of *j*. | Values of *j*. |
| 0.01 | 8.1828468 | 11.1274576 | 14.5237344 | 18.3716732 | 22.6712700 |
| 0.02 | 0.2606785 | 0.3535250 | 0.4604858 | 0.5815609 | 0.7167502 |
| 0.03 | 0.0354151 | 0.0478221 | 0.0620876 | 0.0782115 | 0.0961938 |
| 0.04 | 0.0087669 | 0.0117718 | 0.0152178 | 0.0191049 | 0.0234331 |
| 0.05 | 0.0030252 | 0.0040352 | 0.0051897 | 0.0064888 | 0.0079324 |
| 0.06 | 0.0012908 | 0.0017092 | 0.0021857 | 0.0027203 | 0.0033131 |
| 0.07 | 0.0006380 | 0.0008384 | 0.0010656 | 0.0013197 | 0.0016006 |
| 0.08 | 0.0003515 | 0.0004583 | 0.0005789 | 0.0007132 | 0.0008614 |
| 0.09 | 0.0002103 | 0.0002720 | 0.0005414 | 0.0004184 | 0.0005030 |
| 0.10 | 0.0001343 | 0.0001725 | 0.0002151 | 0.0002623 | 0.0003141 |

| Diameter of the Pipe in 10th parts of a Metre. | Quantities of Water discharged in a Second in thousand parts of a Cubic Metre. | | | | |
|---|---|---|---|---|---|
| | Q = 0,006 | Q = 0,007 | Q = 0,008 | Q = 0,009 | Q = 0,010 |
| 0.10 | 0.0865949 | 0.1168355 | 0.1515927 | 0.1908665 | 0.2346569 |
| 0.11 | 0.0544593 | 0.0733515 | 0.0950481 | 0.1195492 | 0.1468547 |
| 0.12 | 0.0357371 | 0.0480462 | 0.0621704 | 0.0781097 | 0.0958642 |
| 0.13 | 0.0243067 | 0.0326154 | 0.0421406 | 0.0528822 | 0.0648402 |
| 0.14 | 0.0170464 | 0.0228267 | 0.0294468 | 0.0369067 | 0.0452064 |
| 0.15 | 0.0122752 | 0.0164028 | 0.0211252 | 0.0264424 | 0.0323543 |
| 0.16 | 0.0090463 | 0.0120616 | 0.0155076 | 0.0193844 | 0.0236919 |
| 0.17 | 0.0068041 | 0.0090516 | 0.0116172 | 0.0145009 | 0.0177028 |
| 0.18 | 0.0052106 | 0.0069157 | 0.0088597 | 0.0110428 | 0.0134650 |
| 0.19 | 0.0040555 | 0.0053698 | 0.0069666 | 0.0086458 | 0.0105074 |
| 0.20 | 0.0032026 | 0.0042303 | 0.0053992 | 0.0067092 | 0.0081604 |
| 0.21 | 0.0025625 | 0.0033767 | 0.0043014 | 0.0053367 | 0.0064826 |
| 0.22 | 0.0020749 | 0.0027274 | 0.0034676 | 0.0042954 | 0.0052109 |
| 0.23 | 0.0016984 | 0.0022271 | 0.0028259 | 0.0034950 | 0.0042342 |
| 0.24 | 0.0014041 | 0.0018367 | 0.0023259 | 0.0028719 | 0.0034747 |
| 0.25 | 0.0011745 | 0.0015286 | 0.0019319 | 0.0023816 | 0.0028774 |
| 0.26 | 0.0009856 | 0.0012829 | 0.0016182 | 0.0019916 | 0.0024029 |
| 0.27 | 0.0008357 | 0.0010851 | 0.0013660 | 0.0016784 | 0.0020223 |
| 0.28 | 0.0007136 | 0.0009244 | 0.0011615 | 0.0014247 | 0.0017143 |
| 0.29 | 0.0006135 | 0.0007928 | 0.0009942 | 0.0012175 | 0.0014629 |
| 0.30 | 0.0005307 | 0.0006842 | 0.0008563 | 0.0010470 | 0.0012563 |
| 0.31 | 0.0004617 | 0.0005939 | 0.0007419 | 0.0009056 | 0.0010851 |
| 0.32 | 0.0004039 | 0.0005183 | 0.0006462 | 0.0007876 | 0.0009424 |
| 0.33 | 0.0003551 | 0.0004547 | 0.0005658 | 0.0006885 | 0.0008227 |
| 0.34 | 0.0003137 | 0.0004008 | 0.0004978 | 0.0006047 | 0.0007216 |
| 0.35 | 0.0002788 | 0.0003548 | 0.0004399 | 0.0005335 | 0.0006358 |
| 0.36 | 0.0002480 | 0.0003154 | 0.0003904 | 0.0004728 | 0.0005627 |
| 0.37 | 0.0002218 | 0.0002816 | 0.0003487 | 0.0004206 | 0.0004999 |
| 0.38 | 0.0001991 | 0.0002523 | 0.0003111 | 0.0003756 | 0.0004459 |
| 0.39 | 0.0001794 | 0.0002268 | 0.0002792 | 0.0003367 | 0.0003991 |
| 0.40 | 0.0001621 | 0.0002046 | 0.0002515 | 0.0003028 | 0.0003585 |
| 0.41 | 0.0001470 | 0.0001852 | 0.0002272 | 0.0002731 | 0.0003230 |
| 0.42 | 0.0001337 | 0.0001681 | 0.0002059 | 0.0002472 | 0.0002919 |
| 0.43 | 0.0001219 | 0.0001530 | 0.0001871 | 0.0002243 | 0.0002646 |
| 0.44 | 0.0001115 | 0.0001396 | 0.0001705 | 0.0002042 | 0.0002406 |
| 0.45 | 0.0001022 | 0.0001278 | 0.0001558 | 0.0001863 | 0.0002193 |
| 0.46 | 0.0000939 | 0.0001172 | 0.0001427 | 0.0001704 | 0.0002003 |
| 0.47 | 0.0000865 | 0.0001178 | 0.0001310 | 0.0001563 | 0.0001835 |
| 0.48 | 0.0000798 | 0.0000993 | 0.0001206 | 0.0001436 | 0.0001685 |
| 0.49 | 0.0000738 | 0.0000917 | 0.0001112 | 0.0001323 | 0.0001550 |
| 0.50 | 0.0000684 | 0.0000848 | 0.0001027 | 0.0001221 | 0.0001429 |

In order to shew the method of using this Table, let us take the case of the $4\frac{1}{2}$ inch pipe which conveys water to Edinburgh. In this case, (see p. 526, Example II.) we have

| | Reduced to Metres.* |
|---|---|
| $H = 51$ feet . . . . . | 15.54 |
| $D = 0.375$ . . . . . | 0.1143 |
| $l = 14930$ . . . . . | 4550.4 |
| $j = \frac{15.54}{4550.4} =$ . . . . | 0.0034151 |

Since the value of $D = 0.1143$ is in tenth parts of a metre, we must enter the lower part of Table VI. in column 1, and by taking proportional parts, it will be found that the value of Q corresponding to D, and to the value of $j = 0.0034151$ is 0.005104 parts of a cubic metre, which being multiplied by 61023.5, the number of English cubic inches in a cubic metre, gives 311.46 cubic inches discharged in a second. By multiplying this by 60″, and dividing the product by 103.4, the number of cubic inches in a Scotch pint, we obtain 180.7, as the number of Scotch pints that the preceding pipe ought to discharge in a minute, according to Prony's Table.

The following comparison of the results of the different formulæ will be interesting to the reader.

| | Scotch Pints. |
|---|---|
| Quantity of water actually discharged by the pipe | 189.4 |
| Do. by Eytelwein's formula . . . . | 189.77 |
| Do. by Girard's formula . . . . | 188.26 |
| Do. by Du Buat's formula . . . . | 188.13 |
| Do. by Prony's simple formula . . . | 192.32 |
| Do. by Prony's Table . . . . . | 180.7 |

This comparison is by no means favourable to Prony's formulæ.

## Sect. IV. *Account of the Experiments of Du Buat and Girard, on the effect of Heat upon the Motion of Water in narrow Pipes.*

The effect of heat, in augmenting the fluidity of water, seems to have been noticed at a very early period. Plutarch informs us, that the clepsydræ, or water clocks, went faster in summer than in winter, which he seems to ascribe to an increase of fluidity. Ελάυνουσα γαρ η ψυχροτης το ύδωρ ποιει βαρυ και σωματωδες, ως εστιν εν ταις κλεψυδραις καταμαθειν, βραδιον γαρ ελκουσι χειμωνος η θερους. *Quest. Natural.*

M. Du Buat made a series of experiments on the effect of heat upon the velocity of different fluids discharged from small tubes; but these effects were not very striking, as he employed tubes of too great a diameter. The results which he obtained are shewn in the following Table.

TABLE, *Containing Du Buat's Experiments on the Motion of different Fluids, at different degrees of temperature in Tubes of Glass.*

| Diameter and length of the Pipe. | Names of the Fluids. | Degrees of Heat above the freezing point. | Head of water above the head of the tube. | Height of the expense in a minute expressed in inches. | Velocity in a second in inches. |
|---|---|---|---|---|---|
| Horizontal tube 2.9 lines, or 0.24166 of an inch in diameter, and 36.25 inches long . . . . | Rain water | 3 | 2.0833 | 5.2777 | 13.057 |
| | Salt water | 3 | 2 0833 | 5.1666 | 12.7823 |
| | Salt water | 11 | 2.0833 | 5.2222 | 12.9197 |
| | Salt water | 10 to 11 | 4 9166 | 9.25 | 22 8845 |
| | Alcohol | 12 | 5 0000 | 7.5833 | 18.7611 |
| | Mercury | 10 to 12 | 0.8124 | 3.75 | 9.2775 |
| | Mercury | 10 to 12 | 0.9166 | 4.0833 | 10.1021 |
| | Mercury | 10 to 12 | 2.1944 | 6.6111 | 16.3558 |
| Horizontal tube 2 lines, or 0.16666 of an inch in diameter, and 36.25 inches long . . . . | Rain water | 55 | 8.875 | 5.2777 | 27.455 |
| | Rain water | 30 | 15 2916 | 6 9166 | 35.980 |
| | Rain water | 36 | 15.2916 | 7.0833 | 36.847 |
| | Rain water | 56 | 15.2916 | 7.2013 | 37.461 |
| | Alcohol | 12 | 5.292 | 2.50 | 13.005 |
| | Alcohol | 12 | 5.875 | 3.8338 | 19.941 |
| | Mercury | 10 to 12 | 1.125 | 1.75 | 9.103 |
| | Mercury | 10 to 12 | 2.7082 | 3.00 | 15.606 |
| | Mercury | 10 to 12 | 5.1666 | 4.25 | 22.108 |
| | Mercury | 10 to 12 | 0.0555 | 0.0000 | 0.000 |
| Horizontal tube $1\frac{1}{2}$ line in diameter and 34.16666 inches long . . . . | Alcohol | 12 | 9.292 | 1.125 | 10.402 |

From these results Du Buat concludes, that water moves less rapidly as it approaches to congelation, and that it runs more rapidly as its temperature increases; that salt water runs more slowly than rain water at the same temperature; that spirit of wine runs perceptibly less rapidly than water, on account of its viscosity, or its great adhe-

* English feet are reduced to metres by dividing them by 3.281.

sion to the sides of the tube; and that mercury, which, when it is very pure, is not attracted by the glass, flows more rapidly than water.

These experiments are, however, very far from satisfactory; and it was reserved to M. Girard to ascertain the precise influence of temperature on the motion of water in capillary tubes. The experiments of this eminent engineer were made with tubes of copper accurately calibred, and whose lengths could be varied at pleasure. The first series of tubes had a diameter of 2.96 millimetres, and each tube was two decimetres long, having at each of its ends a brass virrel, one of which had a male, and the other a female screw, so that the tubes could be all put together, so as to form different lengths, from 20 to 222 centimetres. The second series of tubes was formed in a similar manner, and each tube had a diameter of only 1.83 millimetres. The experiments were made in the manner which we have already described in our History of Hydrodynamics.

In applying to these experiments the general formula

$$\frac{g\,\omega\,\zeta}{\lambda\,\chi\,U} = \alpha + \beta\,U \text{ or } \frac{g\,D\,H}{4\,\lambda\,U} = \alpha + \beta\,U$$

which expresses the condition of a linear and uniform motion, M. Girard has obtained the following results:

1. That whatever be the head of water, provided the capillary tube is of a sufficient length; the term $\beta\,U$, proportional to the square of the velocity, disappears from the general formula, so that it becomes $\frac{g\,D\,H}{4\,\lambda\,U} = \alpha$ which expresses the conditions of the uniformity of the simplest linear motion.

2. That in every case where the conditions of the motion are expressed by this formula, the variations in the temperature of the water have a very great influence on the velocity with which it flows in the tube, so that if the head of water, and the length and diameter of the pipe remain the same, the velocity which is expressed by 10 at 0° of the centigrade thermometer is expressed by 42 at 85° of that thermometer.

3. That in every case where the formula $\frac{g\,D\,H}{4\,\lambda\,U} = \alpha$ does not satisfy observation, that is, when the length of the tube is below a certain limit, the variations of temperature have but a slight influence on the velocity with which the water is discharged; so that if this velocity by a pipe 55 millimetres long, and at 5° of temperature, is represented by 10, it will be represented by 12 at 87 degrees, every other circumstance in the experiments being the same.

4. That at equal temperatures the expression $\frac{g\,D\,H}{4\,\lambda\,U} = \alpha$ decreases with the diameter of the tube employed.

5. That the influence of temperature upon the velocities follows the same law in capillary tubes of an unequal diameter, that is, that the successive differences of the expression $\frac{g\,D\,H}{4\,\lambda\,U} = \alpha$ becomes as much less for equal differences of temperature as the temperature is raised.

6. That this law shews itself with more regularity, as the observations are made upon tubes of a smaller diameter, or, which is the same thing, that the linearity of the motion is more perfect.

7. That the values of the formula $\frac{g\,D\,H}{4\,\lambda\,U} = \alpha$, calculated in the same circumstances for two tubes of unequal diameters, differ more from one another as the temperature becomes lower, and that these values appear to have a tendency to become identical in proportion as the temperature increases; so that if their difference is represented by 6 at 0° of temperature, it is represented only by 1 when the temperature approaches to 80°.

8. And lastly, that the temperature which exercises so great an influence on the phenomena of the uniform discharge of water by capillary tubes has scarcely any influence in ordinary conduit pipes, whose diameters exceed the limits of capillarity.

An account of the preceding experiments was laid before the Institute of France on the 28th Nov. 1814, and on the 16th January and 13th February 1815. The remaining part of the paper was laid before the same learned body on the 13th January, 1817, and contained various experiments on the discharge of different fluids through capillary tubes. In some future article, we expect to have it in our power to lay before our readers a fuller view of the very interesting results which M. Girard has obtained.

### Sect. V. *Account of Mr Smeaton's Experiments on the Friction of Water in Pipes.*

Mr Smeaton seems to have made a number of valuable experiments on the discharge of water through openings, and from conduit pipes; but no particular account of these has been left among his papers. We have been favoured, however, by Mr Farey, with two Tables, containing the results of Mr Smeaton's experiments, which were found among his MSS. and have never before been published. Although the last of the Tables relates to the subject of a preceding Section, we shall make no apology for inserting it in this place, as it was not in our possession when that part of the volume was printed.

The following Table, computed by Mr Smeaton from his own experiments, shews the head of water which is necessary to overcome the friction, &c. in horizontal pipes 100 feet long, and to produce the velocity contained in the two first columns of the Table. Hence, if a certain supply of water is required from a given pipe, the Table shews us the different heads or heights of the reservoir, by which the velocity necessary to afford this supply will be produced. By comparing this Table with the formula of Du Buat, it will be seen that Mr Smeaton makes the effects of friction considerably greater than that formula, the velocities given by the Table being less than those given by the formula.

## TABLE I.

*Computed by Mr Smeaton, for shewing the Friction of Water in Horizontal Pipes. The Bore of the Pipe being given, and the Velocity of the Water therein, the Height of Head, or Column necessary to overcome the Friction and produce that Velocity, is shewn by this Table for* 100 *Feet in length.*

*Bore of the Pipes.*

| Velocities per Second. | | | ½ Inch. | | ¾ Inch. | | 1 Inch. | | 1¼ Inch. | | 1½ Inch. | | 1¾ Inch. | | 2 Inch. | | 2¼ Inch. | | 2½ Inch. | | 3 Inch. | | 3½ Inch. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ft. | In | Inch. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. |
| 0 | 1 | 1 | 0 | 0.2 | 0 | 0.16 | 0 | 0.12 | 0 | 0.1 | 0 | 0.08 | 0 | 0.07 | 0 | 0.06 | 0 | 0.06 | 0 | 0.05 | 0 | 0.04 | 0 | 0.04 |
| 0 | 2 | 2 | 0 | 0 7 | 0 | 0.5 | 0 | 0 4 | 0 | 0.3 | 0 | 0.25 | 0 | 0.2 | 0 | 0.2 | 0 | 0.17 | 0 | 0.15 | 0 | 0.12 | 0 | 0.10 |
| 0 | 3 | 3 | 0 | 1.2 | 0 | 0.8 | 0 | 0.6 | 0 | 0.5 | 0 | 0.4 | 0 | 0.4 | 0 | 0.3 | 0 | 0.3 | 0 | 0.25 | 0 | 0.2 | 0 | 0.18 |
| 0 | 4 | 4 | 0 | 2.0 | 0 | 1.3 | 0 | 1.0 | 0 | 0.8 | 0 | 0.7 | 0 | 0.6 | 0 | 0.5 | 0 | 0.4 | 0 | 0.4 | 0 | 0.3 | 0 | 0.3 |
| 0 | 5 | 5 | 0 | 3 2 | 0 | 2.1 | 0 | 1.6 | 0 | 1.3 | 0 | 1.1 | 0 | 0 9 | 0 | 0 8 | 0 | 0.7 | 0 | 0.6 | 0 | 0.5 | 0 | 0 5 |
| 0 | 6 | 6 | 0 | 4 5 | 0 | 3.0 | 0 | 2.2 | 0 | 1 8 | 0 | 1.5 | 0 | 1.3 | 0 | 1.1 | 0 | 1.0 | 0 | 0.9 | 0 | 0.7 | 0 | 0.6 |
| 0 | 7 | 7 | 0 | 6.0 | 0 | 4.0 | 0 | 3.0 | 0 | 2.4 | 0 | 2.0 | 0 | 1 7 | 0 | 1.5 | 0 | 1.3 | 0 | 1.2 | 0 | 1.0 | 0 | 0.8 |
| 0 | 8 | 8 | 0 | 8.0 | 0 | 5.3 | 0 | 4.0 | 0 | 3.2 | 0 | 2.7 | 0 | 2.3 | 0 | 2.0 | 0 | 1.8 | 0 | 1.6 | 0 | 1.3 | 0 | 1.1 |
| 0 | 9 | 9 | 0 | 9.5 | 0 | 6.3 | 0 | 4.7 | 0 | 3.8 | 0 | 3.2 | 0 | 2 7 | 0 | 2.4 | 0 | 2.1 | 0 | 1.9 | 0 | 1.5 | 0 | 1 4 |
| 0 | 10 | 10 | 0 | 11.7 | 0 | 7.8 | 0 | 5.9 | 0 | 4.7 | 0 | 3 9 | 0 | 3 4 | 0 | 2.9 | 0 | 2.6 | 0 | 2.3 | 0 | 1.9 | 0 | 1.7 |
| 0 | 11 | 11 | 1 | 2.2 | 0 | 9.5 | 0 | 7.1 | 0 | 5.7 | 0 | 4.7 | 0 | 4.1 | 0 | 3.6 | 0 | 3.2 | 0 | 2 8 | 0 | 2.4 | 0 | 2.0 |
| 1 | 0 | 12 | 1 | 4.7 | 0 | 11.1 | 0 | 8.4 | 0 | 6.7 | 0 | 5.6 | 0 | 4.8 | 0 | 4.2 | 0 | 3.7 | 0 | 3.3 | 0 | 2.8 | 0 | 2 4 |
| 1 | 1 | 13 | 1 | 7.5 | 1 | 1.0 | 0 | 9.7 | 0 | 7.8 | 0 | 6.5 | 0 | 5.6 | 0 | 4.9 | 0 | 4.3 | 0 | 3.9 | 0 | 3.2 | 0 | 2.8 |
| 1 | 2 | 14 | 1 | 10.2 | 1 | 2.8 | 0 | 11.1 | 0 | 8.9 | 0 | 7.4 | 0 | 6.4 | 0 | 5.6 | 0 | 4.9 | 0 | 4.4 | 0 | 3.7 | 0 | 3 2 |
| 1 | 3 | 15 | 2 | 1.0 | 1 | 4.6 | 1 | 0.5 | 0 | 10.0 | 0 | 8.3 | 0 | 7.1 | 0 | 6.2 | 0 | 5.5 | 0 | 5.0 | 0 | 4.2 | 0 | 3.6 |
| 1 | 4 | 16 | 2 | 4.5 | 1 | 7.0 | 1 | 2.2 | 0 | 11.4 | 0 | 9.5 | 0 | 8.1 | 0 | 7.1 | 0 | 6.3 | 0 | 5.7 | 0 | 4.7 | 0 | 4.1 |
| 1 | 5 | 17 | 2 | 7.5 | 1 | 9.0 | 1 | 3.7 | 1 | 0.6 | 0 | 10.5 | 0 | 9.0 | 0 | 7.9 | 0 | 7.0 | 0 | 6.3 | 0 | 5.2 | 0 | 4 5 |
| 1 | 6 | 18 | 2 | 11.0 | 1 | 11.3 | 1 | 5.5 | 1 | 2.0 | 0 | 11.7 | 0 | 10.0 | 0 | 8.7 | 0 | 7.8 | 0 | 7.0 | 0 | 5.0 | 0 | 5.0 |
| 1 | 7 | 19 | 3 | 2.5 | 2 | 1.6 | 1 | 7.2 | 1 | 3.4 | 1 | 0.8 | 0 | 11.0 | 0 | 9.6 | 0 | 8.6 | 0 | 7.7 | 0 | 6.4 | 0 | 5.5 |
| 1 | 8 | 20 | 3 | 6.0 | 2 | 4.0 | 1 | 9.0 | 1 | 4.8 | 1 | 2.0 | 1 | 0.0 | 0 | 10.5 | 0 | 9.3 | 0 | 8.4 | 0 | 7.0 | 0 | 6 0 |
| 1 | 9 | 21 | 3 | 9.7 | 2 | 6.5 | 1 | 10.9 | 1 | 6.3 | 1 | 3.3 | 1 | 1.1 | 0 | 11.4 | 0 | 10.2 | 0 | 9.1 | 0 | 7 6 | 0 | 6.5 |
| 1 | 10 | 22 | 4 | 1.5 | 2 | 9.0 | 2 | 0.7 | 1 | 7.8 | 1 | 4.5 | 1 | 2 1 | 1 | 0.4 | 0 | 11.0 | 0 | 9 9 | 0 | 8.2 | 3 | 7.1 |
| 1 | 11 | 23 | 4 | 5.7 | 2 | 11.8 | 2 | 2 9 | 1 | 9.5 | 1 | 5.9 | 1 | 3.4 | 1 | 1.4 | 0 | 11.9 | 0 | 10.7 | 0 | 9.0 | 0 | 7.7 |
| 2 | 0 | 24 | 4 | 9 7 | 3 | 2.5 | 2 | 4.9 | 1 | 11.1 | 1 | 7.2 | 1 | 4.5 | 1 | 2.4 | 1 | 0.8 | 0 | 11 5 | 0 | 9.6 | 0 | 8.2 |
| 2 | 2 | 26 | 5 | 6 5 | 3 | 8.3 | 2 | 9.2 | 2 | 2.6 | 1 | 10.1 | 1 | 7.0 | 1 | 4.6 | 1 | 2.8 | 1 | 1.3 | 0 | 11.1 | 0 | 9.5 |
| 2 | 4 | 28 | 6 | 3.7 | 4 | 2.5 | 3 | 1.9 | 2 | 6.3 | 2 | 1.2 | 1 | 9.6 | 1 | 6.9 | 1 | 4.8 | 1 | 3.1 | 1 | 0.6 | 0 | 10.8 |
| 2 | 6 | 30 | 7 | 1.7 | 4 | 9.2 | 3 | 6 9 | 2 | 10.3 | 2 | 4.6 | 2 | 0.5 | 1 | 9.4 | 1 | 7.0 | 1 | 5.1 | 1 | 2.3 | 1 | 0.2 |
| 2 | 8 | 32 | 8 | 0.5 | 5 | 4.3 | 4 | 0.2 | 3 | 2.6 | 2 | 8.1 | 2 | 3.6 | 2 | 0.1 | 1 | 9.4 | 1 | 7.3 | 1 | 4.1 | 1 | 1.8 |
| 2 | 10 | 34 | 9 | 0.5 | 6 | 0.3 | 4 | 6.2 | 3 | 7.4 | 3 | 0.1 | 2 | 7 0 | 2 | 3.1 | 2 | 0.1 | 1 | 9.7 | 1 | 6.1 | 1 | 3.5 |
| 3 | 0 | 36 | 10 | 1.0 | 6 | 8.6 | 5 | 0.5 | 4 | 0.4 | 3 | 4.3 | 2 | 10.6 | 2 | 6.2 | 2 | 2.9 | 2 | 0.2 | 1 | 8.2 | 1 | 5.3 |
| 3 | 2 | 38 | 11 | 2.5 | 7 | 5.6 | 5 | 7.2 | 4 | 5.8 | 3 | 8 8 | 3 | 2.2 | 2 | 9.6 | 2 | 5 9 | 2 | 2.9 | 1 | 10.4 | 1 | 7.2 |
| 3 | 4 | 40 | 12 | 5.0 | 8 | 3.3 | 6 | 2 5 | 4 | 11.6 | 4 | 1.7 | 3 | 6.6 | 3 | 0.2 | 2 | 9.1 | 2 | 5 8 | 2 | 0.8 | 1 | 9.3 |
| 3 | 6 | 42 | 13 | 8.0 | 9 | 1.3 | 6 | 10.0 | 5 | 5.6 | 4 | 6.7 | 3 | 10.9 | 3 | 5.0 | 3 | 0.4 | 2 | 8.8 | 2 | 3.3 | 1 | 11.4 |
| 3 | 8 | 44 | 15 | 0.0 | 10 | 0.0 | 7 | 6.0 | 6 | 0.0 | 5 | 0.0 | 4 | 3.4 | 3 | 9.0 | 3 | 4.0 | 3 | 0.0 | 2 | 6.[illegible] | 2 | 1.7 |
| 3 | 10 | 46 | 16 | 4.5 | 10 | 11.0 | 8 | 2 2 | 6 | 6 6 | 5 | 5.5 | 4 | 8.1 | 4 | 1.1 | 3 | 7.7 | 3 | 3.3 | 2 | 8.7 | 2 | 4.1 |
| 4 | 0 | 48 | 17 | 10.0 | 11 | 10.6 | 8 | 11.0 | 7 | 1.6 | 5 | 11.3 | 5 | 1.1 | 4 | 5.5 | 3 | 11.6 | 3 | 6 8 | 2 | 11 7 | 2 | 6.6 |
| 4 | 3 | 51 | 20 | 1.2 | 13 | 4.8 | 10 | 0.6 | 8 | 0.5 | 6 | 8.4 | 5 | 8.9 | 5 | 0.3 | 4 | 5.6 | 4 | 0.2 | 3 | 4 2 | 2 | 10.5 |
| 4 | 6 | 54 | 22 | 6.7 | 15 | 0.5 | 11 | 3.4 | 9 | 0.3 | 7 | 6.2 | 6 | 5 .4 | 5 | 7.7 | 5 | 0.1 | 4 | 6 1 | 3 | 9.1 | 3 | 2.7 |
| 4 | 9 | 57 | 25 | 1.5 | 16 | 9.0 | 12 | 7.7 | 10 | 0 6 | 8 | 4.5 | 7 | 2.1 | 6 | 3.4 | 5 | 7.0 | 5 | 0.3 | 4 | 2.2 | 3 | 7.1 |
| 5 | 0 | 60 | 28 | 0.2 | 18 | 8.1 | 14 | 0.0 | 11 | 2.5 | 9 | 4.1 | 8 | 0.1 | 7 | 0.0 | 6 | 2.7 | 5 | 7 2 | 4 | 8.0 | 4 | 0.0 |
| | | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | 9 | | 10 | | 11 | |

N. B. Find the velocity of the water per second in feet and inches in the first column, or in inches in the second; and underneath the diameter of the bore in inches, (disposed in the uppermost row,) you will find the perpendicular height of a column of water in feet and inches, and 10ths necessary to overcome the friction of that pipe of 100 feet in length, to obtain the given velocity.

TABLE I.—Continued.

*Computed by Mr Smeaton, for shewing the Friction of Water in Horizontal Pipes. The Bore of the Pipe being given and the Velocity of the Water therein, the Height of Head, or Column necessary to overcome the Friction and produce that Velocity, is shewn by this Table for* 100 *Feet in length.*

| | | | *Bore of the Pipes.* | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Velocities. per Second. | | | 4 Inch. | | 4½ Inch. | | 5 Inch. | | 6 Inch. | | 7 Inch. | | 8 Inch. | | 9 Inch. | | 10 Inch. | | 11 Inch. | | 12 Inch. | |
| Ft. | In. | Inch. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. |
| 0 | 1 | 1 | 0 | 0.03 | 0 | 0 03 | 0 | 0.02 | 0 | 0.02 | 0 | 0.02 | 0 | 0.01 | 0 | 0.01 | 0 | 0.01 | 0 | 0.01 | 0 | 0.01 |
| 0 | 2 | 2 | 0 | 0.09 | 0 | 0.08 | 0 | 0.07 | 0 | 0.06 | 0 | 0 05 | 0 | 0.05 | 0 | 0.04 | 0 | 0.04 | 0 | 0.03 | 0 | 0 03 |
| 0 | 3 | 3 | 0 | 0 15 | 0 | 0.14 | 0 | 0.12 | 0 | 0.10 | 0 | 0.09 | 0 | 0.08 | 0 | 0.07 | 0 | 0.06 | 0 | 0.05 | 0 | 0.05 |
| 0 | 4 | 4 | 0 | 0.25 | 0 | 0.2 | 0 | 0.2 | 0 | 0.17 | 0 | 9.14 | 0 | 0.12 | 0 | 0.11 | 0 | 0.10 | 0 | 0.09 | 0 | 0.08 |
| 0 | 5 | 5 | 0 | 0.4 | 0 | 0.4 | 0 | 0 3 | 0 | 0.3 | 0 | 0 2 | 0 | 0.2 | 0 | 0.18 | 0 | 0.16 | 0 | 0.15 | 0 | 0.14 |
| 0 | 6 | 6 | 0 | 0.6 | 0 | 0.5 | 0 | 0.4 | 0 | 0.4 | 0 | 0.3 | 0 | 0.3 | 0 | 0.25 | 0 | 0.2 | 0 | 0.20 | 0 | 0.19 |
| 0 | 7 | 7 | 0 | 0.8 | 0 | 0.7 | 0 | 0.6 | 0 | 0.5 | 0 | 0.4 | 0 | 0.4 | 0 | 0.3 | 0 | 0.3 | 0 | 0.27 | 0 | 0.25 |
| 0 | 8 | 8 | 0 | 1.0 | 0 | 0.9 | 0 | 0.8 | 0 | 0.7 | 0 | 0 6 | 0 | 0.5 | 0 | 0.4 | 0 | 0.4 | 0 | 0.36 | 0 | 0.3 |
| 0 | 9 | 9 | 0 | 1.2 | 0 | 1.1 | 0 | 0.9 | 0 | 0.8 | 0 | 0.7 | 0 | 0.6 | 0 | 0.5 | 0 | 0.5 | 0 | 0.4 | 0 | 0.4 |
| 0 | 10 | 10 | 0 | 1.5 | 0 | 1.3 | 0 | 1.2 | 0 | 1.0 | 0 | 0.8 | 0 | 0.7 | 0 | 0.6 | 0 | 0 6 | 0 | 0.5 | 0 | 0.5 |
| 0 | 11 | 11 | 0 | 1.8 | 0 | 1.6 | 0 | 1.4 | 0 | 1.2 | 0 | 1.0 | 0 | 0.9 | 0 | 0.8 | 0 | 0.7 | 0 | 0.6 | 0 | 0.6 |
| 1 | 0 | 12 | 0 | 2.1 | 0 | 1.9 | 0 | 1.7 | 0 | 1.4 | 0 | 1.2 | 0 | 1.0 | 0 | 0.9 | 0 | 0.8 | 0 | 0.8 | 0 | 0.7 |
| 1 | 1 | 13 | 0 | 2.4 | 0 | 2 2 | 0 | 1.9 | 0 | 1.6 | 0 | 1.4 | 0 | 1.2 | 0 | 1.1 | 0 | 1.0 | 0 | 0.9 | 0 | 0.8 |
| 1 | 2 | 14 | 0 | 2.8 | 0 | 2.5 | 0 | 2.2 | 0 | 1.9 | 0 | 1.6 | 0 | 1.4 | 0 | 1.2 | 0 | 1.1 | 0 | 1.0 | 0 | 0.9 |
| 1 | 3 | 15 | 0 | 3.1 | 0 | 2.8 | 0 | 2.5 | 0 | 2.1 | 0 | 1.8 | 0 | 1.6 | 0 | 1.4 | 0 | 1.2 | 0 | 1.1 | 0 | 1.0 |
| 1 | 4 | 16 | 0 | 3.6 | 0 | 3.2 | 0 | 2.8 | 0 | 2.4 | 0 | 2.0 | 0 | 1.8 | 0 | 1.6 | 0 | 1.4 | 0 | 1.3 | 0 | 1.2 |
| 1 | 5 | 17 | 0 | 4.0 | 0 | 3.5 | 0 | 3.1 | 0 | 2.6 | 0 | 2.2 | 0 | 2.0 | 0 | 1.7 | 0 | 1.6 | 0 | 1.4 | 0 | 1.3 |
| 1 | 6 | 18 | 0 | 4.4 | 0 | 3.9 | 0 | 3.5 | 0 | 2.9 | 0 | 2.5 | 0 | 2.2 | 0 | 1·9 | 0 | 1.7 | 0 | 1.6 | 0 | 1.5 |
| 1 | 7 | 19 | 0 | 4 8 | 0 | 4 3 | 0 | 3.8 | 0 | 3.2 | 0 | 2.7 | 0 | 2.4 | 0 | 2.1 | 0 | 1.9 | 0 | 1.7 | 0 | 1.6 |
| 1 | 8 | 20 | 0 | 5.2 | 0 | 4.7 | 0 | 4.2 | 0 | 3.5 | 0 | 3.0 | 0 | 2.6 | 0 | 2.3 | 0 | 2.1 | 0 | 1.9 | 0 | 1.8 |
| 1 | 9 | 21 | 0 | 5 7 | 0 | 5.1 | 0 | 4.6 | 0 | 3.8 | 0 | 3.3 | 0 | 2.9 | 0 | 2.5 | 0 | 2.3 | 0 | 2.1 | 0 | 1.9 |
| 1 | 10 | 22 | 0 | 6.2 | 0 | 5.5 | 0 | 4.9 | 0 | 4.1 | 0 | 3.5 | 0 | 3.1 | 0 | 2.7 | 0 | 2.5 | 0 | 2.2 | 0 | 2.1 |
| 1 | 11 | 23 | 0 | 6.7 | 0 | 6.0 | 0 | 5.4 | 0 | 4.5 | 0 | 3.8 | 0 | 3.4 | 0 | 3 0 | 0 | 2.7 | 0 | 2.4 | 0 | 2.2 |
| 2 | 0 | 24 | 0 | 7 2 | 0 | 6.4 | 0 | 5.8 | 0 | 4.8 | 0 | 4.1 | 0 | 3.6 | 0 | 3.2 | 0 | 2.9 | 0 | 2.6 | 0 | 2.4 |
| 2 | 2 | 26 | 0 | 8.3 | 0 | 7.4 | 0 | 6.6 | 0 | 5.5 | 0 | 4.7 | 0 | 4.2 | 0 | 3.7 | 0 | 3.3 | 0 | 2.9 | 0 | 2.8 |
| 2 | 4 | 28 | 0 | 9.5 | 0 | 8.4 | 0 | 7.6 | 0 | 6.8 | 0 | 5.4 | 0 | 4.7 | 0 | 4 2 | 0 | 3.8 | 0 | 3.4 | 0 | 2.2 |
| 2 | 6 | 30 | 0 | 10 7 | 0 | 9.5 | 0 | 8.6 | 0 | 7.1 | 0 | 6.1 | 0 | 5.4 | 0 | 4.8 | 0 | 4·3 | 0 | 3.9 | 0 | 3.6 |
| 2 | 8 | 32 | 1 | 0.1 | 0 | 10.7 | 0 | 9.6 | 0 | 8.0 | 0 | 6.9 | 0 | 6.0 | 0 | 5.4 | 0 | 4.8 | 0 | 4.4 | 0 | 4.0 |
| 2 | 10 | 34 | 1 | 1.6 | 1 | 0.1 | 0 | 10.8 | 0 | 9.0 | 0 | 7.7 | 0 | 6.8 | 0 | 6.0 | 0 | 5.4 | 0 | 4.9 | 0 | 4.5 |
| 3 | 0 | 36 | 1 | 3.1 | 1 | 1.4 | 1 | 0.1 | 0 | 10.1 | 0 | 8.6 | 0 | 7.6 | 0 | 6.7 | 0 | 6 0 | 0 | 5.5 | 0 | 5.0 |
| 3 | 2 | 38 | 1 | 4.8 | 1 | 3.0 | 1 | 1.4 | 0 | 11.2 | 0 | 9.6 | 0 | 8.4 | 0 | 7.5 | 0 | 6.7 | 0 | 6.1 | 0 | 5.6 |
| 3 | 4 | 40 | 1 | 6.6 | 1 | 4.6 | 1 | 2.9 | 1 | 0.4 | 0 | 10.6 | 0 | 9.3 | 0 | 8.3 | 0 | 7.4 | 0 | 6.8 | 0 | 6 2 |
| 3 | 6 | 42 | 1 | 8.5 | 1 | 6.2 | 1 | 4.4 | 1 | 1.7 | 0 | 11.7 | 0 | 10.2 | 0 | 9.1 | 0 | 8.2 | 0 | 7.5 | 0 | 6.8 |
| 3 | 8 | 44 | 1 | 10.5 | 1 | 8.0 | 1 | 6.0 | 1 | 3.0 | 1 | 0.9 | 0 | 11.2 | 0 | 10.0 | 0 | 9.0 | 0 | 8.2 | 0 | 7.5 |
| 3 | 10 | 46 | 2 | 0.6 | 1 | 9.8 | 1 | 7.6 | 1 | 4.4 | 1 | 2 0 | 1 | 0.3 | 0 | 10.9 | 0 | 9.8 | 0 | 6.0 | 0 | 8.2 |
| 4 | 0 | 48 | 2 | 2.7 | 1 | 11.8 | 1 | 9.4 | 1 | 5.8 | 1 | 3.3 | 1 | 1.4 | 0 | 11.9 | 0 | 10.7 | 0 | 9 7 | 0 | 8.9 |
| 4 | 3 | 51 | 2 | 6.1 | 2 | 2.8 | 2 | 0.1 | 1 | 8.1 | 1 | 5.2 | 1 | 3.1 | 1 | 1.4 | 1 | 0.0 | 0 | 11 0 | 0 | 10.1 |
| 4 | 6 | 54 | 2 | 9.8 | 2 | 6.1 | 2 | 3.1 | 1 | 10.6 | 1 | 7 3 | 1 | 4.9 | 1 | 3.0 | 1 | 1.5 | 1 | 0.3 | 0 | 11.3 |
| 4 | 9 | 57 | 3 | 1.7 | 2 | 9.5 | 2 | 6.1 | 2 | 1.1 | 1 | 9.5 | 1 | 6.9 | 1 | 4.7 | 1 | 3.1 | 1 | 1.7 | 1 | 0.6 |
| 5 | 0 | 60 | 3 | 6.0 | 3 | 1.4 | 2 | 9.6 | 2 | 4.0 | 2 | 0.0 | 1 | 9.0 | 1 | 6.7 | 1 | 4 8 | 1 | 3.3 | 1 | 2.0 |
| | | | 12 | | 13 | | 14 | | 15 | | 16 | | 17 | | 18 | | 19 | | 20 | | 21 | |

N. B. Find the velocity of the water per second in feet and inches in the first column, or in inches in the second; and underneath, the diameter of the bore in inches (disposed in the uppermost row) you will find the perpendicular height of a column of water in feet and inches and 10ths, necessary to overcome the friction of that pipe for 100 feet in length, to obtain the given velocity.

The second Table, which is copied from the original one used by Mr Smeaton, shews the expence of water through a rectangular notch, or over a waste-board of different widths and depths. The term thickness of water, employed by Mr Smeaton, is the same as the depth of the lower edge of the waste-board below the level surfaces of the water in the river or reservoir. The water gauge is nothing more than the rectangular orifice or notch through which the water issues.

## TABLE II.

*For finding the Expence of Water by the Water Gauge, having an Aperture of* 1, 2, 3, 6, 12, *or* 18 *Inches in width, at any given thickness of Water running through the same.*

*1 Inch Gauge.*

| Thickness of Water. | Mean Velocity per Minute. | Difference. | Expence per Minute. | Difference. |
|---|---|---|---|---|
| Inches. | Feet. | | Cubic Feet. | |
| ¼ | 46.29 | — | 0.05 | — |
| | | 19.2 | | .09 |
| ½ | 65.46 | — | 0.14 | — |
| | | 14.7 | | .11 |
| ¾ | 80.16 | — | 0.25 | — |
| | | 12.4 | | .12 |
| 1 | 92.58 | — | 0.37 | — |

*2 Inch Gauge.*

| Thickness of Water. | Mean Velocity per Minute. | Difference. | Expence per Minute. | Difference. |
|---|---|---|---|---|
| ¼ | 46.29 | — | 0.11 | — |
| | | 19.2 | | .18 |
| ½ | 65.46 | — | 0.29 | — |
| | | 14.7 | | .24 |
| ¾ | 80.16 | — | 0.53 | — |
| | | 12.4 | | .28 |
| 1 | 92.58 | — | 0.81 | — |
| | | 10.9 | | .30 |
| 1¼ | 103.50 | — | 1.11 | — |
| | | 9.9 | | .31 |
| 1½ | 113.40 | — | 1.42 | — |
| | | 9.1 | | .34 |
| 1¾ | 122.47 | — | 1.76 | — |
| | | 8.4 | | .36 |
| 2 | 130 92 | — | 2.12 | — |

*3 Inch Gauge.*

| Thickness of Water. | Mean Velocity per Minute. | Difference. | Expence per Minute. | Difference. |
|---|---|---|---|---|
| ¼ | 46.29 | — | 0.16 | — |
| | | 7.2 | | .08 |
| ⅓ | 53.46 | — | 0.24 | — |
| | | 12.0 | | .20 |
| ½ | 65.46 | — | 0.44 | — |
| | | 10.1 | | .23 |
| ⅔ | 75.60 | — | 0.67 | — |
| | | 4.6 | | .13 |
| ¾ | 80.16 | — | 0.80 | — |
| | | 12.4 | | .43 |
| 1 | 92.58 | — | 1.23 | — |
| | | 20.8 | | 1.00 |
| 1½ | 113.40 | — | 2.23 | — |
| | | 17.5 | | 1.14 |
| 2 | 130.2 | — | 3.37 | — |
| | | 15.5 | | 1.20 |
| 2½ | 146.40 | — | 4 57 | — |
| | | 13 9 | | 1.27 |
| 3 | 160.32 | — | 5.84 | — |

*6 Inch Gauge.*

| Thickness of Water. | Mean Velocity per Minute. | Difference. | Expence per Minute. | Difference. |
|---|---|---|---|---|
| Inches. | Feet. | | Cubic Feet. | |
| ½ | 65.46 | — | .91 | — |
| | | 27 1 | | 1.58 |
| 1 | 92.58 | — | 2.49 | — |
| | | 20.8 | | 2.06 |
| 1½ | 113.40 | — | 4.55 | — |
| | | 17.5 | | 2.42 |
| 2 | 130.92 | — | 6.97 | — |
| | | 15.5 | | 2.71 |
| 2½ | 146 40 | — | 9.68 | — |
| | | 13.9 | | 2.94 |
| 3 | 160.32 | — | 12.62 | — |
| | | 12.9 | | 3.17 |
| 3½ | 173.21 | — | 15.79 | — |
| | | 11.9 | | 3.81 |
| 4 | 185.16 | — | 19.10 | — |
| | | 11.2 | | 3.40 |
| 4½ | 196.40 | — | 22.50 | — |
| | | 10.6 | | 3.38 |
| 5 | 207.00 | — | 25.88 | — |
| | | 10.1 | | 3.71 |
| 5½ | 217.14 | — | 29.59 | — |
| | | 9.7 | | 3.51 |
| 6 | 226.80 | — | 33.10 | — |

*12 Inch Gauge.*

| Thickness of Water. | Mean Velocity per Minute. | Difference. | Expence per Minute. | Difference. |
|---|---|---|---|---|
| 1 | 92.58 | — | 5.14 | — |
| | | 38 3 | | 8.96 |
| 2 | 130.92 | — | 14.10 | — |
| | | 29.4 | | 11.63 |
| 3 | 160.32 | — | 25.73 | — |
| | | 24.8 | | 13.71 |
| 4 | 185.16 | — | 39.44 | — |
| | | 21.8 | | 15 32 |
| 5 | 207.00 | — | 54 76 | — |
| | | 19.8 | | 16.64 |
| 6 | 226.80 | — | 71.40 | — |
| | | 18 1 | | 17.90 |
| 7 | 244.94 | — | 89.30 | — |
| | | 16.9 | | 18.76 |
| 8 | 261.84 | — | 108.06 | — |
| | | 15 9 | | 19.24 |
| 9 | 277.73 | — | 127.30 | — |
| | | 15.0 | | 19.07 |
| 10 | 292.74 | — | 146.37 | — |
| | | 14.3 | | 20.43 |
| 11 | 307.05 | — | 166 80 | — |
| | | 13.7 | | 20 30 |
| 12 | 320.70 | — | 187.10 | — |

| 18 *Inch Gauge.* | | | | |
|---|---|---|---|---|
| Thickness of Water. | Mean Velocity per Minute. | Difference. | Expence per Minute. | Difference. |
| Inches. | Feet. | | Cubic Feet. | |
| 1 | 92.58 | — | 7.71 | — |
| | | 38.3 | | 13.43 |
| 2 | 130.92 | — | 21.14 | — |
| | | 29.4 | | 17.69 |
| 3 | 160.32 | — | 38.83 | — |
| | | 24.8 | | 20.60 |
| 4 | 185.16 | — | 59.43 | — |
| | | 21.8 | | 23.23 |
| 5 | 207.00 | — | 82.66 | — |
| | | 19.8 | | 26.01 |
| 6 | 226.80 | — | 108.67 | — |
| | | 18.1 | | 27.41 |
| 7 | 244.94 | — | 136.08 | — |
| | | 16.9 | | 28.78 |
| 8 | 261.84 | — | 164.86 | — |
| | | 15.9 | | 31.86 |
| 9 | 277.73 | — | 196.72 | — |
| | | 15.0 | | 31.98 |
| 10 | 292.74 | — | 228.70 | — |
| | | 14.3 | | 32.66 |
| 11 | 307.05 | — | 261.36 | — |
| | | 13.6 | | 36.44 |
| 12 | 320.70 | — | 297.80 | — |
| | | 25.7 | | 65.93 |
| 14 | 346.41 | — | 363.73 | — |
| | | 23.9 | | 75.17 |
| 16 | 370.32 | — | 438.90 | — |
| | | 22.5 | | 76.64 |
| 18 | 392.79 | — | 515.54 | — |

It will be seen, from a comparison of this Table with Du Buat's formula in p. 841, that there is a considerable agreement between them. For great depths of the wasteboard, Du Buat's formula gives a much greater discharge than Smeaton's Table. At small depths of the wasteboard, Du Buat's formula gives results less than those of Smeaton's Table, while for intermediate depths the results approach very near each other. The 18 inch gauge, for example, with a depth of 18 inches, discharges, according to Smeaton, 515.54 cubic feet in a minute; whereas, according to Buat, it should discharge 554.15 cubic feet. The same gauge, at a depth of only one foot, discharges 7.71 cubic feet; whereas, according to Du Buat, it should discharge only 7.254 cubic feet. The same notch, with a depth of 8 inches, discharges 164.86 cubic feet; and, according to Du Buat, it should discharge 164.20 cubic feet, which is very nearly the same result.

## CHAP. V.

### On the Percussion and Resistance of Fluids.

As the laws of the resistance of fluids can be determined only from experiment, we shall not occupy our pages with theoretical discussions, which are of no practical utility. It will be necessary, however, to make the reader acquainted with the ordinary theory of the resistance of fluids, which may be comprehended in a few propositions.

### Sect. I. *On the Theory of the Resistance of Fluids.*

If a body is moved through a fluid medium, it experiences an obstruction in its motion, which is called the resistance of the fluid; but if the fluid is in motion, and strikes the body at rest, the force sustained by the body is called the percussion of the fluid. The force exerted upon the body is obviously the same in both these cases; and the percussion and the resistance of fluids follow the same laws. The ordinary theory which we are about to explain, may be used without much risk of error in all cases where the angle of impulse is not below 60°, which is the case in wheels moved by the force of water.

Prop. I.

If a fluid, whose particles have all the same velocity, strikes a plane surface, the resistance will be as the product of the squares of the velocity of the fluid, the density of the fluid, and the area of the plane.

The resistance must obviously be equal to the force with which each particle strikes the plane, multiplied by the number of particles which strike it in a given time. But the force of each particle is as its velocity, and the number of particles which strike the plane in any given time must also be as the velocity. Hence the resistance will be as the square of the velocity. It is obvious also, that the resistance will be proportional to the density of the fluid, as the number of particles which strike the plane in the same time must be proportional to the density; the number of particles which strike the plane must likewise increase with the area of the plane; and therefore the whole resistance must be proportional to the square of the velocity of the fluid, the density of the fluid, and the area of the surface of the plane.

Prop. II.

If a fluid in motion strikes a plane surface at rest, inclined to the direction in which the fluid moves, the resistance perpendicular to the plane is proportional to the square of the sine of the angle of inclination.

Let AB, Plate CCCXIX. Fig. 9. be the plane surface, inclined at an angle ABC to the direction DE, or CB of the motion of the fluid. Draw AC perpendicular to DE. Then it is obvious that the number of particles which strike against the surface AB is proportional to AC, for none of those which are beyond A and C can have any effect upon the plane. Likewise, if we take EF to represent the velocity of the fluid, and resolve this velocity into the two velocities FG, perpendicular to the surface of the plane, and GE parallel to the same surface, it is manifest that the part GE has no effect in acting against the plane. Hence the part of the force which acts perpendicular to the plane is FG, or the sine of the angle GEF $=$ ABC, the inclination of the plane. That is, the force which acts perpendicular to the plane is proportional to sin. ABC; and the number of particles which strike the plane is also proportional to sin. ABC; consequently the resistance must be protional to sin. ABC $\times$ sin. ABC $=$ $\sin.^2$ ABC, or the square of the sine of the angle of inclination.

Cor. The resistance which the plane experiences in the direction of its motion is proportional to the cube of the sine of the angle of inclination. For as the resistance in a direction FG, perpendicular to the plane, is proportional to the square of the sine of the angle of inclination, it must itself vary as the sine of the angle when reduced to the direction DE; that is, the whole resistance must vary as $\sin.^2 ABC \times \sin. ABC = \sin.^3 ABC$, or the cube of the sine of the angle of inclination.

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The two preceding propositions enable us to compare together the resistance experienced by plane surfaces moving in a fluid with different velocities, and at different angles of inclination. It is necessary, however, to know the absolute measure of the resistance for perpendicular impulses, in order that we may determine the absolute measures in all other cases. It follows from the experiments of Bossut, that the resistance experienced by a plane surface, which strikes directly and perpendicularly an indefinite fluid, is sensibly equal to the weight of a column of the fluid, which has for its base the area of the plane surface, and for its altitude the height due to the velocity of the surface; that is, if R is the resistance, A the area of the resisted surface, $s$ the specific gravity of the fluid, and $h$ the height due to the velocity, we have $R = s A^2 h$.

If the fluid is not of indefinite extent, but is merely a vein which strikes a plain surface at rest, the absolute measure of the resistance is quite different, being equal to a little less than the weight of a column of fluid whose base is the area of the surface, and whose height is double the height which is due to the velocity of the issuing vein, or $R = s A^2 2h$. This measure of the resistance was first determined accurately by G. W. Krafft. Duhamel had made experiments on the same subject in 1669, and several other philosophers followed in the same path; but the result which they obtained was, that the height of the column was equal only to that which was due to the velocity. Krafft employed a rectangular lever, against the vertical arm of which the water issuing from an additional tube impinged, while the weights requisite to balance that force were placed in a scale placed on the horizontal arm. In this way he obtained the results which we have already given in p. 415. See *Comment Petropol.* 1736, vol. viii. p. 253.

M. Bossut has given an account of similar experiments in the 2d edition of his Hydrodynamics, vol. ii. p. 293, from which it follows, that the resistance is a little less than the weight of a column whose height is double that which belongs to the velocity. In Bossut's experiments the water issued vertically from the bottom of a reservoir, upon one of the arms of a horizontal balance; and he observed that the resistance was always less when the flat arm of the balance touched the orifice, than when there were some interval between them.*

These two simple propositions constitute the whole of the ordinary theory of the resistance of fluids. They are founded upon two suppositions, neither of which are correct. 1. That after any particle of fluid strikes the plane, it is supposed to be annihilated, or to produce no farther effect; and, 2. That the part of the force which in oblique impulses is parallel to the surface of the plane, has no influence whatever upon the resistance which the plane experiences from the perpendicular part of the force. The first of these suppositions is obviously incorrect, for as the particles are not annihilated after impulse, they must some how or other get out of the way of the particles which succeed them, which can only be done by acting upon them, and consequently affecting their velocity. The second supposition appears also to be incorrect, for Mr Vince found that the part of the force which is parallel to the plane is not entirely lost.

By proceeding upon the principle laid down in the preceding proposition, it is easy to determine the resistance experienced by globes, cones, cylinders, and, in short, bodies of any form. Such determinations, however, are of no use, as they differ too widely from the experimental results to be capable of any practical application.

For a general account of D'Alembert's theory of the resistance of fluids, we must refer our readers to the historical part of this article, where a short notice of Don George Juan's theory is also given. The explanation of this last theory, however, belongs more properly to Mechanics, as it is a deduction from that author's physico-mathematical theory of percussion.

SECT. II. *Account of Experiments on the Resistance of Fluids.*

1. *Account of Bossut's Experiments.*

IN our History of HYDRODYNAMICS, we have already given a general account of the experiments made by Bossut, D'Alembert, and Condorcet, in the year 1775, and by Bossut alone in 1778, on the resistance of fluids. The following were the leading results which they obtained.

1. That the resistance of the same body of any figure which divides a fluid with different velocities, are sensibly proportional to the squares of these velocities.

2. That the direct and perpendicular resistances of plane surfaces, are sensibly proportional for the same velocity to the area of the surface.

3. That the resistances which arise from oblique impulses are not in the ratio of the squares of the sines of the angles of incidence; but that, when the angles of incidence are between 50° and 90°, the ordinary theory may be employed as an approximation, by observing that it always gives resistances a little less than experiment, and as much less as the angle differs from 90°.

4. That the absolute measure of the direct and perpendicular resistance of a plane surface in an indefinite fluid, is the weight of a column of the fluid, which has for its base the area of the surface, and for its altitude the height due to the velocity.

The resistance is much greater, and nearly double, in a mill course, which conveys the water to the float-boards of an undershot wheel.

5. That the tenacity of the water is a force which may be regarded as infinitely small, in relation to that which a body experiences in striking the water, particularly when the velocity is considerable.

The next set of experiments by Bossut were made on the resistances experienced in narrow canals. Dr Franklin had ascertained, by a rude experiment, when he was tra-

* The experiments of the Chevalier Borda gave a different result. He employed a cube, which floated upon the stagnant water of a large basin, and he found that the height due to the resistance did not much exceed that which was due to the velocity. See *Mem. Acad. Par.* 1763, 1767.

velling in Holland, that barges experienced a greater resistance when the waters of the canal were low; but no precise measure of this increase of resistance, nor any explanation of its cause, were given till Bossut published his experiments. The following were the general results which he obtained.

1. That in narrow canals the resistances are proportional to the squares of the velocities, following the same law as in a fluid of indefinite extent.

2. That the resistances in narrow canals, and canals which have little depth, is greater than in fluids of indefinite extent.

The cause of this is obvious. When the velocity of the body is considerable, the fluid which that body pushes before it has not liberty to expand itself on every side, but forms a current more or less rapid, as the velocity of the body is more or less great. If the body entirely filled the canal, it would push all the water before it like the piston of a pump; but as, in narrow canals, there is always some room for the water to run both below the boat and at its sides, a part of the fluid escapes in this way, while another part is driven back; and in this way a variety of contrary currents are formed, by which the resistance is increased. This augmentation of resistance is produced, not only by the heaping up of the fluid on its anterior part, but also by the want of hydrostatical support behind.

The preceding results furnish an excellent lesson to the engineer, in so far as they point out the advantage of making all canals of navigation as wide and deep as is consistent with a proper economy.

In 1778, M. Bossut undertook, in conjunction with Condorcet, a series of experiments, the object of which was to determine the law according to which the resistance varied in an indefinite fluid like the sea, by varying the angle of the prow of a vessel from a straight line, or 180°, to an angle of 12°. These experiments were made in the great reservoir, now destroyed, which formerly existed on the north side of the Boulevards of Paris. This reservoir was 200 long, 100 wide, and 8½ deep. The form of the apparatus employed is shewn in Plate CCCXIX. Fig. 10. where MQNOP is the small vessel. The prow, MQN, had various angles, from 180° to 12°. The vessel was drawn along by a cord C attached to its centre of gravity, which passing below a pulley on the same level with *c*, rises nearly in a vertical line, and passing again over a pulley descends and is attached to the weights, by the descent of which the motion of the vessel is produced. A rope QR stretching across the whole length of the reservoir, serves to regulate the motion of the vessel. The vessel was then brought, by another rope fixed at *o*, to one end of the reservoir, and the time in which it described 96 feet uniformly by different weights suspended to the end of the rope, was carefully measured by an excellent seconds watch. Each experiment was repeated five times, and the mean of these times was adopted as the true measure. The general results of these experiments are given in the following Table, and compared with those given by the ordinary theory. The Table contains the resistances for fifteen different kinds of prows. The base MN, Fig. 10. remains always the same, while the angle MQN of the prow, formed into an isosceles triangle, is made variable.

*Comparative Table of the Resistances experienced by 15 Angular Prows, as deduced by Bossut from his Experiments.*

| Angles of the Prow, or values of MQN = $x$. | Calculated Resistances, according to the common theory, or values of Cos.$^2 x$ | Observed Resistances. | Difference between the observed and calculated Resistances. |
|---|---|---|---|
| 180° | 10000 | 10000 | 0 |
| 168 | 9893 | 9890 | 3 |
| 156 | 9578 | 9568 | 10 |
| 144 | 9084 | 9045 | 39 |
| 132 | 9446 | 8346 | 100 |
| 120 | 7710 | 7500 | 210 |
| 108 | 6925 | 6545 | 380 |
| 96 | 6148 | 5523 | 625 |
| 84 | 5433 | 4478 | 955 |
| 72 | 4800 | 3455 | 1345 |
| 60 | 4404 | 2500 | 1904 |
| 48 | 4240 | 1654 | 2586 |
| 36 | 4142 | 955 | 3187 |
| 24 | 4063 | 432 | 3631 |
| 12 | 3999 | 109 | 3890 |

The resules in column third, as given by the ordinary theory, are calculated by the formula 1000 Cos. $^2 x, x$ being the angle of the prow. In order to obtain a formula which will express the law of the experimental resistances, Bossut observes, that when the angle $x$ undergoes a variation of 12°, each of the angles at the base of the isosceles prow will vary 6°. Calling this variation $q$, Bossut finds that the experimental resistance may be expressed by the formula

$$10000 \times \text{Cos.}^2 x + 3153 \left(\frac{x}{q}\right)^{3.25}.$$

This formula, however, though it answers well for prows with large angles, yet when the angle is small, it errs considerably in excess. In a prow of 12°, for example, the term $3.153 \left(\frac{x}{q}\right)^{3.25}$ becomes 4766 instead of 3631.

### 2. *Account of Du Buat's Experiments.*

The attention of Du Buat was first directed to the determination of the resistance experienced by an immoveable surface, when struck by an insulated vein of fluid. whose area is either greater than, or equal to, the area of the surface. In order to measure this resistance, he balanced it by a column of fluid, the height of which measured the height due to the impulse. A tube of glass, about 1½ lines of interior diameter, was bent into a right angle at its lower extremity. Into this bent part were fitted different surfaces for receiving the impulse of the fluid vein, which was to be balanced by the weight of column which ascended in the tube.

The result of these experiments was, that the height due to the impulse is the same as the height due to the velocity of the vein; whereas Bossut made it equal to the height due to twice the velocity. Du Buat accounts for this difference with great success. The vertical vein of fluid in Bossut's experiments enlarged itself in striking the surface upon the balance; and the fluid filaments took a horizontal direction, after they had given the shock to the surface. The resistance, therefore, measured by Bossut was not merely the impulse of a vein whose diameter was that of the orifice, but also the additional pressure of a ring of fluid of a certain extent, around the circular base of the vein in contact with the resisted surface.

M. Du Buat next proceeds to ascertain the amount of the resistance, when an immoveable surface is placed in a current of indefinite extent. The instrument which he used for this purpose was a box of white iron, presenting a surface of one square foot. It had a thickness of nearly four lines, and was shut on all sides except a small opening in its posterior surface, into which was soldered the horizontal branch of a rectangular tin tube sixteen lines in diameter, which received a float that indicated the height to which the water rose within the tube. By means of a bar of iron of about ten feet long, which could be attached to the back of the box, the box could be fixed at any distance below the surface of the current. Five holes, each about a line in diameter, were perforated in the anterior side of the tin box. The first was in the middle, the second equidistant, in a horizontal line, from the middle and the edge, and the third in the same horizontal line, but only ten lines distant from the edge; the fourth was quite close to the edge; and the fifth in the lower angle of the square. When the box was fixed, and the current of water was allowed to enter one or more of these holes, the fluid rose in the rectangular tin tube to a height due to the pressure of the current. In this way Du Buat made several experiments, which gave very singular results. The pressure was not only found to diminish from the centre of the surface to the edge or margin, but it became nothing at a certain distance from the centre, and afterwards negative at the margin. That is, when the water entered through the central hole, it rose to a certain height in the tin tube above the level of the stream. This height diminished when the water entered at a hole nearer the margin, the height became nothing at a certain distance, and still nearer the margin the fluid was actually depressed in the tin tube below the surface of the current. Du Buat explains this remarkable fact by saying, that the real pressure against any part of the surface is only the difference of the pressure against that part considered separately from the rest of the surface, and the height due to the variable velocity with which the water moves along the surface which is struck; that is, the water in escaping along the surface always diminishes the real pressure of the current; but towards the edges it becomes more powerful than the real current, and therefore that part is less pressed than if the fluid were immoveable, and will therefore sink in the tin tube.

In order to ascertain the mean pressure upon the whole surface, Du Buat shut up the holes already mentioned, and perforated the same surface with 625 holes, disposed symmetrically, with 25 on each side. By exposing this surface to the current, it appeared that the height of the water in the tube was $25\frac{1}{2}$ lines, when the mean velocity was 36 inches per second, which is due to a height of $21\frac{1}{2}$ lines. Hence the height due to the mean resistance is equal to 1.186 times the height due to the velocity.

By a similar contrivance Du Buat measured the diminution of pressure, or the *non-pressure*, as he calls it, experienced by the posterior part of a body fixed in a current. He found, 1*st*, That the diminution of pressure increased considerably by lengthening the body; 2*d*, That it increased a little from the circumference of the body to its centre; and 3*dly*, That the diminution of pressure is proportional to the area of the surface that is submerged.

It had hitherto been supposed by all authors, that the resistance experienced by a surface at rest from a fluid in motion, was exactly equal to the resistance of the same surface when it moved in stagnant water, with a velocity equal to that of the current. M. Du Buat resolved to examine this point experimentally, and from a variety of experiments made on the river Hayne, between Mons and Condé, he concluded, 1*st*, That the phenomena are by no means the same when the body is at rest as when it is in motion. 2*d*, That in the latter case, the pressure does not diminish so sensibly from the centre to the circumference, and instead of a negative pressure towards the sides, that the pressure is then so great, as to be measured by the third of the height due to the velocity, which shows that the water runs along the anterior surface with less velocity, or with more uniformity. 3*d*, That the pressures diminish in a less ratio than the square of the velocity, when the velocities are less than three or four feet per second. 4*th*, That the mean pressures are measured by the exact height due to the velocity, instead of 1.186 times the height, as before: And, 5*thly*, That the diminution of pressure diminishes little from the centre to the circumference in the same order as the pressures.

The next object of M. Du Buat is to determine the quantity of fluid which globes and plane surfaces drag along with them, when oscillating in a fluid. The globes were of wood, lead and glass. They oscillated in a vessel 51 inches long, 17 inches wide, and 14 inches deep: They were entirely immersed about three inches below the surface, and the wire which suspended them was as delicate as their weight would permit. The general result of these experiments is, that a globe oscillating in water drags along with it, both before and behind, a portion of fluid, whose volume exceeds a little its own volume, or nearly $\frac{585}{1000}$ of its own volume.

Similar experiments were made with various plane surfaces of white iron cylinders oscillating in the plane of their axes, quadrangular prisms oscillating in the plane of their axes, triangular prisms oscilliating in the plane of their axes, cubes oscillating directly, cubes oscillating by the common section of two of their bounding planes, cubes oscillating by a solid angle, quadrangular prisms oscillating by the common section of two oblique faces, cylinders oscillating in the direction of their diameters, and cones, pyramids and mixed bodies oscillating in the plane of their axes; but our limits will not permit us to give any account of these experiments, which will be found in Part III. sect. 1. chap. viii. of Du Buat's *Principes D'Hydraulique*, tom. ii.

The attention of Du Buat is next directed to the important subject of the resistance opposed to vessels in narrow canals. From a comparison of several experiments, he has deduced the following formula:

$$R = \frac{K}{\frac{C}{b} + 2} \qquad \text{or } R = \frac{8.46}{\frac{C}{b} + 2},$$

in which C is the area of the section of the canal, $b$ the area of the section of the vessel, and R the resistance; the resistance in a fluid of indefinite extent being = 1.

In order to compare this formula with experiments, Du Buat employed five kinds of prismatic boats, several feet in length, and terminated both before and behind by a plane surface, The boat

No. 1, had the immersed part = a rectangle of one foot of base upon 1 foot of height.

NO. 2, had two feet of base upon one foot of height immersed.

No. 4, and 5, had 19 inches 8 lines upon 12 inches $5\frac{1}{2}$ lines immersed, and differed only in their lengths.

No. 6, has its section like the great section of a vessel, and the area of the part immersed was 190 square inches.

The following Table shews the results of the experiment :

Table *shewing the Resistance of Boats in Narrow Canals.*

| Numbers of the Boats. | Ratio of the Sections or Values of $\frac{C}{b}$ | Observed Resistances, or Values of R. | Resistances calculated by the Formula. |
|---|---|---|---|
| *Canal* 28½ *Inches Wide, and* 15 *Inches* 2 *Lines Deep.* | | | |
| 1 | 3.00 | 1.66 | 1.69 |
| 2 | 1.50 | 2.50 | 2.41 |
| 4 & 5 | 1.76 | 2 25 | 2.25 |
| 6 | 2.275 | 1.94 | 1.97 |
| *Canal* 40 *Inches Wide, and* 15 *Inches* 2 *Lines Deep.* | | | |
| 1 | 4.212 | 1.33 | 1.36 |
| 2 | 2.106 | 2.11 | 2 05 |
| 4 & 5 | 2.476 | 1.90 | 1.89 |
| 6 | 3.192 | 1.62 | 1.62 |

From these experiments Du Buat has concluded that a canal cannot be considered as of indefinite width, unless its width is 4.46, or 4½ times that of the vessel; or what is the same thing, that when this is the ratio between the width of the vessel and the canal, the vessel experiences the same resistance as if it moved in the open sea. In order to confirm this result, the following experiments were made, in which $\frac{c}{b}$ and R in the last column are calculated by reducing the canal to 4½ times that of the vessel.

| Numbers of the Boats. | Ratio of the Sections or Values of $\frac{C}{b}$ | Observed Resistances, or Values of R. | Resistances calculated by the Formula. |
|---|---|---|---|
| *Canal* 75 *Inches Wide, and* 15½ *Deep.* | | | |
| 1 | 5.81 | 1.053 | 1.08 |
| 2 | 4.036 | 1 384 | 1.40 |
| *Canal of Indefinite Width, and* 15 *Inches* 4 *Lines Deep.* | | | |
| 2 | 5.75 | 1.125 | 1.09 |
| 5 | 5 53 | 1 143 | 1.12 |
| *Canal of Indefinite Width, and* 27 *Inches* 3 *Lines Deep.* | | | |
| 2 | 4.46 | 1.1 | 1.00 |

The law of oblique resistances does not appear to be the same in a narrow canal as in a fluid of indefinite extent, and an angular prow added to a prismatic vessel produces a less diminution of the resistance as the canal becomes more narrow. M. Du Buat expresses the resistance of an angular prow in a narrow canal by the following formula :

$$r = R - \frac{\left(R - \frac{R}{q}\right)\left(\frac{C}{b} - 1\right)}{5\,46}, \text{ in which}$$

R is the resistance of a plane prow in a narrow canal.
$r$ the resistance of an angular prow of the same base.
$q$ the ratio between the resistances of these two prows, in an indefinite fluid ; and
$\frac{C}{b}$ the ratio of the section as formerly.

When the boat No. 2. had an angular prow of 45°, and moved in a canal 28½ inches wide, and 15½ deep, the resistance was 4.42 ; whereas, the formula gives $r = 4.444$.

When the same boat had an angular prow of 14° 3′, the resistance was = 3.2 ; whereas, the formula gives $r = 3.25$

When these experiments were repeated in a canal shut at both ends, the resistance of boat No. 1. was sensibly the same as when it was open ; but when No. 2. was used, the resistance was considerably augmented. The effects in this case become very complicated, particularly for a canal which is short. When the sluices in canals are three or four miles distant, the part of the canal may be considered as of indefinite length, and if approaching one of its extremities, the boats ought to experience more resistance from this cause, yet the heaping up and the driving back of the water obliges the boats to rise, and thus allows the fluid to escape more easily behind.

3. *Account of the Experiments of Vince on the Resistance of Fluids.*

The experiments of Mr Vince on the resistance of fluids, were published in 1798, in the *Transactions of the Royal Society of London*. They were made with bodies moving at a considerable depth below the surface of water, and the resistance was measured both when the body moved in the fluid, and when the body was struck by the fluid in motion. The results of his experiments on the resistance of a plane surface moving in a fluid, are given in the following Table.

Table *shewing the Resistance of a Plane Surface moving in a Fluid with a Velocity of* 0.66 *of a Foot in a Second, and inclined at different Angles to the Line of its Motion.*

| Inclination of the Plane to the Line of its Motion. | Resistances Observed. | Resistances calculated from Theory. | Power of the Sine of the Inclination to which the resistance is proportional. |
|---|---|---|---|
| Degrees. | Ounces Troy. | Ounces Troy. | Experiments. |
| 10 | 0.0112 | 0.0012 | 1.73 |
| 20 | 0.0364 | 0 0093 | 1.73 |
| 30 | 0 0769 | 0.0290 | 1.54 |
| 40 | 0.1174 | 0 0616 | 1.54 |
| 50 | 0.1552 | 0.1043 | 1.51 |
| 60 | 0.1902 | 0.1476 | 1.38 |
| 70 | 0.2125 | 0.1926 | 1.42 |
| 80 | 0.2237 | 0.2217 | 2.41 |
| 90 | 0.2321 | 0 2321 | |
| 1 | 2 | 3 | 4 |

In the preceding Table, column 1st contains the angles of inclination at which the plane surface struck the fluid. Column 2d shews the resistance by experiment in the direction of their motion in Troy ounces. Column 3d shews the resistance by theory, the perpendicular resistance being supposed the same as that which is deduced from experiment. Column 4th contains the exponent of the power of the sine of the angle to which the resistance is proportional. This column was computed in the following manner: Calling $s$ the sine of the inclination, and $r$ the corresponding resistance; then, if $r$ is proportional to the $m$th power of $s$, or to $s^m$, we have sin. 90°, or $1^m s^m = 0.2321 : r$ and $s^m = \frac{r}{0.2321}$; and, consequently, $m = \frac{\text{Log. } r - \text{Log. } 0.2321}{\text{Log. } s}$. According to theory, the resistance in the direction of the motion of the plane should vary as the cube of the sine (Prop. II. Cor. p. 883); but it appears from the Table, that it varies in a much less ratio, but not as any constant power, or as any function of the sine and cosine. The actual resistance, therefore, must always exceed the theoretical resistance, which Mr Vince attributes partly to the part of the force parallel to the plane being neglected in the theory, but which appears to be really a part of the force which acts upon the plane.

When the plane surface was struck by the fluid in motion, Mr Vince obtained the results contained in the following Table.

Table *shewing the Resistance of a Plane Surface struck by a Fluid in Motion, and inclined at different Angles to the line of its Motion.*

| Inclination of the Plane to the Sine of its Motion. | Resistances observed. | | | Resistances calculated from Theory. | | |
|---|---|---|---|---|---|---|
| Degrees. | Oz. | Dwts. | Grs. | Oz. | Dwts. | Grs. |
| 90 | 1 | 17 | 12 | 1 | 17 | 12 |
| 8 | 1 | 17 | 0 | 1 | 16 | 22 |
| 70 | 1 | 15 | 12 | 1 | 15 | 6 |
| 60 | 1 | 12 | 12 | 1 | 12 | 11 |
| 50 | 1 | 18 | 10 | 1 | 18 | 17 |
| 40 | 1 | 4 | 10 | 1 | 4 | 2 |
| 30 | 0 | 18 | 18 | 0 | 18 | 18 |
| 20 | 0 | 12 | 12 | 0 | 12 | 19 |
| 10 | 0 | 6 | 4 | 0 | 6 | 12 |

The coincidence between the experimental and the theoretical results is very surprising, the difference being nothing more than might have been expected from the ordinary inaccuracy of experiments. It follows, therefore, from Mr Vince's experiments, that when the fluid is in motion, the resistance varies as the sine of the angle of the plane's inclination.

The difference between the resistances in the two cases confirm the results obtained by Du Buat, and prove, that the resistance when the plane moves is to the resistance when the fluid moves as 5 to 6, a result which Mr Vince ascribes to the action of the fluid behind the body when in motion.

4. *Account of Coulomb's Experiments on the Resistance of Fluids in Slow Motions.*

Notwithstanding the great value of the experiments of Bossut and Du Buat, yet none of these authors succeeded in determining the true law of the resistance of fluids. This honour was reserved for the late M. Coulomb, who first entertained the happy idea of ascertaining the laws of the resistance of fluids in slow motions, by the oscillation of horizontal discs in consequence of the torsion, or the twisting and untwisting of the wire by which they were suspended. In the present Section we shall endeavour to lay before our readers as distinct an account as possible of the investigations of this celebrated philosopher.

When a body in motion strikes a fluid at rest, it experiences two kinds of resistance. One of these arises from the cohesion of the fluid particles, which are separated from each other by the moving body; and as the number of molecules thus separated is proportional to the velocity of the body, this part of the resistance, depending upon the cohesion, will likewise be proportional to the simple velocity.

The other part of the resistance arises from the inertia of the fluid particles, which, being struck by the body, acquire a degree of velocity proportional to the velocity of the body; but as the number of these parts is proportional to the velocity, there ought to arise a resistance proportional to the square of the velocity. Hence the theory seems to inform us, that the *resistance of fluids should be represented by the sum of two quantities, one of which is proportional to the simple velocity, and the other to the square of the velocity.* This theoretical result was completely verified by Coulomb's experiments.

In order to submit these views to the test of experience, the ordinary methods of measuring the resistance of fluids are of no avail. When the moving body has a velocity about eight or nine inches per second, the resistance is always proportional to the square of the velocity; but when the velocity does not exceed four-tenths of an inch per second, the part proportional to the simple velocity becomes sensible; but as the velocity is extremely small, the resistance is also very small, and therefore the ordinary means cannot be used either in measuring the resistance, or in separating the parts due to the different terms of the formula. Coulomb therefore found it necessary, 1. To employ a measure, by which he could determine with great exactness very small forces. And, 2. To have it in his power to give to the moving body a degree of velocity so small, that the part of the resistance proportional to the square of the velocity might be compared with the other terms of the function which represent the resistance; or to be able to make the part of the resistance proportional to the square of the velocity, so small compared with the other terms, that it might be safely neglected.

These objects were completely gained, by employing the apparatus represented in Plate CCCXIX. Fig. 11. where ABC is a stand, having a horizontal arm BC, to which is fixed the small circle *e f*, perforated in the centre for the purpose of admitting the cylindrical pin *b a*. Into a slit in the extremity of this pin is fastened, by means of a screw, the brass wire *a g*, whose force of torsion is to be compared with the resistance of the fluid; and its lower extremity is fixed in the same way into a cylinder of copper *g d*, whose diameter is about four-tenths of an inch. The cylinder *g d* is perpendicular to the disc DS, whose circumference is divided into 480 equal parts. When this horizontal disc is at rest, which happens when the torsion of the brass wire is nothing, the index RS is placed upon the point 0, the zero of the circular scale. The small rule R $m$ may be elevated or depressed at pleasure round its axis $n$; and the stand GH which supports it may be brought into any position round the horizontal disc. The lower extremity of the cylinder $gd$ is immersed about two inches in the vessel of water MNOP, and to the extremity $d$ is attached the discs, or the bodies, whose resistance is to be determined when they oscillate in the fluid by the torsion of the brass wire.

In order to produce these oscillations, the disc DS, supported by both hands, must be turned gently round to a certain distance from the index, without deranging the vertical position of the suspended wire. The disc being then left to itself, the force of torsion causes it to oscillate, and the successive diminution of these oscillations is carefully observed. A simple formula gives in weights the force of torsion that produces the oscillations; and another formula well known to geometers, determines (by an approximation sufficiently accurate in practice,) by means of the successive diminution of the oscillations, compared with their amplitude, what is the law of the resistance, relative to the velocity which produces these diminutions.

The method employed by Coulomb in reducing his experiments, is nearly the same as that by which Newton and others determined the resistance of fluids from the successive diminution of the oscillations of a pendulum vibrating in a fluid; but Coulomb's apparatus is not liable to any of the objections which attach to the use of the pendulum. It would be impossible, without a previous explanation of the principles of torsion, and a discussion too long and minute for the limits of our work, to make our readers acquainted with the various steps of Coulomb's investigation. All that we can pretend to do is, to give an account of the different physical results which he obtained.

Having attached to the lower extremity of the cylinder $gd$ a circular white iron plate, about 6.677 inches in diameter, he found that when its oscillations were so slow, that the part of the resistance proportional to the square of the velocity was greatly inferior to the other part, the resistance which diminished the oscillations of the horizontal plate was uniformly proportional to the simple velocity, and that the other part produced no sensible effect upon the motion of the disc. He likewise found, in conformity with theory, that the momenta of resistance in different circular plates oscillating in a fluid, are as the fourth power of the diameters of these circles, when the resistance is proportional to the simple velocity; and that when a circle, 6.677 inches in diameter, oscillated with the velocity of 5.512 inches per second in its circumference, the momentum of resistance which the fluid opposed to its circular motion was equal to $\frac{1}{10}$th of a gramme, multiplied by a lever 143 millimetres long, or 1.544 English Troy grains, at the end of a line 5.63 English inches long. Hence it follows, that the resistance of the two circular surfaces of the disc is equal to a weight of 0.587 grammes.

If the plane or disc had only a velocity of ten millimetres, or one centimetre, the resistance would be only 0.042 grammes. In like manner it follows, that the resistance experienced by a surface of one square metre, moving with a velocity of one centimetre per second, is 0.703 grammes.

In order to determine comparatively with water the cohesion of different fluids, he filled a large vessel with clarified oil, such as is used in commerce for the lamps called *Quinquet;* and he found its temperature to be 16° of Reaumur's scale, which he marked, because the cohesion of oil varies with the temperature, though this variation is not sensible in water by small changes of temperature. By causing discs of different diameters to oscillate in the oil, he found that the momenta of resistance for two circles, moving round their centre in the plane of their superficies, varies as the fourth power of the diameter, a result which is also conformable with theory. The agreement of these results, Coulomb considers as leaving no doubt respecting the certainty of the term proportional to the velocity in the resistance of fluids.

From these experiments, Coulomb likewise concluded, that the difficulty which the same disc moving with the same degree of velocity experienced in separating the particles of oil, was to the difficulty which it experienced in separating the particles of water as 17.5 to 1, which will therefore express the ratio between the mutual cohesion of the particles of oil, and the mutual cohesion of the particles of water.

The next object of our author was to determine two important points. 1*st*, If the resistance of a body was influenced by the nature of its surface; and, 2*d*, if it was influenced by the pressure of the superincumbent fluid. In order to settle the first of these points, he covered the surface of a circle of white iron with a film of tallow, and wiped it slightly away, that the thickness of the plate might not be sensibly increased. He then caused this circle to oscillate as before; and he observed that the successive diminution of the oscillations was exactly the same as before the application of the tallow. Upon the coat of tallow he next scattered, by means of a sieve, a quantity of sand, which adhered to the surface; and he found that the resistance to the oscillations of the plate was not sensibly increased. Hence he concludes, that the part of the resistance proportional to the simple velocity arises from the mutual cohesion of the fluid particles, and not from the adhesion of these particles to the surface of the body. Whatever, indeed, was the nature of the surface, there was an infinite number of inequalities where the fluid particles were permanently lodged.

In order to determine the second point, M. Coulomb caused the bodies to oscillate at two different depths; one at a depth of .787 inches, and another at a depth of 19.6855 inches, and he found no difference in the resistances; but as the surface of the water supported the whole weight of the atmosphere, it was scarcely to be expected that a pressure of 19 inches of fluid would produce a very sensible increase of resistance. In order to decide the question, therefore, M. Coulomb employed another method.

Having placed a vessel full of water under the receiver of an air-pump, the receiver being furnished with a rod and collar of leather at its top, he fixed to the hook at the end of the rod a harpsicord wire numbered 7 in commerce, and suspended to it a cylinder of copper like $g$, $d$. Fig. 11. which plunged in the water of the vessel, and under this cylinder he fixed a circular plane, whose diameter was 101 millimetres (3.975 English inches). When the oscillations were finished, and consequently the force of torsion nothing, the zero of torsion was marked by the aid of an index fixed to the cylinder. The rod was then made to turn quickly round through a complete circle, which gave to the wire a complete circle of torsion, and the successive diminution of the oscillations were carefully observed. The diminution for a complete circle of torsion was found to be nearly a fourth part of the circle for the first oscillation, but always the same, whether the experiment was made in a vacuum or in the atmosphere. A small pallet, 50 millimetres long (1.969 English inches), and 10 millimetres broad (0.3937 English inches), which struck the water perpendicular to its plane, furnished a similar result. We may therefore conclude, that when a submerged body moves in a fluid, the pressure which it sustains, measured by the altitude of the superior fluid, does not perceptibly increase the resistance; and consequently that the part of this resistance proportional to the simple velocity, can in no respect be compared with the friction of solid bodies, which is always proportional to the pressure.

These experiments were twice repeated in the cabinet of the Institute, in the presence of M. Charles and M. Lassuze.

The attention of M. Coulomb was next directed to the determination of the resistance experienced by cylinders that moved very slowly, and perpendicular to their axes. When a cylinder, however small be its diameter, moves perpendicularly to its axis, the fluid particles which it strikes partake necessarily of its motion, and therefore it is not possible, in the reduction of the experiments, to neglect the part of the resistance which is proportional to the square of the velocity. Hence he was obliged to perform the experiments in such a manner that both parts of the resistance might be computed. The three cylinders, which were successively subjected to trial, had a length of 9.803 inches. The cylinders were fixed by their middle under the cylinder *g d*, so that they formed two horizontal radii, the length of each of which was $\frac{9.803}{2}=4.9015$ inches. The diameters of the cylinders were determined from their weight. After making the necessary experiments with cylinders whose diameters were 0.87 millimetres, 11.2 millimetres, and 21.1 millimetres, he found, from a comparison of the results, that the part of the resistance proportional to the simple velocity, which we shall call $r$, is not in different cylinders in the same ratio as the circumference of these cylinders, the ratio of their circumferences being as 24 to 1, while the values of $r$ were as 3 to 1. In order to explain this result, Coulomb supposes that the particles which immediately touch the cylinder take the same velocity as the cylinder; that the particles a little farther distant take a smaller velocity; and that at the distance of about one-tenth of an inch, the velocity ceases entirely. Hence it is at this last point that the cohesion ceases to have an influence on the resistance. Upon these suppositions, which Coulomb thinks require confirmation, he proposes to augment, by a constant quantity, the circumferences of all the cylinders, before comparing them with their resistance. This constant quantity to be added to the circumferences, he found to be 9.68 millimetres, or nearly an addition of three millimetres to their diameter; which shews that the portion of the fluid molecules detached from one another by the moving cylinder extends nearly to a distance of 1.5 millimetres from their circumferences.

In comparing the part of the resistance proportional to the square of the velocity, which we shall call R, with the diameters of the cylinders, it will be seen that these quantities in small cylinders are much greater than they ought to be in relation to their diameters, but in a much less ratio than in the preceding case. The augmentation of the circumferences is in this case only 1.77 millimetres, which is scarcely one-fifth of the former augmentation. Coulomb explains this difference from the theory in the following manner. All the fluid particles, when they are detached from one another, oppose the same resistance, whatever be the velocity which they take; so that as the quantity $r$ depends only on the cohesion, the resistance due to their cohesion will extend only to the point where the velocity of the molecules of the fluid is nothing. In the comparison of the quantities R, all the particles are supposed to take a velocity equal to that of the cylinder; but as it is only the molecules in immediate contact with the cylinder that take this velocity, it follows, that the augmentation of the diameter in determining the value of R, which answers the square of the velocity, should be less than in determining $r$, which is due to the cohesion. Besides, as Coulomb observes, these different degrees of lateral velocity, from the point of contact with the cylinder, where the velocity is equal to that of the cylinder, to the point where the cohesion renders the velocity nothing, ought to follow laws which new observations may soon determine, and which may throw great light upon this interesting branch of physics.

In determining by experiment the part of the momentum of resistance proportional to the velocity in two cylinders of the same diameter, but of different lengths, Coulomb found that the momentum of resistance was proportional to the cubes of their diameters. The same result is obtained from theory; for supposing each cylinder to be divided into the same number of parts, the length of each part will be proportional to the total length. The velocity of the corresponding parts will be as the same lengths, and also as the distance of these parts from the centre of rotation. The theory likewise indicates that the part of the momentum of resistance depending on the square of the velocity, in two cylinders of the same diameter, but of different lengths, is proportional to the fourth power of the length of the cylinder.

Coulomb now proceeds to determine the real resistance due to the simple velocity which a cylinder experiences while oscillating parallel to itself, and perpendicular to its axis. When the cylinder 9.803 inches long, and 0.04409 inches in circumference, was made to oscillate with a velocity of 5.512 inches per second, the part of the resistance $r$ was equal to 58 milligrammes, or .8952 troy grains; and when the velocity was 0.3937 inches per second, the resistance was 0.00414 grammes, or 0.637 troy grains. Hence we may conclude, that the resistance of a cylinder of the same diameter, but of a metre in length, or 39.37 inches, will be about 17 milligrammes.

The preceding experiments were repeated in the same oil which was formerly used, and at the same temperature; and he found, as formerly, that the cohesion of oil was to that of water as 17 to 1. He considers oil as preferable to water for determining $r$; for in the case of small velocities, the part R disappears almost entirely.

In these experiments Coulomb observed an effect which he could not have anticipated. Although the cohesion of the oil is 17 times greater than that of water, yet the augmentation of the diameters of the cylinders, which it was necessary to apply, was only 3 millimetres, the same as for water. He observed also another curious fact, which is more easily understood, viz. that the part of the resistance R is almost the same in oil as in water; for since this part arises merely from the inertia of the particles, it ought in different fluids to be proportional to their density.

Coulomb intended, in a second memoir, to determine numerically the value of the part of the resistance proportional to the square of the velocity; and to ascertain the resistance of globes, of pallets, of convex and concave surfaces; and also the difference between the resistance of a floating body and one entirely submerged; in consequence of his having found, that in slow motions the submerged body suffered a much less degree of resistance. We have to regret, however, that Coulomb did not live to complete these valuable researches. He died on the 3d August 1806, in the 70th year of his age; and left behind him the reputation of being one of the most able and original natural philosophers of the age in which he lived.

### 5. *Account of the Experiments of the Society for the Advancement of Naval Architecture.*

We regret that our limits will only permit us to lay before our readers some of the results of these excellent experiments.

The following experiments were made with a surface of 40 square feet, moving in its own direction with different velocities.

| Velocities in Natural Miles per hour. | Friction in Pounds. |
|---|---|
| 1 | 0.563 |
| 2 | 1.992 |
| 4 | 6.642 |
| 6 | 12 839 |
| 8 | 19.856 |

When the same body had prows differently inclined, the following results were obtained.

| Inclination of the Prows. | Friction. |
|---|---|
| 9° 44′ 10″ | 30.67 |
| 14 28 40 | 35.34 |
| 19 28 15 | 41.71 |
| 30 0 0 | 51.44 |
| 90 0 0 | 148.25 |

The Society likewise found, that the direct resistance varied in a ratio a little greater than that of the square of the velocity, being proportional to $V^{2.106}$. A body which has the form of a fish appeared to move with the least resistance; and soaked planks suffered a greater resistance than those which were not soaked.

### 6. *Comparison of the Results of different Formulæ and Experiments.*

Dr Thomas Young has drawn up the following valuable Table, containing a comparison of different formulæ with the experiments of Eytelwein, Bossut, and those of the Society for the advancement of Naval Architecture. In these formulæ, $a$ is the angle of inclination, and R the resistance.

Formula A deduced by Dr Young, is $R = \cos.^2 a + \frac{1}{10}$ tang. $a$.

Formula B deduced by Dr Young from theory is $R = \frac{2}{10} + \frac{4}{100}$ tang. $a + 288 \cos.^2 a : 360 + a°$.

Formula C deduced by Dr Young from experiments, is $R = \cos.^2 a + .0000004217\, a^{3.18}$ in which the last term is a little less than the millionth of the cube of the angle of incidence expressed in degrees.

Eytelwein's formula is $\cos.^2 a + \frac{4}{10}$ versed sin. $a$.

TABLE *containing Dr Thomas Young's Comparison of different Formulæ and Experiments.*

| Angles of Inclination or values of $a$. | Cos. $^2 a$. | Tang. $a$. | Formula A. | Formula B. | Formula C. | Eytelwein's Formula. | Bossut's Experiments. | Experiments of the Society for Naval Architecture. |
|---|---|---|---|---|---|---|---|---|
| 0 | 1.0000 | .000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | |
| 6 | .9890 | .105 | .9995 | .9824 | .9891 | .9910 | .9893 | |
| 12 | .9568 | .912 | .9780 | .9492 | .9580 | .9656 | .9578 | |
| 18 | .9045 | .325 | .9370 | .9022 | .9086 | .9241 | .9084 | |
| 24 | .8346 | .445 | .8791 | .8438 | .8449 | .8690 | .8446 | |
| 30 | .7500 | .577 | .8077 | .7769 | .7710 | .8036 | .7710 | |
| 36 | .6544 | .726 | .7270 | .7049 | .6919 | .7308 | .6925 | |
| 42 | .5523 | .900 | .6423 | .6317 | .6135 | .6551 | .6148 | |
| 48 | .4478 | 1.111 | .5589 | .5606 | .5414 | .5802 | .5433 | |
| 54 | .3455 | 1.376 | .4831 | .4985 | .4816 | .5103 | .4800 | |
| 60 | .2500 | 1.732 | .4232 | .4407 | .4403 | .4500 | .4404 | .347 |
| 66 | .1654 | 2.246 | .4000 | .3924 | .4231 | .4026 | .4240 | |
| 72 | .0955 | 3.078 | .4033 | .3869 | .4344 | .3719 | .4142 | .269 |
| 78 | .0432 | 4.705 | .5137 | .4166 | .4816 | .3600 | .4063 | .222 |
| 84 | .0109 | 9 514 | (.9623) | .5875 | .5658 | .3693 | .3999 | |

We have purposely omitted giving any account of the experiments of Hutton, Schober, and Colonel Beaufoy, on the resistance of air, as they do not belong to the present article.

## CHAP. VI.

### On the Oscillation of Fluids, and the Undulation of Waves.

#### Prop. I.

The oscillations of a fluid in a syphon are isochronous, and are performed in the same time as those of a pendulum, whose length is equal to half the length of the oscillating columns.

Let MNOP, Plate CCCXIX. Fig. 12. be a syphon, consisting of two vertical branches MN, OP, connected together by a horizontal branch NO, and having the same internal diameter throughout its whole length. If water is poured into the syphon till it stands at AB in one leg, it will stand at CD in the other, ABCD being a horizontal line. Let a piston be now introduced at P, so as to cause the water to descend through the space C$g$, it will of course rise in the other branch to the height $ef$, so that A$e$ = C$g$. Upon withdrawing the piston, the elevated fluid in MN will descend in order to recover its level; the fluid in PO will also rise above its natural level, and again descending, a series of oscillations will be performed by the fluid similar to those of a pendulum, the surface AB vibrating between $ef$ and $\epsilon\varphi$, and the surface CD between $gh$ and $\gamma\chi$. On account of the friction of the water, however, against the sides of the tube, the height

$C\gamma$ will not be so great as $Ac$; and consequently, from the same cause, the oscillations will gradually diminish like those of a pendulum, till the water resume its state of equilibrium.

It is obvious from the Figure, that the force which produces the oscillations is the weight of the column of fluid $ef\varphi\epsilon$, or twice the column $ABfe$, which is to the whole weight of the fluid column as 2 A $e$ to ANOD, or as A $e$ to the length of a pendulum EF, Fig. 13. which describes arcs FI equal to A$e$, or to one half of the oscillating column. Consequently since the length of the oscillating column ANOD is a constant quantity, the force which produces the oscillations is proportional to the space described by the water, and therefore the oscillations are isochronous.

Since the force by which the pendulum is made to describe the small arch FI is to the weight of the pendulum as FI is to FE, or as A $e$ : EF; and since the force which makes the water oscillate is to the weight of thé whole water in the same ratio, the oscillations of the pendulum and of the fluid being produced by the same forces, must be performed in equal times.

Cor. The oscillations of a column of fluid will be proportional to the square roots of the length of the column of fluid. For as this is true of the pendulum, it must be true also of the oscillating fluid, which follows the same laws. See Mechanics.

Those who wish to study farther the subject of the oscillation of fluids, are referred to the *Principia* of Sir Isaac Newton, lib. ii. Prop. 45, 46. and to Bossut's *Traité Theorique et Experimental d'Hydrodynamique*, tom. i. chap. ix. p. 403. edit. 1796, where they will find a general method of determining the oscillations of water in a syphon of any form, with an application of the method to a cylindrical syphon, and to a rectilineal syphon composed of three tubes, two vertical, and one horizontal. The subject is also treated in Bernoulli's *Works*, tom. iii. p. 125, and in Hutton's *Mathematical Tracts*, vol. iii. p. 350.

Prop. II.

The undulations of waves are performed in the same time as the vibrations of a pendulum, whose length is equal to AC or BD, Fig. 14. the breadth of the wave, or the distance between two adjoining eminences or depressions.

Let ABCDE represent the section of two waves. It is obvious that the eminences A, C must descend, by the force of gravity, or a force equal to the weight of the elevated portion, and that the undulations are performed like the oscillations of water in a syphon, the highest parts AC becoming the lowest, while the lowest BD become the highest. Hence, if we take a pendulum, whose length is equal to half the distance between A and C, or B and D, the parts A, C will descend so as to be the lowest in the time of one oscillation of the pendulum, and in the time of another oscillation they will become the highest parts; that is, the pendulum will make two vibrations in the time of one undulation, or the time that one of the summits C has described a space comprehended between two adjacent summits. And as a pendulum, whose length is four times that of the preceding, oscillates once in the same time that it oscillated twice, it follows, that the waves perform their oscillations in the same time as a pendulum, whose length is equal to AC or BD, the breadth of a wave. Hence a wave $3\frac{2}{9}\frac{5}{6}$ feet broad, will have a velocity of $3\frac{2}{9}\frac{5}{6}$ feet in a second; and a wave 18 inches broad will have a velocity of 26.538 inches per second.

The preceding doctrine of the oscillation of waves was first published by Sir Isaac Newton, in lib. ii. prob. 44. of the *Principia*. As the motion of waves, however, is partly circular, Sir Isaac considered his theory as only an approximation. M. La Place, in the *Memoirs of the Academy of Sciences* for 1776, has applied to this subject, particularly to rectilineal waves, the general laws of the motion of fluids, and obtained some interesting results, of which we have given a general account in our History of Hydrodynamics. La Grange has treated the subject in a general manner in the *Berlin Memoirs* for 1786, and M. Poisson and M. Cauchy have more recently written upon the same subject. The reader will find a general account of their labours in the History of Hydrodynamics. The same subject has likewise been treated by Dr Thomas Young, with his usual ability, in his *Lectures on Natural Philosophy*, vol. ii. p. 63.

## Part III. ON HYDRAULIC MACHINERY.

The term Hydraulic Machinery is, in strict propriety of language, applicable only to those machines which are driven by the force of water, whether it descends by its own weight, or acts by its impulsive power when in motion, or exerts a force in virtue of its re-action. It has, however, been applied in a more extended sense, so as to include various machines, by which water is raised or projected. The application of wind, and the force of animals, as the moving power of machinery, will be fully discussed under Mechanics, and the important application of steam will be considered at great length under the separate article of Steam *Engine*. As pumps and fire engines are pneumatical machines, they will be described under the articles Pneumatics and Pump.

### CHAP. I.

#### On Water Wheels.

The usual method of employing water as the moving power of machinery, is to apply it to the circumference of wheels, from the axis or axletree of which the power is conveyed to the other parts of the machine. When the water is introduced into buckets placed round the circumference of a wheel moving in a vertical plane, so as to put the wheel in motion merely by its weight in the buckets, the wheel is called an *overshot wheel*, from the water being introduced over or near the summit of the wheel. When the water, after having acquired a considerable velocity by its descent along an inclined plane, is made to strike plane surfaces, or floatboards, arranged round the wheel's circumference, so as to put the wheel in motion merely by its impulsive force, it is called an *undershot wheel*, from the water being introduced at or near the under part of its circumference. When the water is introduced neither at the upper nor the lower point of the wheel, but at a point between them, so as to fall upon floatboards fixed in the wheel's circumference, and to act both by its weight and by its impulse, it is called a *breast wheel*. When the water is made to issue from an aperture in the circumference of a wheel in the direction of the tangent, the wheel is said to be driven by the re-action or counter-pressure of the water. We shall now proceed to consider, in separate Sections, the best mode of constructing water wheels of these four different forms.

### Sect. I. *On the Construction of Overshot Wheels.*

An overshot wheel of the common kind, is represented in Plate CCCXIX. Fig. 15, where ABCD is the rim of the wheel, having a number of buckets *a*, *b*, *c*, *d*, arranged round its circumference. When the wheel is in a state of rest upon its axis O, and water is introduced into the bucket *c* from the horizontal mill course or canal EF, the weight of the water in the bucket, acting at the end of a lever equal to *m* O, puts the wheel in motion in the direction *c d*. When the subsequent bucket *b* comes into the position *c*, it is also filled with water, and so on with all the rest. When the bucket *c* reaches the situation of *d*, its mechanical effect to turn the wheel is increased, being now equal to the weight of water acting at the end of a lever *n* O, equal to the distance of its centre of gravity *d* from a vertical line passing through the axis O, so that the mechanical effect of the water in the bucket increases all the way to B, and of course diminishes while the buckets are moving from B to C.

The buckets, however, between B and C, have not the same power upon the wheel as those between A and B; for the water begins to fall out of the buckets before they approach to B, and are almost completely empty when they reach the point H. The construction of the buckets, therefore, as shewn in the Figure, is very improper, as it not only allows the water to escape before it has reached the point B, where its mechanical effect is a maximum; but also to escape completely, long before they have reached the lowest point C of the wheel. The power, therefore, of an overshot wheel must depend principally upon the form which is given to the buckets, which should always be fullest when they are at the point B, and should retain the water as long as possible. If the buckets were to consist of a single partition in the direction of the radii of the wheel, all the water would escape from the buckets before they passed the point B on a level with the axis O.

The form of a bucket, which has been regarded as the best, is represented in Fig. 16, by the line DCBAGIKL, where it is represented as composed of three partitions, viz. AB and GI, called the *start* or *shoulder*, which lies in the direction of the radius; BC and IK, called the *arm*, and inclined at an obtuse angle to the radius; and CD, KL, called the *wrest*, and inclined at an angle less than 180° to the arm BC or IK. The depth AG of each bucket is about $1\frac{1}{5}$ of GH; AB is $\frac{1}{2}$ of AM; and the angle ABC is such, that BC and GI prolonged would pass through the same point H. It ends, however, in C; so that FC is $\frac{5}{6}$ths of GH; and CD is placed so, that HD is nearly $\frac{1}{5}$th of HM. Hence it follows, that the arc FABC is nearly equal to DABC; so that the quantity of water FABC will still continue in the bucket when AD is a horizontal line, which happens when AB forms an angle of about 35° with a vertical line. The preceding construction of the buckets is obviously too complicated, and very little additional power is gained by the angle BCD. Hence the general practice is to continue BC to H, and AB is generally only $\frac{1}{3}$d of GH.

Such is the general view of the construction of buckets, which is given by Dr Robison; but we cannot agree with him in thinking that this form is the best. It must be obvious, upon the slightest consideration, that the power of the wheel would be a maximum, if the whole of its semi-circumference were loaded with water. This effect would be produced, if the buckets had the shape shewn in Fig. 17, where ABC is the form of the bucket, AB being in the direction of the radius, and BC part of the circumference of the wheel, and nearly equal to AD. This construction is, however, impracticable, as the aperture EC is not large enough either for the admission or the escape of the water, and when the last portion of the water flows out along BC, it would strike against the bottom DE of the bucket immediately above it. We must therefore consider what modification this form should receive, in order to give a free passage to the water at EC. This may be effected, by making BC (Fig. 18.) a little larger than BE, and diminishing AB, so as to make the angle ABC a little greater than 90°. In this way an aperture *d* E will be obtained, of sufficient magnitude both for the introduction and the discharge of the fluid; and the last portion of water will no longer strike against the bottom D *d* of the upper bucket. When the water is properly introduced by the methods afterwards to be described, this construction will be found to give great additional power to the wheel. Hence we see the reason why the inclination of DC, in Fig. 16, is advantageous, as it is an approximation to the preceding construction.

The late Mr Robert Burns of Cartside in Renfrewshire, a most ingenious millwright and mechanic, proposed what appeared to be a very great improvement upon the form of the buckets in overshot wheels. It consisted in using a double bucket, as shewn in Fig. 19, where LM is a partition almost concentric with the rim, and placed so as to make the inner and outer portions of the bucket hold equal quantities of water. When these buckets are filled $\frac{1}{3}$d, they retain the whole water at 18° from the bottom of the arch, and they retain $\frac{1}{2}$ of the water at 11°. Another great advantage of this construction is, that when there is little water to drive the wheel, it may be directed by a slight adjustment of the spout, into the outer bucket, so as to make up, by the additional length of lever, for the small quantity of water which is in use. These advantages, however, are found in practice to be counterbalanced by disadvantages which cannot be got the better of. The water is found never to fill the inner buckets, and on this account we believe Mr Burns did not put the construction in practice.

It has in general been assumed by writers on water wheels, that the diameter of overshot wheels should always be less than the height of the fall of water by which it is to be put in motion, and various ratios have been assigned between the height of the fall and the diameter of the wheel. The Chevalier de Borda has shewn, that overshot wheels will produce a maximum effect when their diameter is equal to the greatest height of the fall, but that a slight diminution of the wheel's diameter produces only a very small diminution of the maximum effect. If the height of the fall, for example, is 12 feet, and if the diameter of the wheel is made only 11 feet, the effect is diminished only $\frac{1}{12}$. This theoretical result has been confirmed by the admirable experiments of Mr Smeaton, who found, "*that the higher the wheel is in proportion to the whole descent, the greater will be the effect;*" because, as he remarks, "it depends less upon the impulse of the head, and more upon the gravity of the water in the buckets; and if we consider how obliquely the water issuing from the head must strike the buckets, we shall not be at a loss to account for the little advantage that arises from the impulse thereof, and shall immediately see of how little consequence this impulse is to the effect of an overshot wheel."

If the diameter of the wheel were equal to the whole height of the fall, the water would be laid in the buckets without having acquired any velocity; so that a portion of the power of the wheel would be spent in dragging this inert mass into motion, and also by the impulse of the buckets against the water, which will dash a part of it over the wheel. Hence it is necessary that the difference between the head of water and the diameter of the wheel should be such, that the water may acquire in its descent through that space a velocity a little greater than that of the circumference of the wheel. In this view of the subject, the water should fall through a height of $2\frac{1}{2}$ or 3 inches per second, in order to acquire the velocity of the wheel; and therefore the diameter of the wheel should be only 3 inches less than the height of the fall.

The determination of the diameter of an overshot wheel, as given by Borda, Smeaton, Robison, and other authors, is founded upon the assumption, that it never should exceed the height of the fall. Let us suppose that we have a fall of 12 feet, and that the wheel should have a diameter of 11 feet according to Borda, then it appears to us, that a great advantage will be derived from making the wheel 15 feet. Now it is obvious, that the advantage of using the 15 feet wheel is, that we apply the water where it will act most perpendicularly to the line OD, Fig. 15. or the radius of the wheel, whereas the disadvantage of such a wheel is, that it begins to lose its water much sooner than the small one. We differ in opinion from Robison when he says, that the loss of power in the latter case exceeds what is gained in the former case; but we shall admit that it is so, and still maintain the superiority of the 15 feet wheel. When the wheel has a diameter less than the height of the fall, any augmentation of the quantity of water discharged by the mill course is of no use in increasing the effect of the wheel. The issuing water indeed acquires a velocity greater than it usually has, but this additional velocity is injurious to the motion of the wheel instead of being of any advantage. In the case of a 15 feet fall, however, when the water rises 1 or 2 feet above its usual level, we have it in our power, by a particular form of the delivering sluice, which will afterwards be described, (see p. 555,) to introduce this water upon the wheel 1 or 2 feet higher up the wheel, so that we are actually enabled to increase the height of the fall by this quantity.

From a series of experiments on overshot wheels, by M. Deparcieux, and published in 1754, he has concluded, that most work is performed by an overshot wheel when it moves slowly, and that the more we retard its motion by increasing the work to be performed, the greater will be the performance of the wheel. These experiments were made with a wheel 20 inches in diameter, and having 48 buckets. Cylinders of different diameters were placed upon the axle, and the effect of the wheel under different velocities was measured by the height to which it raised a weight suspended to a rope, which was wound round the different cylinders; and the general result was, that the slower the wheel turns, the greater is the effect, or the height to which the weight is raised.

In opposition to these results, the Chevalier D'Arcy maintained that there is a certain velocity when the effect is a maximum; and he has shewn, from a comparison of Deparcieux's experiments with his own formulæ, that the wheel never moved with such a small velocity as would have given the maximum effect, and that if he had increased the diameter of his cylinders, he would have found that there was a velocity when the maximum effect began to diminish.

The experiments of Smeaton afford an excellent confirmation of the preceding reasoning. The wheel which he used was 25 inches in diameter. The depth of the buckets or of the shrouding, was 2 inches, and the number of buckets 36. When it made about 20 turns in a minute, the effect was nearly the greatest. When the number of turns was 30, the effect was diminished $\frac{1}{20}$th part. When the number was 40, the diminution was $\frac{1}{4}$th; when the number was less than $18\frac{1}{4}$, its motion was irregular; and when it was loaded so as not to be able to make 18 turns, the wheel was overpowered by its load.

"It is an advantage in practice," says Mr Smeaton, "that the velocity of the wheel should not be diminished farther than what will procure some solid advantage in point of power; because, *cæteris paribus*, as the motion is slower the buckets must be made larger; and the wheel being more loaded with water, the stress upon every part of the work will be increased in proportion. The best velocity for practice, therefore, will be such, as when the wheel here used made about 30 turns in a minute; that is, when the velocity of the circumference is a little more than three feet in a second.

"Experience confirms, that this velocity of three feet in a second is applicable to the highest overshot wheels as well as the lowest; and all other parts of the work being properly adapted thereto will produce very nearly the greatest effect possible; however, this also is certain from experience, that high wheels may deviate farther from this rule before they will lose their power by a given aliquot part of the whole, than low ones can be admitted to do; for a wheel of 24 feet high may move at the rate of six feet per second without losing any considerable part of its power; and, on the other hand, I have seen a wheel of 33 feet high, that has moved very steadily and well with a velocity but little exceeding two feet."

The experiments of the Abbé Bossut afford the same results. He used a wheel three feet in diameter. The height of the buckets was three inches, their width five inches, and their number 48; and the canal which conveyed the water furnished uniformly 1194 cubic inches in a minute. When the wheel was unloaded, it made $40\frac{1}{4}$ turns in a minute. The following Table, for which we have computed the fourth column, contains the results which he obtained.

| Number of pounds raised. | Number of seconds in which the load was raised. | Number of revolutions performed by the wheel. | Effect of the wheel, or the product of the number of turns multiplied by the load. |
|---|---|---|---|
| 11 | 60″ | $11\frac{46}{48}$ | $131\frac{32}{48}$ |
| 12 | 60 | $11\frac{11}{48}$ | $134\frac{36}{48}$ |
| 13 | 60 | $10\frac{25}{48}$ | $136\frac{37}{48}$ |
| 14 | 60 | $9\frac{40}{48}$ | $137\frac{32}{48}$ |
| 15 | 60 | $9\frac{10}{48}$ | $138\frac{6}{48}$ |
| 16 | 60 | $8\frac{31}{48}$ | $138\frac{16}{48}$ |
| 17 | 60 | $8\frac{9}{48}$ | $139\frac{9}{48}$ |
| 18 | 60 | $7\frac{32}{48}$ | 138 |
| 19 | The wheel turned very slowly. | | |
| 20 | The wheel stopped, though first put in motion by the hand to make it catch the water. | | |

From this Table it appears, that the effect is a maximum when the number of turns is $8\frac{9}{48}$, or when the velocity of the circumference is 1 foot 4 inches per second. The effect diminished by diminishing the velocity, and the wheel was at last overpowered by its load, as in Smeaton's experiments, which ought always to happen when the resistance or load is equal to the effect of all the buckets, when acting upon a semicircumference of the wheel with their respective quantities of water.

In comparing the relative effects of water wheels, the Chevalier de Borda maintains, that an overshot wheel will raise through the height of the fall a quantity of water equal to that by which it is driven; while Albert Euler affirms that the effect is greatly inferior to this. The experiments of Mr Smeaton shew, that when the heads and quantities of water are least, the ratio between the power and the effect at the maximum is nearly as 4 : 3 ; but when the heads and quantities of water were greater, it is as 4 : 2 ; and by a medium of the whole, it is as 3 : 2. When the powers of the water, computed for the height of the wheel only, are compared with the effects, they observe a more constant ratio, the variation being only between the ratio of 10 : 8.1 and 10 : 8.5. Hence the ratio of the power, computed upon the height of the wheel only, is to the effect, at a maximum, as 10 : 8, or as 5 : 4 nearly; and the effects, as well as the powers, are as the quantities of water and perpendicular heights multiplied together respectively.

The form of the delivering sluice, and the method of introducing the water into the buckets, will be best explained in the description of different overshot wheels.

*Smeaton's Overshot Wheel.*

The overshot wheel, as constructed by Mr Smeaton for the upper paper mill of Thornton, is shewn in Plate CCCXX. Fig. 1, where the diameter of the wheel is as nearly as possible equal to the height of the fall; and another wheel, which he considered as of an improved form, is represented in Fig. 2. where the diameter of the wheel exceeds the height of the fall. In both these Figures AB is the wheel, and MN the extremity of the mill course, where the water is delivered into the buckets. A vertical lever *a b c* turning round *b* as a centre, gives motion to the horizontal arm *c d*, and causes one of the shuttles *e f* to advance or recede ; in consequence of which the aperture on the right hand of *f* may be either increased or diminished, for the purpose of regulating the supply of water which the wheel may require. The iron bolt *g* goes through the bottom of the trough between the two shuttles, and is intended to prevent the bottom from sinking by the weight of the water. From the form of the aperture at *f*, it will be seen that the water will glide easily into the buckets without any waste. In both these machines, the water is turned back on the near half of the wheel ; the consequence of which is, that the resistance of the lower water is removed, as it runs off in the same direction with the motion of the wheel. The wheel in Fig. 1. is made to fit its sweep and the sides of the conduit as if it were a breast wheel, so that the water does not get out of the buckets till it reaches the lowest point.

*Improved Overshot Wheel.*

An excellent overshot wheel, which we understand is used in Yorkshire, is represented in Fig. 3. It differs from the wheel in Fig. 2. in the construction of the extremity of the mill course, and in the mode of delivering the water upon the wheel. A pinion *d*, turned with a handle, works in the teeth of a rack *c a*, having a roller *a*, whose breadth is equal to that of the mill course, fixed at its extremity. Upon this roller is fixed a large piece of leather, which, after wrapping round part of the cylindrical circumference, extends downwards to *b*, where it is fixed, as seen in the Figure, between two plates of iron or wood held together by screws. This leather forms the shuttle in the following manner. When the water stands so low in the mill course MN, that none of it runs over the roller so as to fall into the buckets, the pinion *d* is made to move from right to left, so as to cause the rack *c a* and roller *a* to descend. The leather shuttle is thus wound up upon the roller, and the water is allowed to pass over the surface *a*, and to fall into the buckets through the apertures made of iron bars, as shewn in the Figure. When the water, on the contrary, rises in the mill course, so that too much of it flows over the roller, the rack is made to move in the opposite direction, so as to diminish the supply. In this construction of the regulator, we see at once the advantages of having the diameter of the wheel AB greater than the height of the fall ; for we are at liberty to take advantage of the additional head which is gained by any increase in the quantity of water which is conveyed to the wheel.

*Description of Mr Burns' Overshot Wheel without a Shaft.*

This very ingenious machine was invented and erected by the late Mr Burns, whose mechanical ingenuity we have already had occasion to admire. It is represented in two different sections, in Figs. 4 and 5, and forms a large hollow cylinder by its buckets and sole, without having any shaft or axle tree.

This wheel is 12½ feet diameter, and 7 feet broad over all, and has 28 buckets. The gudgeon is 6 inches diameter, by 9 inches long. The flaunch is 1¼ inch thick at the extreme points. The arms are of redwood fir, 6 inches square ; one piece making two arms in length, where they cross one another at the wheel's centre, 1¼ inch of the wood remaining in each, connecting the two opposite arms as one piece. The wheel was made, by first fitting the gudgeon into a large piece of hard wood, with the flaunch parallel to the horizon, and in that position the arms and rings were trained and bound fast to it. All the grooves for starts or raisers, and buckets, were cut out before it was removed; first one piece was bolted to the flaunch at *a a*, and so of the others, leaving the distant openings for the cross bars that reach between each arm and its opposite arm. These bars, or pieces, were only 4 inches square, and were of good beech wood, turned round in the body. They were 10 inches square at each end, in which was fitted a strong nut for a bolt, 1¼ inch thick, to go through *b*, and connect the two sides together.

After the arms were trained and fixed right upon the gudgeons, the innermost ring was completed ; the tenons were trained on the arms first, and the rings, 4½ inches thick and 8 inches deep, put on by keys driven into the mortice. The remaining tenons were then reduced from 1½ to 1 inch thick, and the outermost ring, only 3 inches thick by 6 inches deep, was firmly wedged thereon, and bound fast at the other ends by three strong wooden pins, as at O C ; to the lower ring, the outside of the uppermost and undermost rings are flush, all the additional thickness of the lower ring projecting inside the buckets.

Some difficulty was found in laying the water properly into the buckets of this wheel, owing to the narrowness of the mouths of the buckets, by the high start or raiser, which was remedied by adopting the following plan.

The openings in the bottom of the troughing should be of iron, and so distant from each other that the water from them is thrown into two separate buckets. The iron curved parts should also be moveable, to adjust the openings to the quantity of water necessary for the wheel. Unless the head of water is 12 or 14 inches above these openings, it will be difficult to give it the proper direction into the buckets, especially if the openings are pretty wide for them ;

for then it deviates the more down from the line of direction, and tends to retard the wheel, by striking on the outside of the bucket.

The openings from which the buckets are filled, ought to be 10 inches less in length than the buckets, *i. e.* 5 inches at each side, otherwise the water is apt to jerk over on each side of the wheel, as the edge of the bucket passes by.

The mode of making and finishing the wheel at Cartside requires very little workmanship, compared to the usual method; and any good joiner will do it as well as a millwright. The joiner finished Cartside wheel in six or seven weeks. The construction will be better understood from the following reference to the figures.

Fig. 4. Represents three distinct transverse views. The part marked A, supposes a part of the shrouding in section shewing the pins; the part marked B, is a section of the wheel through any part of the buckets, and shewing three of the ties, 1, 2, 3, in section. Part C shews the manner in which the exterior ends of the wheel are finished, also the gudgeons, flaunch, &c.

Fig. 5. Is a longitudinal section of the wheel through one of the arms, shewing the projection of the shrouding—the manner in which the arms of the wheel are connected together—and likewise the manner in which the ties are connected to the gudgeon.

*Description of a Double Overshot Wheel with a Chain of Buckets.*

When there is a very small supply of water falling from a very great head, the overshot wheel which it is necessary to employ is so large and expensive, and so apt to be injured from its unwieldy size, that few persons would be disposed to erect one. We have seen at Coalbrook Dale a very excellent overshot wheel, of about fifty feet in diameter, which went remarkably well; and we understand that there are in Wales some wheels of nearly double this diameter. In circumstances like this, the double overshot wheel, with a chain of buckets, is a most invaluable machine, not merely from the small price at which it can be erected, but from the great power which it possesses. A machine of this kind seems to have been first erected by M. Francini in 1668, in the garden of the king of France's old library. This machine of Francini's was driven by waste water, and raised water from a natural spring, by means of another chain of buckets fixed upon the same wheel.

M. Costar substituted a similar machine in place of the overshot wheel; and more recently Mr Gladstanes, an ingenious millwright at Castle Douglas, without knowing that he had been anticipated in the invention, erected several in Galloway for the purpose of giving motion to threshing mills.

The double overshot wheel is represented in Plate CCCXX. Fig. 6, where A and B are two rag wheels, as they are called, and CDEF a series of buckets fixed to an endless chain, whose links fall into notches in the circumference of the rag wheels. The water issuing from the mill course at MN is introduced into the buckets on the side C. The descent of the loaded buckets on the side C puts the wheels A and B in motion, and the power is conveyed from the shaft of the wheel A to turn any kind of machinery. When the buckets reach F, they allow the water to escape, and ascending empty on the side E, they again return to the spout MN, to be filled as before. In this machine, the buckets have in every part of their path the same mechanical effect to turn the wheels, and they will not allow the water to escape till they have reached almost the lowest part of the fall.

This species of wheel possesses another advantage, which can be obtained from no other, namely, that by raising the wheel B, and taking out two or three of the buckets, it may be made to work when there is such a quantity of backwater as would otherwise prevent it from moving.

Dr Robison, in his Dissertation on Water Works, published in the second volume of his *System of Mechanical Philosophy*, has described a machine of this kind, in which plugs, or horizontal floatboards, are fixed to a chain. On the side C these plugs pass through a tube, a little greater in diameter than that of the floats, and the water acting by its pressure upon these floats, as it does in the case of a breast wheel, gives motion to the wheels A and B.

The double overshot wheel is the best and the most economical which can be adopted for a small supply of water falling from a great height; but it is liable to get out of order, unless the chain which carries the bucket is made with great care and nicety.

For farther information on overshot wheels, the reader is referred to Belidor's *Architecture Hydraulique*, vol. ii. p. 254. Desagulier's *Course of Experimental Philosophy*, edit. 3d, vol. ii. p. 455. Deparcieux, *Mem. Acad. Par.* 1754, p. 603, 671. Smeaton *On Mills*, p. 33. Albert Euler, *Comment. Soc. Gotting.* 1754. Kæstner, *Hydrodynamique.* Lambert, *Mem. Acad. Berl.* 1755. Borda, *Mem. Acad. Par.* 1767, p. 286. Bossut, *Traité d'Hydrodynamique*, edit. 1796, tom. i. chap. xvii. p. 538; and tom. ii. chap. xviii. p. 425. Fenwick's *Four Essays on Practical Mechanics.* Robison, *System of Mechanical Philosophy*, vol. ii.; and Ferguson's *Lectures on Mechanics*, &c. vol. ii. Appendix.

## Sect. II. *On Undershot Water Wheels.*

An undershot water wheel is a wheel with a number of floatboards, or plane surfaces arranged round its circumference for the purpose of receiving the impulse of the water, which is conveyed to the under part of the wheel from an inclined canal. A wheel of this kind of the ordinary construction, is shewn in Plate CCCXX. Fig. 7. where AB is the wheel with 24 floatboards, *c d* a floatboard receiving the impulse of the water, which moves with great velocity in consequence of having fallen from a considerable height down the inclined mill course MN. The principal points to be attended to in the construction of undershot wheels are, the construction of the mill course, the number, form, and position of the floatboards, and the velocity of the wheel in relation to that of the water when the effect is a maximum. The following rules for the construction of mill courses are given in the Appendix to Ferguson's *Lectures*, vol. ii.

"As it is of the highest importance to have the height of the fall as great as possible, the bottom of the canal, or dam, which conducts the water from the river, should have a very small declivity; for the height of the water-fall will diminish in proportion as the declivity of the canal is increased. On this account, it will be sufficient to make AB slope about one inch in 200 yards, taking care to make the declivity about half an inch for the first 48 yards, in order that the water may have a velocity sufficient to prevent it from flowing back into the river. The inclination of the fall, represented by the angle GCR, should be 25° 50′; or CR, the radius, should be to GR, the tangent of this angle, as 100 to 48, or as 25 to 12; and since the surface of the water S *b* is bent from *a b* into *a c*, before it is precipitated down the fall, it will be necessary to incurvate the upper part BCD of the course into BD, that the water at the bottom may move parallel to the water at the top of the stream. For this purpose, take the points B, D, about 12 inches distant from C, and raise the perpendiculars BE, DE: the point of intersection E will be the centre from which the arch BD is to be described; the radius being about $10\frac{1}{6}$ inches. Now, in order that the water may act more advantageously upon the floatboards of the wheel WW, it must assume a horizontal direction HK, with the same velocity which it would have acquired when it came to the point G: But, in falling from C to G, the water will dash upon the horizontal part HG, and thus lose a great part of its velocity; it will be proper, therefore, to make it move along FH an arch of a circle, to which DF and KH are tangents in the points F and H. For this purpose make GF and GH each equal to three feet, and raise the perpendiculars HI, FI, which will intersect one another in the point I distant about 4 feet 9 inches and $\frac{4}{10}$ths from the points F, and H, and the centre of the arch FH will be determined. The distance HK, through which the water runs before it acts upon the wheel, should not be less than two or three feet, in order that the different portions of the fluid may have obtained a horizontal direction: and if HK be much larger, the velocity of the stream would be diminished by its friction on the bottom of the course. That no water may escape between the bottom of the course KH and the extremities of the floatboards, KL should be about three inches, and the extremity *o* of the floatboard *n o* should be beneath the line HKX, sufficient room being left between *o* and M for the play of the wheel, or KLM may be formed into the arch of a circle KM concentric with the wheel. The line LMV, called by M. Fabre, the course of impulsion (*le coursier d'impulsion*) should be prolonged, so as to support the water as long as it can act upon the floatboards, and should be about 9 inches distant from OP, a horizontal line passing through O, the lowest point of the fall; for if OL were much less than 9 inches, the water having spent the greater part of its force in impelling the floatboards, would accumulate below the wheel and retard its motion. For the same reason, another course, which is called by M. Fabre, the course of discharge (*le coursier de decharge*) should be connected with LMV by the curve VN, to preserve the remaining velocity of the water, which would otherwise be destroyed by falling perpendicularly from V to N. The course of discharge is represented by VZ, sloping from the point O. It should be about 16 yards long, having an inch of declivity in every two yards. The canal which reconducts the water from the course of discharge to the river, should slope about 4 inches in the first 200 yards, 3 inches in the second 200 yards, decreasing gradually till it terminates in the river. But if the river to which the water is conveyed, should, when swollen by the rains, force the water back upon the wheel, the canal must have a greater declivity, in order to prevent this from taking place. Hence it will be evident, that very accurate levelling is necessary for the proper formation of the mill course."

The general ideas contained in the preceding constructions appear to have been first suggested by Du Buat, and afterwards fully explained by M. Fabre in his *Traité sur les Machines Hydrauliques*.

The diameters of undershot wheels must in general be accommodated to the nature of the machinery which they are to put in motion. If a great velocity is necessary, the wheel should for this purpose be made of a less diameter than would otherwise be advisable; but if a great velocity is not required, the diameter of the wheel ought to be considerable.

M. Pitot, one of the earliest writers who attended to this subject, recommended that the number of floatboards should be equal to 360° divided by the arch of the circle plunged in the canal, and that their depth should be equal to the versed sine of that arch. The slightest consideration, however, is sufficient to convince us that the number of floatboards obtained by this rule is greatly too small. M. Du Petit Vandin, and afterwards M. Fabre, have, on the other hand, maintained, that the greatest possible number of floatboards should be used, provided the wheel is not too much loaded by them.

In Mr Smeaton's model, by which his experiments were performed, the diameter of the wheel was 24 inches, and the number of floatboards 24. When the number was reduced to 12, a diminution in the effect was produced on account of a greater quantity of water escaping between the floats and the floor; "but a circular sweep being adapted thereto of such a length that one float entered the curve before the preceding one quitted it, the effect came so near to the former, as not to give hopes of advancing it, by increasing the number of floats beyond 24 in this particular wheel."

The experiments of Bossut were made with a wheel, whose exterior diameter was 3 feet 1 inch 10 lines. It was used successively with 48, 24, and 12 floatboards directed to the centre. They were exactly five inches wide, and from four to five inches high. The edges and the extremities of the floatboards were distant about half a line from the bottom and sides of the inclined canal in which the wheel was placed, and the arch plunged in the water was 24° 54′. When this wheel was tried, it made $33\frac{1}{2}$ turns in a minute, when it had 48 floatboards, and when the weight raised was 12 pounds. When 24 floatboards were put on, it made only 29 turns in a minute, the weight raised being the same; and when 12 floatboards were used, it made no more than $25\frac{1}{4}$ turns in a minute. The velocity of the water in the canal, which had a declivity of $10\frac{1}{2}$ feet in 50, was 300 feet in 33 seconds. Hence Bossut concludes, that the wheel ought to have at least 48 floatboards, whereas wheels 20 feet in diameter, and with only 25° or 30° of the circumference immersed, have generally only 40.

When wheels are moved by a river, they ought to have a different number of floatboards. In order to find the number, M. Bossut used a different wheel, in which the floatboards were so placed that he could set them at any inclination to the radius, and employ any number of them at pleasure. The exterior diameter was 3 feet, the width of the floatboards 5 inches, and their height 6 inches. This wheel was made to move in a current from 12 to 13 feet wide, and in a depth of water of from 7 to 8 inches. The floatboards were plunged 4 inches in the water, so that the circumstances were the same as in an open river. When 24 floatboards were used, a load of forty pounds was raised with a velocity of $15\frac{28}{48}$ turns in 40 seconds; whereas when 12 floatboards were used, the velocity with which the same load was raised was only $13\frac{15}{48}$ turns in the same time. When 48 floatboards were put on, 24 pounds were raised, with a velocity of $27\frac{19}{48}$ turns in a minute; and 24 floatboards raised the weight with a velocity of $\frac{27}{48}$, the difference being perfectly trifling. Hence 24 floatboards at least should be used in cases of this kind. A smaller number would be sufficient, if a greater arch of the wheel were plunged in the stream. In practice, it was the general custom to use only 8 or 10 floatboards, and sometimes fewer, on wheels placed in rivers; but the number ought to have been from 12 to 18.

From theoretical considerations, M. Pitot has shewn, that floatboards should always be a continuation of the radius; but this rule is found to be quite incorrect in practice. The advantages arising from inclining the floatboards were first pointed out in 1753 by Deparcieux, who shews, that the water will thus heap up upon them, and act by its weight as well as by its impulse. This opinion has been amply confirmed by the experiments of Bossut with the wheel already mentioned, moving in a canal where the velocity of the water was 300 feet in 27 seconds. When the floatboards were a continuation of the radius, a weight of 34 pounds was raised with a velocity of $\frac{26}{48}$ turns in forty seconds. When their inclination was 8°, the same load was raised with a velocity of $19\frac{20}{48}$ in forty seconds. When the inclination was 12°, the velocity was $19\frac{40}{48}$ in 40″; and when the inclination was 16°, the velocity was $20\frac{24}{48}$ turns in 40 seconds, nearly the same, but still a little less than when the floatboards were a continuation of the radius. Hence it follows, that a wheel placed upon canals which have little declivity, and in which the water is at liberty to escape easily after the impulse, the floatboards ought to be a continuation of the radius.

The same wheel being placed in the current already mentioned, viz. from 12 to 13 feet wide, and from 7 to 8 inches deep, floatboards which were a continuation of the radius raised 40 pounds with a velocity of $13\frac{17}{48}$ turns in 40 seconds. With those inclined 15°, the number of turns in the same time was $14\frac{21}{48}$; with those inclined 30°, the number was $14\frac{22}{48}$; and with those inclined 37°, the number was $14\frac{15}{48}$. Hence it follows, that the most advantageous obliquity is, in this case, about 15 or 30 degrees. The difference of effect, however, appears to be very trifling, particularly beyond 15°. M. Fabre is of opinion, that when the velocity of the stream is 11 feet per second or greater, the inclination should never be less than 30°; that, as the velocity diminishes, the number of floatboards should diminish in proportion; and that when the velocity is four feet or under, the floatboards should be a continuation of the radius. The experiment of inclining the floatboards a little in the opposite direction, has not been tried by any of the authors whom we have quoted, but we think it worth trying, as it might increase the effect, by allowing the water to escape more readily from below the floatboards.

In order to determine the ratio between the velocity of the wheel and that of the water which drives it, Parent and Pitot considered only the action of the fluid upon one floatboard, and consequently they made the force of impulsion proportional to the square of the relative velocity, or to the square of the difference between the velocity of the stream and that of the floatboard. Desaguliers, Maclaurin, Lambert, Atwood, Du Buat, and Dr Robison, have gone upon the same principle, and have therefore fallen into the same error, of making the velocity of the wheel $\frac{1}{3}$ of the velocity of the current when the effect is a maximum. The Chevalier de Borda, whose valuable Memoirs have been too much overlooked by later writers, has, however, corrected this error. He has shewn, that the supposition is perfectly correct when the water impels a single floatboard; for as the number of particles which strike the floatboard in a given time, and also the momentum of these, are each as the relative velocity of the floatboards, the momentum must be as the square of the relative velocity, that is, $M \div R^2$, M being the momentum, and R the relative velocity. But as the water acts on more than one floatboard at once, the number acted upon in a given time will be as the velocity of the wheel, or inversely as the relative velocity; for if we increase the relative velocity, the velocity of the water remaining the same, we must diminish the velocity of the wheel. Consequently, we shall have $M \div \frac{R^2}{R}$ or $M \div R$; that is, the momentum of the water acting upon the wheel varies as the relative velocity.

Now, let V be the velocity of the stream, F the force with which it would strike the floatboard at rest, and $v$ the velocity of the wheel. Then the relative velocity will be $V-v$; and since the velocity of the water will be to its momentum, or the force with which it would strike the floatboard at rest, as the relative velocity is to the real force which the water exerts against the moving floatboards, we shall have $V : V-v = F : F\times\frac{\overline{V-v}}{V} = \frac{F}{V}\times V-v$. But the effect of the wheel is measured by the product of the momentum of the water and the velocity of the wheel, consequently the effect of the undershot wheel will be

$$v\times\frac{F}{V}\times\overline{V-v} = \frac{F}{V}\times\overline{V-v^2}.$$

Now this effect is to be a maximum, and therefore its differential must be equal to 0, that is, $v$ being the variable quantity, $V\,dv - 2\,v\,dv = 0$, or $2\,v\,dv = V\,dv$. Dividing by $dv$, we have $2v = V$, and $v = \frac{V}{2}$, that is, the velocity of the wheel will be *one-half* the velocity of the fluid when the effect is a maximum.

This has been amply confirmed by the experiments of Mr Smeaton. "The velocity of the stream (says he, p.77,) varies at the maximum between one-third and one-half that of the water; but in all the cases in which most work is performed in proportion to the water expended, and which approach the nearest to the circumstances of great works, when properly executed, the maximum lies much nearer to *one-half* than *one-third*, one-half seeming to be the true maximum, if nothing were lost by the resistance of the air, the scattering of the water carried up by the wheel, &c. all which tend to diminish the effect more at what would be the maximum if these did not take place than they do when the motion is a little slower." Smeaton considers 5 to 2 as the best general proportion.

A result, nearly similar to this, was deduced from the experiments of Bossut. He employed a wheel whose diameter was three feet. The number of floatboards was at one time 48, and at another 24, their width being 5 inches, and their depth six. The experiments with the wheel, when it had 48 floatboards, were made in the inclined canal, in which the velocity was 300 feet in 27 seconds. The experiments with the wheel, when it had 24 floatboards, were made in a canal, contained between two vertical walls, 12 or 13 feet distant. The depth of the water was about 7 or 8 inches, and its mean velocity about 2740 inches in 40 seconds. The floatboards of the wheel were immersed about four inches in the stream.

| Time in which the weight is raised. | Weight raised. | Number of turns made by the wheel. | Weight raised. | Number of turns made by the wheel. |
|---|---|---|---|---|
| Seconds. | 48 Floatboards. | | 24 Floatboards. | |
| | Pounds. | Pounds. | Pounds. | Pounds. |
| 40 | $30\frac{1}{2}$ | $22\frac{12}{48}$ | 30 | $17\frac{22}{48}$ |
| 40 | 31 | $22\frac{4}{48}$ | 35 | $16\frac{26}{48}$ |
| 40 | $31\frac{1}{2}$ | $21\frac{42}{48}$ | 40 | $15\frac{28}{48}$ |
| 40 | 32 | $21\frac{32}{48}$ | 45 | $14\frac{31}{48}$ |
| 40 | $32\frac{1}{2}$ | $21\frac{20}{48}$ | 50 | $13\frac{34}{48}$ |
| 40 | 33 | $21\frac{8}{48}$ | 55 | $12\frac{37}{48}$ |
| 40 | $33\frac{1}{2}$ | $20\frac{44}{48}$ | 56 | $12\frac{28}{48}$ |
| 40 | 34 | $20\frac{32}{48}$ | 57 | $12\frac{19}{48}$ |
| 40 | $34\frac{1}{2}$ | $20\frac{21}{48}$ | 58 | $12\frac{10}{48}$ |
| 40 | 35 | $19\frac{44}{48}$ | 59 | $12\frac{1}{48}$ |
| 40 | $35\frac{1}{2}$ | $19\frac{15}{48}$ | 60 | $11\frac{40}{48}$ |
| 40 | 36 | $18\frac{28}{48}$ | 61 | $11\frac{30}{48}$ |
| 40 | | | 62 | $11\frac{19}{48}$ |
| | | | 63 | $11\frac{7}{48}$ |
| | | | 64 | $10\frac{41}{48}$ |
| | | | 65 | $10\frac{25}{48}$ |
| | | | 66 | $10\frac{5}{48}$ |

As the effect of the machine is measured by the product of the load raised, and the time employed, it will appear, by multiplying the second and third columns, that the effect was a maximum when the load was $34\frac{1}{2}$ pounds, the wheel performing $20\frac{21}{48}$ revolutions in 40 seconds. By comparing the velocity of the centre of impression computed from the diameter of the wheel, and the number of turns which it makes in 40 seconds, with the velocity of the current, it will be found that the velocity of the wheel, when its effect is the greatest possible, is nearly two-fifths that of the stream; the very same ratio which Smeaton has given. From the two last columns of the Table, where the effect is a maximum when the load is 60 pounds, the same conclusion may be deduced.

The following are the other results which Mr Smeaton deduced from his experiments. He found, that in undershot wheels, the power employed to turn the wheel is to the effect produced as 3 to 1; and that the load which the wheel will carry at its maximum, is to the load which will totally stop it as three to four. The same experiments inform us, that the impulse of the water on the wheel, in the case of a maximum, is more than double of what is assigned by theory, that is, instead of four-sevenths of the column, it is nearly equal to the whole column. In order to account for this, Mr Smeaton observes, that the wheel was not, in this case, placed in an open river, where the natural current, after it had communicated its impulse to the float, has room on all sides to escape, as the theory supposes; but in a conduit or race, to which the float being adapted, the water could not otherwise escape than by moving along with the wheel. He likewise remarks, that when a wheel works in this manner, the water as soon as it meets the float, receives a sudden check, and rises up against it like a wave against a fixed object; insomuch, that when the sheet of water is not a quarter of an inch thick before it meets the float, yet this sheet will act upon the whole surface of a float, whose height is three inches. Were the float, therefore, no higher than the thickness of the sheet of water, as the theory supposes, a great part of the force would be lost by the water dashing over it. Mr Smeaton likewise deduced, from his experiments, the following maxims.

1. That the virtual or effective head being the same, the effect will be nearly as the quantity of water expended.

2. That the expense of water being the same, the effect will be nearly as the height of the virtual or effective head.

3. That the quantity of water expended being the same, the effect is nearly as the square of the velocity.

4. That the aperture being the same, the effect will be nearly as the cube of the velocity of the water.

*Undershot Wheel moving at Right Angles to the Stream.*

Undershot wheels have sometimes been constructed like windmills, having large inclined floatboards, and being driven in a plane perpendicular to the direction of the current. Albert Euler, who has examined theoretically this species of water wheel, concludes that the effect will be twice as great as in common undershot wheels, and that in order to produce this effect, the velocity of the wheel, computed from the centre of impression, should be to the velocity of the water as radius is to thrice the sine of the inclination of the floatboards to the plane of the wheel. When the inclination is 60°, the ratio will be as 5 to 13 nearly, and when it is 30°, it will be nearly as 2 to 3. In this kind of wheel, a considerable advantage may also be gained by inclining the floatboards to the radius. In this case, the area of the floatboards ought to be much greater than the section of the current, and before one floatboard leaves the current, the other ought to have fairly entered it. This construction may be employed with advantage in deep rivers that have but a small velocity.

*Besant's Undershot Wheel.*

This wheel, invented by Mr Besant of Brompton, is constructed in the form of a hollow drum, to resist the admission of water; but its principal peculiarity consists in the arrangement of the floatboards in pairs on the periphery of the wheel. Each floatboard is set obliquely to the plane of the wheel's motion, and the corresponding floatboard is inclined at the same angle, but in an opposite direction, the plane of the wheel bisecting the angle formed by the two floatboards. The acute angle which the one floatboard forms with its corresponding one is open at the vertex; but one of the floatboards extends beyond the other. By this construction, the resistance from the tail water is diminished; but so far as we know, the machine has never come into use. See Ferguson's *Lectures*, vol. ii.

*Horizontal Water Wheels.*

Horizontal water wheels differ in no respect from common undershot wheels except in the circumstance of their extremities being placed vertically. The mill course is constructed nearly in the same manner for both. The principal object of this form of the water wheel is to save machinery, by placing the mill-stone directly on the vertical shaft of the wheel. The water wheel must therefore move with a very great velocity, so as to enable the mill-stones to perform their work. The water is turned into a horizontal direction before it strikes the floatboards, which may be either vertical or inclined to the radius, as in undershot wheels.

Horizontal wheels are often constructed so that the floatboards have a very great inclination to the radius. In this case, the water is not turned into a horizontal direction, but is made to strike the floatboards perpendicularly, as in Fig. 9. where AB is the wheel, MN the mill-course discharging its contents perpendicularly upon the floatboard C, which ought to have a surface more than twice the area of the section of the stream. In this construction, the maximum effect will be produced when the velocity of the floatboards is not less than $\frac{5.67\sqrt{h}}{2\sin.a}$, where $h$ is tho height of the fall, and $a$ the angle which the direction of the fall makes with a vertical line. But since this quantity increases as the sine of $a$ decreases, we may diminish the angle $a$, and thus increase the velocity of the floatboards, to suit the nature of the work to be performed, without lessening the maximum effect, which cannot be done in vertical wheels where a determinate velocity is necessary to produce the greatest possible effect. See Ferguson's *Lectures*, vol. ii. Appendix.

In the southern departments of France, the floatboards are made of a curvilineal form, so as to present a concave surface to the stream. This construction is shewn in Figs. 10, 11, where AB is the wheel, CD the vertical shaft, and *m*, *n*, the concave floatboards. The Chevalier Borda remarks, that in theory a double effect is produced when the floatboards have this form; but that the advantage is not so great in practice, from the difficulty of making the fluid enter and leave the course in a proper manner. They appear, however, to be decidedly superior to those in which the floatboards are plane, as the water acts by its weight as well as by its impulsive force. The ratio of the effects in the two cases, with five or six feet of fall, is nearly as 3 to 2. An advantage may be gained by dividing the current, and throwing it in separate portions upon different floatboards. See Leopold's *Theatrum Mach. General.*

A different kind of horizontal wheel, invented by Mr Robert Leslie, which works by the tide upon the principle of a smoke jack, is shewn in Figs. 12, 13. This machine, which is shewn in a vertical section in Fig. 12, and in a horizontal section in Fig. 13, consists of a circular box or drum *op*, widened at top into another circular drum AB, two parts of which, GO and EF, are made to open and shut, as shewn by the dotted lines. When the tide moves in the direction OE, the part GO shuts into the position GH, and admits the water upon the wheel; but when the tide returns, GH assumes the position GO, and EF shuts into the dotted position E*f*, and admits the water to the wheel. The axis EF, Fig. 12, stands vertically, and has the vanes *m*, *n* fitted upon it like those of a smoke jack. The water enters at O, and at F*f* when the tide returns, descends in the direction of the arrows, acts by its impulse and its weight on the oblique vanes *m*, *n*, and after turning the wheel about its vertical axis EF, escapes at the aperture P, or P′ when the tide returns.

*Wheels with Spiral Floatboards.*

In some of the southern provinces of France a conical horizontal wheel with spiral floatboards is frequently used. It has the form of an inverted cone, with a number of spiral floatboards winding round its surface, so as to be nearer one another at the smaller or lower end of the cone, than at the larger or upper end. When the water has acted upon these floatboards by its impulse, it descends along the spirals, and continues to drive the machine by its weight. A drawing of this machine will be seen in Ferguson's *Lectures*, vol. ii. App.

Dr Robison describes another wheel with spiral floatboards, which was moved by a screw. "It was," he says, "a long cylindrical frame, having a plate standing out from it, about a foot broad, and surrounding it with a very oblique spiral like a cork screw. This was plunged about ⅘th of its diameter (which was about 12 feet,) having its axis in the direction of the stream. By the work which it was performing, it seemed more powerful than a common wheel, which occupied the same breadth of the river."

For farther information on the subject of undershot wheels, see Pitot, *Mem. Acad Par.* 1729, 8vo. p. 359; Desagulier's *Experimental Philosophy*, vol. ii. p. 424; Du Petit Vandin, *Mem. des Scavans Etrangers*, tom. i.; Deparcieux, *Mem. Acad.* 1754, p. 614; Fabre *Sur les Machines Hydraulique*, p. 55; Bossut's *Traite d'Hydrodynamique*, vol. i. chap. xiv. xv p. 482; vol. ii. chap. xviii. edit 1797; Maclaurin's *Fluxions*, § 907, p. 728; Lambert, *Nouv. Mem. de l'Acad. Berlin.* 1775, p. 63; Smeaton's *Experiments on Mills*; Borda, *Mem Acad. Par*; *Leopold's Theatrum Machin General.*; *Repertory of Arts*, vol. i. p. 385; Ferguson's *Lectures*, vol. ii. App.; and Dr Robison's *System of Mech. Philosophy*.

## Sect. III. *On Breast Wheels.*

A breast water wheel is a wheel in which the water is delivered at a point intermediate between the upper and under point of a wheel with floatboards. It is generally delivered at a point below the level of the axis, as in Fig. 1, but sometimes at a point higher than the level of the axis, as in Fig. 2. On breast wheels, buckets are never employed, but the floatboards are fitted accurately, with as little play as possible, to the mill course, so that the water, after acting upon the floatboards by its impulse, is retained between the floatboards and the mill-course, and acts by it weight till it reaches the lowest part of the wheel.

A breast wheel as constructed by Mr Smeaton, is represented in Fig. 1, where AB is a portion of the wheel, MN the canal which conveys the water to the wheel, MOP the curvilineal mill-course accurately fitted to the extremities of the floatboards, and *c d* the shuttle moved by a pinion *a*, for the purpose of regulating the admission of water upon the wheel.

An improved breast wheel is shewn in Fig. 2. The water is delivered on the wheel through an iron grating *a b*, and its admission is regulated by two shuttles *c d*, the lowermost of which, *d*, is adjusted till a sufficient quantity of water passes over it; while the other, *c*, which is generally moved by machinery, is made to descend upon *d*, so as to stop the wheel.

According to Mr Smeaton, "the effect of a breast wheel is to the effect of an undershot wheel, whose head of water is equal to the difference of level between the surface of water in the reservoir and the part where it strikes the wheel, added to that of an overshot whose height is equal to the difference of level between the part where it strikes the wheel and the level of the tail water.

M. Lambert observes, that when the fall of water is between 4 and 10 feet, a breast water wheel should be erected, provided there is enough of water; that an undershot wheel should be used when the fall is below 4 feet, and an overshot wheel when the fall exceeds 10 feet. He recommends also, that when the fall exceeds 10 feet, it should be divided into two, and two breast wheels erected upon it. These rules are not of great value. The other results of Lambert's investigation will be found either in his *Memoir*, or in Ferguson's *Lectures*, Appendix, vol. ii.

*Comparative effects of Water Wheels.*

M. Belidor very strangely maintained that overshot wheels were inferior to undershot ones. It appears, however, from Smeaton's experiments, that in overshot wheels the ratio of the power to the effect is nearly as 3 to 2, or as

5 to 4, whereas in undershot wheels the ratio is only as 3 to 1; from which it follows, that the effect of overshot wheels is nearly double of the effect of undershot wheels. The Chevalier de Borda has concluded that overshot wheels will raise through the height of the fall a quantity of water equal to that by which they are driven; that undershot wheels moving vertically will produce $\frac{3}{8}$ths of this effect; that horizontal wheels will produce a little less than $\frac{1}{2}$ of it when the floatboards are plain, and a little more than $\frac{1}{2}$ when they are curvilineal.

Sect. IV. *On Wheels Driven by the Reaction or Counterpressure of Water.*

The first mills which were driven by the reaction of water were called *Barker's* mill, and sometimes *Parent's* mill. We are not acquainted with the nature of M. Parent's claim to the invention; nor can we determine whether the priority is due to him or to Dr Barker. Dr Desaguliers, who seems to have been the first person who published an account of the machine, describes it as having been invented by Dr Barker. "Sir George Savile says, he had a mill in Lincolnshire to grind corn, which took up so much water to work it, that it sunk his ponds visibly, for which reason he could not have constant work; but now, by Dr Barker's improvement, the waste water only from Sir George's ponds keeps it constantly to work."

Dr Barker's mill is shewn in Fig. 3. where CD is a vertical axis, moving on a pivot at D, and carrying the upper millstone *m*, after passing through an opening in the fixed millstone C. Upon this axis is fixed a vertical tube TT communicating with a horizontal tube AB, at the extremities of which A, B are two apertures in opposite directions. When water from the mill-course MN is introduced into the tube TT, it flows out of the apertures A, B, and by the reaction or counterpressure of the issuing water the arm AB, and consequently the whole machine, is put in motion. The bridgetree *a b* is elevated or depressed by turning the nut *c* at the end of the lever *c b*. In order to under stand how this motion is produced, let us suppose both the apertures shut, and the tube TT filled with water up to T. The apertures A, B, which are shut up, will be pressed outwards by a force equal to the weight of a column of water whose height is TT, and whose area is the area of the apertures. Every part of the tube AB sustains a similar pressure; but as these pressures are balanced by equal and opposite pressures, the arm AB is at rest. By opening the aperture at A, however, the pressure at that place is removed, and consequently the arm is carried round by a pressure equal to that of a column TT, acting upon an area equal to that of the aperture A. The same thing happens on the arm TB; and these two pressures drive the arm AB round in the same direction. This machine may evidently be applied to drive any kind of machinery, by fixing a wheel upon the vertical axis CD.

In the preceding form of Barker's mill, the length of the axis CD must always exceed the height of the fall ND, and therefore, when the fall is very high, the difficulty of erecting such a machine would be great. In order to remove this difficulty, M. Mathon de la Cour proposed to introduce the water from the millcourse into the horizontal arms A, B, which are fixed to an upright spindle CT, but without any tube TT. The water will obviously issue from the apertures A, B, in the same manner as if it had been introduced at the top of a tube TT as high as the fall. Hence the spindle CD may be made as short as we please. The practical difficulty which attends this form of the machine is, to give the arms A, B a motion round the mouth of the feeding pipe, which enters the arm at D, without any great friction, or any considerable loss of water. This form of the mill is shewn in Plate CCCXXI. Fig. 4. where F is the reservoir, K the millstones, KD the vertical axis, FEC the feeding pipe, the mouth of which enters the horizontal arm at C. In a machine of this kind which M. Mathon de la Cour saw at Bourg Argental, AB was 92 inches, and its diameter three inches; the diameter of each orifice was $1\frac{1}{6}$ inch, FG was 21 feet; the internal diameter of D was two inches, and it was fitted into C by grinding. This machine made 115 turns in a minute when it was unloaded, and emitted water by one hole only. The machine, when empty, weighed 80 pounds, and it was half supported by the upward pressure of the water. This improvement, which was published in Rozier's *Journal de Physique* for January and August 1775, appeared about 20 years afterwards as a new invention of Mr Waring's, in the *Transactions of the American Philosophical Society of Philadelphia*, who was probably not aware of the labours of M. Mathon de la Cour.

In the year 1747, Professor Segner of Gottingen published, in his *Exercitationes Hydraulicæ*, an account of a machine which differs only in form from Dr Barker's mill. It consisted of a number of tubes arranged as it were in the circumference of a truncated cone; the water was introduced into the upper ends of these tubes, and flowing out at the lower ends, produced, in virtue of its reaction, a motion round the axis of the cone.

Another form of this machine has been suggested by Albert Euler. He proposes to introduce the water from the mill course into an annular cavity in a fixed vessel of the shape nearly of a cylinder. The bottom of this vessel has several inclined apertures, for the purpose of making the water flow out with a proper obliquity into the inferior and moveable vessel. This inferior vessel, which has the form of an inverted frustum of a cone, moves about an axis passing up through the centre of the fixed vessel, and has a variety of tubes arranged round its circumference. These tubes do not reach to the very top of the vessel, and are bent into right angles at their lower ends. The water from the upper and fixed vessel being delivered into the tubes of the lower vessel, descends in the tubes, and issuing from theirs horizontal extremities gives motion to the conical drum by it reaction.

The excellence of this method of employing the reaction of water was first slightly pointed out by Dr Desaguliers, and no further notice seems to have been taken of the invention till the appearance of Segner's machine in 1747. The attention of Leonhard Euler, John Bernoulli, and Albert Euler, was then directed to the subject, and it would appear, from the results of their investigations, that this is the most powerful of all hydraulic machines, and is therefore the best mode of employing water as a moving power. Leonhard Euler published his theory of this machine in the *Memoirs of the Berlin Academy*, vol. vi. p. 311; and the application of the machine to all kinds of work was explained in a subsequent paper in the seventh volume of the same work, for 1752, p. 271. John Bernoulli's investigations will be found at the end of his *Hydraulics*.

Albert Euler concluded, that when the machine had the form given to it by Segner, the effect was equal to the power, and that the effect is a maximum when the velocity is infinite. Mr Waring, in the paper which we have already quoted, makes the effect of the machine equal only to that of a good undershot wheel driven with the same quantity of water falling through the same height. The Abbé Bossut has likewise investigated the theory of this machine, and has found that an overshot wheel, and a wheel of the form given to it by Albert Euler, will produce equal effects with the same quantity of water, if the depth of the orifice below the mill-course in the latter machine is equal to the vertical height of the loaded arch in the overshot wheel; and he, upon the whole, recommends the overshot wheel as preferable in practice. The preceding result, however, proves the inferiority of the overshot wheel, as the height of the loaded arch must be always much less than that of the fall. A new and ingenious theory of this machine has lately been given by Mr Ewart in the *Manchester Memoirs*.

For farther information on this subject, see Desagulier's *Experimental Philosophy*, vol. ii. p. 453; Segner's *Exercitationes Hydraulicæ*, Gotting. 1747; L. Euler, *Mem. Acad. Berl.* 1751, vol. vi. p. 311; *Id.* 1752, vol. vii. p. 271; Waring, *American Transactions*, vol. iii. p. 185; M. Mathon de la Cour in Rozier's *Journal*, Jan. and Aug. 1775; Krafft, *Nov. Comment. Petropol.* 1792, vol. x. p. 137; Robison's *System of Mechanical Philosophy*, Bossut's *Hydrodynamique*, tom. i. chap. xviii; Ferguson's *Lectures*, vol. ii. p. 97, and Appendix, p. 205; Gregory's *Mechanics*, vol. ii. p. 106.

### Sect. V. *On Machines for Raising Water, and various Hydraulic purposes.*

#### 1. *Description of a Sluice Governor for regulating the Introduction of Water upon Water Wheels of all kinds.*

As there is a particular velocity at which water wheels produce a maximum effect, and as the work to be performed is often injured by an irregularity in the velocity of the machinery, it is of great importance to regulate the admission of the water so as to prevent any increase of velocity when there is too much water in the mill-course. In corn mills, the meal becomes heated and injured by too great a velocity, and in cotton mills, the threads are broken from the same cause.

The machine for this purpose, which is minutely represented in Plate CCCXXI. Figures, 5, 6, 7, and 8, was actually constructed by the late Mr Burns for Cartside cotton mill, who considered it of such advantage as to produce a saving of more than 100*l*. per annum. The motion of the water wheel is communicated by a belt or rope going round the pulley I to the axis EF, which carries the balls G, H, Fig. 5. This motion is conveyed to the upright shaft T by the wheels and pinions Q, R, S, T, and the wheel N at the bottom of the shaft drives the wheels O, P, Fig. 6 and 7, in opposite directions. When the velocity of the wheel is such as is required, the wheels O, P move loosely about the axis, and carry the motion no farther. But when the velocity of the wheel is too great, the balls G, H, separated by the increase of centrifugal force, raise the box *a* upon the shaft EF. An iron cross *b c*, see Fig. 8, is fitted into the box *a*. This cross works in the four prongs of the fork *e b c*, Fig. 6, at the end of the lever *d q f e*, which moves horizontally round *f* as its centre of motion. When the box *a* is stationary, which is when the wheel has its proper velocity, the iron cross works within two of the prongs so as not to affect the lever *d f c*, but to allow the clutch *q q*, fixed at the end of the lever, to be disengaged from the wheels. When the cross *b c* rises, it strikes in turning round the prong 3, see Fig. 8. which drives aside the lever *e f d*, and throws the clutch *q* into the arms of the wheel P, Figs. 6, 7. This causes it to drive round the shaft DC in one direction. When the iron cross *b c*, on the contrary, is depressed by any diminution in the velocity of the wheel, it strikes, in turning round, the prong 4, which pushes aside the lever *e f d*, and throws the clutch *q'* into the wheel O. This causes the wheel O to drive the shaft in an opposite direction to that in which it was driven by P. Now the shaft DC. which is thus put in motion, drives. by means of the pinion C and wheel B, the inclined shaft BW, which by an endless screw X working in the toothed quadrant Z, elevates or depresses the sluice KL, and admits a greater or a less quantity of water, according as the motion is given to the shaft by the wheel P or O. This change in the aperture is produced very gradually, as the train of wheelwork is made so as to reduce the motion at the sluice. The centre in which the sluice turns should be $\frac{1}{3}$ of its height from the bottom, in order that the pressure of the water on the part above the centre may balance the pressure on the part below the centre.

#### 2. *Description of Archimedes's Screw.*

The screw engine for raising water invented by Archimedes, was formerly constructed so as to consist of a cylinder with a flexible pipe, wrapped round its circumference like a screw; but it is now more frequently constructed in the manner shewn in Plate CCCXXII. Fig. 1. where AB is a cylindrical axis, having a flat plate of wood or thin iron, coiled as it were round it like the threads of a screw. The plane of this plate is perpendicular to the surface of the cylindrical axis AB, but inclined to this axis at an angle, which must always exceed the inclination of the cylindrical axis AB to the horizon. This last angle is commonly between 45° and 60°. This wooden screw, with a very deep thread, is fixed in a cylindrical box CDEF, so that we have a spiral hollow groove as it were running up the tube from B to A, which will have the same effect as if a pipe of lead or leather had been coiled round the cylindrical axis.

The lower end B of the screw is plunged in the water of the vessel E, which is to be raised to the upper vessel F, and when the screw is turned round its axis, either by a handle or winch placed at A, or by any other power acting upon the pinion at A, the water at E will fall into the hollow spiral groove, and as the screw turns round, the water will necessarily remain in the lower part of the spiral, and will at last reach the top of the spiral pipe, where it is discharged as seen at F. In this engine, therefore, the water rises by a constant descent in the spiral tube. The operation of this engine, which appears at first sight to be paradoxical, will be best understood by wrapping a cord spirally round a bottle containing a little water, and inclining the bottle at a less angle to the horizon than the inclination of the cord to the axis. It will then be seen, that if water falls into the lowest part of the spiral when it is at rest, the motion of the bottle about its axis will remove as it were the spiral out from below the water, which must therefore occupy the part of the spiral immediately above it, and so on till the water reaches the top of it. When the outer case CDEF is fixed, and the screw revolves within it, the engine is called a *water screw*, which should be inclined only about 30° to the horizon.

As we conceive this engine to be entitled to more notice than it has generally received from practical mechanics, we have given a drawing of a very excellent screw engine, which was erected in 1816 at the Hurlet Alum works, upon the Water of Levern, near Paisley; for which we have been indebted to the kindness of John Wilson, Esq. one of the proprietors. The water-wheel A, constructed of iron, with wooden buckets, (see Plate CCCXXII. Fig. 2.) is 12 feet diameter, and conveys its motion to the screw by the bevel wheels C, C, and the shafts B, B, 126 feet long, and $5\frac{1}{2}$ inches diameter. At the end of the shaft B is fixed another bevel wheel D, which works in a similar wheel D′, fixed on the circumference of the screw which rests upon an inclined plane of solid masonry, and is inclined 37° 30′ to the horizon. The axis KK of the screw, which is represented without its covering in Fig. 2. No. 2. is octagonal, and 8 inches in diameter. The diameter of the spiral is 22 inches, and the thickness of the covering 2 inches, so that the whole diameter is 26 inches. The distance of the threads is 9 inches, and their number 168. The thickness of the spiral is 2 inches, so that the spiral tube in which the fluid is to be raised is 7 inches wide, and 7 inches deep. The screw is supported on five sets of friction rollers, constructed as shewn at L in No. 3; two rollers having been found preferable to a greater number, which were at first employed. The well or stone cistern in which the foot of the screw is immersed, and from which the alum liquors are raised, is shewn at O; and at M there is an ingenious contrivance for supplying the pivot regularly with oil. The foot of the screw N is supported by a step of bell metal, inserted into a piece of wood, the socket for which is of cast iron wedged in the foot of the screw, and well lapped in woollen cloth dipped in rosin and tallow, to prevent the liquor from acting upon it. The fall of water which drives the wheel is 9 feet, and the water strikes the wheel 3 feet above the horizontal axle; the width of the mill course is $4\frac{1}{2}$ feet, the depth of water 14 inches, and the aperture of the sluice $2\frac{1}{2}$ inches. The water wheel revolves 12 times in a minute, and the screw performs two revolutions for one of the wheel, and consequently 24 revolutions in a minute. The quantity of liquor discharged is 70 wine gallons; but as the specific gravity of the fluid raised is 1.065, the weight of the quantity discharged in an hour is 17 tons. The pump is wholly built of timber, as the alum liquor acts upon the iron. Its total length is 127 feet, and the height to which the liquor is raised is $=$ sin. $37° 30' \times 127$ feet $=$ 76 feet 9 inches. The water wheel, besides driving the screw, moves two pumps for lifting liquor to the height of 30 feet. The pumps make each $2\frac{1}{2}$ strokes for one turn of the wheel, and the bore is $5\frac{1}{2}$ inches in diameter.

A very ingenious double screw engine has recently been invented by M. Pattu, engineer of roads and bridges in the department of Calvados. It is represented in section in Fig. 3, and consists of two ordinary and concentric screws, one of which, AB, is long and narrow, and serves for the nucleus of the other, CD, which is much wider and shorter. These two screws turn round the axis in opposite directions, so that when one of them appears to be moving upwards, the other appears to be moving downwards. The screw is inclined 35° to the horizon. The water from the stream MN is introduced into the larger screw, and puts the whole in motion, and the water, after its fall into OP, enters the smaller screw, in which it is raised to the cistern at B. When it is used for draining, and when the moving power of the water can be applied at A, the small screw serves to drive the larger one, which raises the water to a height sufficient to carry it off, as shewn in Fig. 4. Figures 5 and 6 shew other modes of applying this screw. Fig. 5 is the form used for raising water to irrigate high grounds, to fill the reservoirs of baths, gardens, and manufactories. The large screw is here the moving power. Fig. 6 is the form used for keeping dry those places where foundations are building. The large screw is here the mover.

M. Eytelwein has shewn that the screw should always be placed so that only one half a convolution may be filled at each turn. When the height of the water is so variable that this precaution is impracticable, he prefers the water screw, although nearly one-third of the water in this case generally runs back, and though it is easily clogged by accidental impurities in the water.

Fig. 7. shews the form of Archimedes's screw, as recommended by D. Bernoulli.

These machines are particularly useful when the water to be raised is not pure, but is mixed with gravel, weeds, or sand, which could not be elevated by ordinary pumps. For farther information on this subject, see *Vitruvius*. Pitot, *Mem. Acad. Par.* 1736, p. 173. Bernoulli, *Hydrodynamica*. Hennert, *Dissertation sur la vis d'Archimede*, Berl. 1767. Euler, *Nov. Comment. Petrop.* tom. v. p. 259. Ferguson's *Lectures*, vol. ii. p. 113. Pattu, *Journal des Mines*, Nov. 1815, vol. xxxviii. p. 321. Eytelwein's *Handbuch der Mechanik*, Berl. 1805. chap. xxi. Gregory's *Mechanics*, vol. ii. p. 348.

### 3. *On the Spiral Pump, or Zurich Machine.*

This machine, represented in Plate CCCXXIII. Fig. 1. was invented about 1746 by Andrew Wirtz, a pewterer in Zurich, who erected it for a dye-house on the river Limmat. It consists of a spiral pipe ABCDEF, either coiled round in one plane, as shewn in the Figure, or arranged round the circumference of a cone or a cylinder. The interior end of the spiral G, or the remote end of it, is connected by a water tight joint to an ascending pipe GH, in which the water is to be raised. When this spiral, immersed in the water MN, which is to be raised, is put in motion in the direction ABCD, the scoop BA, which begins to widen from C, takes in a portion of water. As the scoop emerges, this water passes along the spiral, driving the air before it into the pipe GH, where it escapes. Air is again admitted into the scoop after it emerges, and when the scoop has performed one revolution, it again takes up another portion of water, which is driven along the spiral as before, and is separated from the first portion by a column of air of nearly equal length. By continuing to turn the spiral, a second column of water and another of air will be introduced, and so on. Now, the water, on every turn of the spiral, will have both its ends horizontal, and the included air will have its natural density. But as the diameter of the spirals diminish towards the centre, the column of water, which occupied a semicircle in the outer spiral, will occupy more and more of the inner spirals as they approach to the centre G, till there will be a certain spiral, of which it will occupy a complete turn. Hence it will occupy more than the entire spiral within this spiral, and consequently the water will run back over the top of the succeeding spiral, as at No. 4. into the right hand side of spiral No. 3. The water in spiral No. 3. will consequently be pushed upwards till it runs over at 3 into the right hand side of spiral No. 2., and so on till some of the water escapes at the scoop A into the cistern MN. When the water enters the pipe GH at G, and rises a little in it, the escape of the air is prevented when the scoop AB takes in its next quantity of water. "Here then," as Dr Robison has remarked, "are two columns of water acting against each other by hydrostatic pressure, and the intervening column of air. They must compress the air between them, and the water and air columns will now be unequal. This will have a general tendency to keep the whole water back, and cause it to be higher on the left or rising side of each spire, than on the right descending side. The excess of height will be just such as produces the compression of the air between that and the preceding column of water. This will go on increasing as the water mounts in the rising pipe; for the air next to the rising pipe is compressed at its inner end with the weight of the whole column in the main. It must be as much compressed at its outer end. This must be done by the water column without it; and this column exerts this pressure, partly by reason that its outer end is higher than its inner end, and partly by the transmission of the pressure on its outer end by air, which is similarly compressed from without. And thus it will happen, that each column of water being higher at its outer than at its inner end, compresses the air on the water column beyond or within it, which transmits this pressure to the air beyond it, adding to it the pressure arising from its own want of level at the ends. Therefore, the greatest compression, viz. that of the air next the main, is produced by the sum of all the transmitted pressures, and these are the sum of all the differences between the elevation of the inner ends of the water columns above their outer ends; and the height to which the water will rise in the main will be just equal to this sum."

The spiral pumps seem to have remained long unnoticed. They were erected, however, at Florence, in 1778, with the improvement suggested by Bernoulli, of having the spiral coiled on the circumference of a cylinder, as represented in Fig. 2. In 1784, a spiral pump was erected at Archangelsky, near Moscow, which raised a hogshead of water in a minute to the height of 74 feet, and through a pipe 760 feet long. It has not yet been ascertained whether the plane, the cylindrical, or the conical spiral is best. The only practical difficulty consists in making the joint perfectly water-tight. The machine erected at Florence had its spiral cylindrical. Its diameter was ten feet, and that of the pipe six inches. The enlarged part occupied $\frac{3}{4}$ of the circumference, and was $7\frac{8}{10}$ inches wide at the outer end. The enlarged part contained 6844 English cubic inches. The spiral revolved six times in a minute, and raised 22 cubic feet of water 10 feet high in a minute. Eytelwein considers this as a very powerful machine, and well deserving the attention of the engineer. The length of the pipe becomes extremely cumbersome when the water is to be raised through a great height. Dr Young found that 100 feet of pipe $\frac{3}{4}$ of an inch in diameter was necessary for a height of 140 feet; and he considers that the machine would succeed better if the pipes were entirely of wood, or of tinned copper, or even of earthen-ware. See Sulzer's *Sammlungen Vermischten Schriften*, 1754; Daniel Bernoulli, *Nov. Comment. Petrop.* 1772, tom. xvii. p. 249: Bailey's *Machines approved of by the Society of Arts*, vol. i. p. 151; Dr Robison's *System of Mechanical Philosophy;* Eytelwein *Handbuch der Mechanik*, &c.; and Dr Thomas Young's *Natural Philosophy*, vol. i. p. 330, &c.

### 4. *Description of Pitot's Bent Tube for measuring the Velocity of Water.*

One of the most ingenious instruments for measuring the velocity of water is the *tube recourbé*, or bent tube, invented by M. Pitot, and described in the Memoirs of the Academy of Sciences for 1732. It is represented in Plate CCCXXIII. Fig. 3, and consists of a prism of wood ABCDEF, one of the angles of which is presented to the current. On the hinder face BCFE are fixed two tubes of glass parallel to each other, and having a graduated scale between them; one of them, viz. MNO, being bent into a right angle at O, so that the part MN may pass through the prism horizontally. When this instrument is plunged in a running stream, the general level of the current is shewn by the rise of the water in the straight tube PQ, while the height of the water in the bent tube MNO becomes a measure of the force of the stream. The difference between these heights will therefore be the height due to the velocity. In the practical use of this instrument, it is however difficult to fix it sufficiently steady, to prevent the water from oscillating in the tubes.

M. Du Buat having examined the instrument experimentally, found that it could be trusted no farther than to give the ratio of different velocities. He therefore suppressed the tube PQ altogether, and substituted, in place of the bent tube of glass MNO, a simple tube of white iron, sufficiently large to admit a float for pointing out the height of the water in the tube. The lower end of the white iron tube is bent back as at MN, and is terminated by a plane surface, perforated at its centre with a small orifice, which will greatly diminish the oscillations of the elevated column. If we then take *two-thirds* of the height of the water in the tube above the level of the stream, we shall have very exactly the height due to the velocity of the current for the depth to which the orifice is immersed. See Pitot. *Mem. Acad. Par.* 1730, 1772, p. 363; Du Buat's *Principes d'Hydraulique*, tom. ii. p. 332, edit. 1786; Bossut's *Traité d'Hydrodynamique*, tom. ii. p. 267, 268, edit. 1796.

### 5. *Description of the Hydraulic Quadrant for measuring the Velocity of Water.*

The hydraulic quadrant which has been recommended by several authors for measuring the velocity of water is shewn in Plate CCCXXIII. Fig. 4. It consists of a quadrant ABC, with a divided arch AB, and having two threads moving round its centre. One of these, CP is short, and carries a weight P, which always hangs in air, while the other CH or CM is longer, and carries a weight, whose specific gravity is greater than that of water, and which plunges more or less deep in the current as the thread is lengthened. The instrument is then held as in the figure, so that the plummet CP passes through 0°; and the angle ACD, or the angular distance of the other thread from a vertical line, will be a measure of the force, and consequently of the velocity of the current. Bossut has shewn that the force is as the tangent of the angle ACD, and that if $u$ be the velocity when the thread has the position CH, and V the velocity when it has the position CM, we shall have $u : V = \sqrt{\left(\frac{\sin. XCR}{\sin. XRC}\right)} : \sqrt{\left(\frac{\sin. XCS}{\sin. XSC}\right)}$. If we therefore know $u$, we also know V. We have therefore only to determine $u$, when H is at the surface, for any given angle ACD, and V will be had for any other velocity, either at the surface or at any depth below it. See Bossut's *Traité d'Hydrodynamique*, tom. ii. p. 265, 266. Eytelwein's experiments with the hydraulic quadrant will be found in the *Samml. zur Bauk.* 1799.

### 6. *Machines for discharging a uniform quantity of Water.*

In Plate CCCXXIII. Figs. 5, 6, 7 we have represented three ingenious contrivances for discharging equal quantities of water from a vessel which is constantly emptying itself, or where there is a variable head of water. The contrivance in Fig. 5. where MNOP is a vessel nearly full of water, consists of a tube BA moving round a joint at B, and having its upper end B connected with a hollow floating ball C. The velocity with which the water enters the extremity B is that which is due to the height BC, or the depth of B below the surface. As the surface MN descends the float C also descends, so that whatever be the height of the water in the vessel, it will always enter B with the same velocity. The discharge at the other end A will not be quite uniform, as the water will acquire greater velocity in descending the tube BA when it is much inclined than when it is nearly horizontal.

A floating syphon, which produces the same effect in a more correct manner, is shewn in Fig. 6, where ABD is a syphon with a hollow floating ball at its shorter end. This syphon is suspended by the chains EP, EP, which pass over two pulleys P, P, upon a horizontal axle PP, and suspend at their other extremities counterweights W, W. As the water in the vessel MNOP sinks by being discharged at D, the syphon descends and the counterweights rise, and an uniform stream is obtained till the end A reaches the bottom of the vessel.

Another very ingenious contrivance for the same purpose is shewn in Fig. 7. A cone AB attached to a lenticular float C, and fixed upon the axis *c f*, rises and falls in the aperture *m n*, by which the water of the vessel MNOP is to be discharged. It is kept in an upright position by the horizontal axes *o p*, *r s*. Now, when the vessel is full of water, and the head therefore great, the velocity at *m n* will also be great; but as the float C rises with the surface MN, the aperture *m n* will be partly filled by a thicker part of the cone AB; whereas, when the surface MN has descended, the float AB will also descend, and the aperture at *m n* will be widened, in consequence of a smaller part of the cone being included in it. In this way, the varying diameter of the cone always adjusts the aperture *m n* to the variable head of water, so that the quantity discharged through the tube *m n o p* is nearly always the same.

### 7. *Water-blowing Machine, or Shower-Bellows.*

The water-blowing machine, called *trombe* by the French, seems to have been first introduced in Italy about the year 1672, for the purpose of procuring a blast of air by the descent of water. It is represented in Figs. 8 and 9, where MN is a reservoir of water, in the bottom of which is inserted a long tube AB, consisting of a conical part *a b*, seen upon an enlarged scale in Fig. 9, communicating with a cylindrical tube *d* B, which enters the vessel CDEF. A number of openings *c*, *d*, &c. are made at the top of the tube *d* B, so that when the water is discharged at the conical aperture *b*, it drags along with it the adjacent air. This mixture of air and water falls upon a stone pedestal G, so as to separate the air from the water. The water descends to the bottom of the vessel, while the air escapes through the pipe CIK to supply the furnace. Another form of the machine is shewn in Fig. 9. where $\alpha\,\beta$ is the conical pipe, and the water is supplied with air from the pipes $\kappa\,\beta$, $\delta\,\beta$.

In the water-blowing machines used in Dauphiny, in the neighbourhood of the town of Alvar, the diameter of *a b* is 12 inches at *a*, and 5 at *b*; the diameter of *d* B is 10 inches. Only four holes are used at *c*, *d*, and the end B enters 1½ feet into the vessel CDEF, which is 4 feet high and 4 feet broad. The water is discharged at an aperture above F, a foot in diameter; and sometimes the admission of the water and its discharge are regulated by sluices *m* and *n*. A strong, equal, and continued blast is obtained by this machine; but it is thought to be too moist and too cold. We have seen in Switzerland one of these machines working with great effect at the lead works of M. Lenay, in the valley of Servoz near Chamouni.

Kircher appears to have been the first who explained the production of wind by a fall of water. Barthes long afterwards gave another theory, and Dietrich and Fabri ascribed the wind to the decomposition of the water. In 1791, the Academy of Tholouse invited philosophers to investigate this phenomenon, and it was probably in consequence of this that Venturi directed his attention to the subject. This ingenious philosopher has proved, that the air is dragged down upon the principle of the lateral communication of motion in fluids; and he has pointed out the best mode of constructing the machine, so as to produce the greatest quantity of air. The diameter of the tube *d* B should be at least double of the aperture at *b*. To a height about 1½ feet above C D, the tube should be completely air-tight, as well as the vessel CDEF, but above that part the tube *d* B may be perforated in every part with holes. M. Venturi has calculated, that the quantity of air which passes in one second into the tube is $= 6.1\,a^2\sqrt{(a+b-1.4)}-0.4a^2\sqrt{(a\times 0.1)}$, where *a* is the diameter of the aperture at *b*, and *b* the diameter of the tube *d* B. From this quantity about one-fourth should be deducted in practice, on account of the dashing of the scattered water against the lower part of the tubes. If the pipe CIK does not discharge all the air which is generated, the surface of the water in the vessel will descend, and part of the air will issue out of the lower apertures of the tube *d* B.

Phenomena similar to those produced by the water-blowing machine have been observed in nature. At the foot of the cascades which fall from the glacier of Roche Melon, on the naked rock of La Novalese towards Mount Cenis, Venturi found that the force of the wind arising from the air dragged down by the water could scarcely be withstood. The *ventaroli* or natural blasts, which are most frequently found to issue from volcanic mountains, arise from the air carried down the hollows by the falls of water; and what are called the *rain winds* have the same origin. See Kircher's *Mundus Subterraneus*, lib. xiv. cap. 5. edit. 1663. Barthes, *Mem. des Sçavans Etrangers*, tom. iii. p. 378. Dietrich, *Gites de Minerai des Pyreneés*, p. 48, 49. Fabri, *Physic. Tract.* lib. ii. prop. 243. Belidor. *Arch. Hydraul.* tom. ii. p. 1. Mariotte, *Traité des Mouv. des Eaux*, Part i. Disc. 3. *Arts et Metiers*, Art. des Forges, p. 88 Venturi in *Nicholson's Journal*, tom. ii. p. 487. *Nicholson's Journal*, vol. i. 4to, p. 229, and vol. xii. 8vo, p. 48. Wolfius, *Opera Mathematica*, tom. i. p. 830. Lewis's *Commerce of Arts*. *Journal des Mines*, No. 91.

### 8. *Description of the Gaining and Losing Buckets.*

This very ingenious machine seems to have been first proposed by Schottus, but was afterwards greatly improved and actually constructed by George Gerves, for Sir John Chester, Bart. at his seat at Chichley in Buckinghamshire. The object of this machine is to raise water from a well or spring A, Fig. 10. to a reservoir R. In order to effect this, a wheel WW, 6 feet in diameter, is fixed above R, and on the same axis another wheel *w w*, 2 feet in diameter. To the circumference of W is fixed a chain W *x*, to which is hung a small bucket *b* with a valve in its bottom, and suspended as seen at *b* in Fig. A. To the circumference of *w w* is fixed another chain *w w y*, fastened to a rod *y z*, to which is suspended the large bucket B, with a valve in its bottom, as seen above B. This valve is fixed at the end of the arm *o* B, and is kept in its place by the weight *m*, acting at the end of the lever *m o*, whose fulcrum is at *n*; but is raised from its place by raising the arm *m o*, as shewn in Fig. B.

Let us now suppose that the small bucket *b* is filled with water, and that in consequence of water being poured into the large bucket B, this bucket descends. The bucket *b* will therefore ascend till it strikes the hook at *s*. This hook catching the edge of the bucket, turns it to a side, as shewn in Fig. A. and empties it into the reservoir R. By this time the descending bucket B has reached nearly the bottom of the cistern *z* Z. The arm *m o* of the lever falling upon the projection M is raised, as shewn in Fig. B. The valve in the bottom is consequently raised also, and the water is discharged at B into the cistern Z. The small bucket *b* is now an overmatch for B, in consequence of its acting at the end of a longer lever, and therefore *b* descends to the cistern A, while B ascends to the position it has in the figure. When *b* reaches the cistern A, the lower end of the valve strikes against a fixed obstacle; it is therefore raised out of its place, and admits the water of the cistern into the bucket. At the same instant the arm *o n* of the lever in the large bucket B striking against the bottom of a valve, seen below *a*, in a branch *a* of the cistern A, raises it, and allows the water from the cistern to run into the bucket B, till the weight of the bucket is sufficient to raise *b* out of the cistern A. As soon as it has received this weight of water it descends, the valve below *a* falls into its place, the valve in the bottom of *b* also falls into its place, when it rises above the fixed obstacle, and the bucket *b* ascends as before, to discharge its contents into the reservoir, while the large bucket descends to M to get rid of its load of waste water. It is obvious that the equilibrium of the chains and rods will be different in different positions of the buckets. When *b* is at R, and B at Z, B will be loaded with an additional quantity of chain. In order to regulate the weight of the chains in every position, a quadrant Q moves round C as a centre, and a chain *c d* attached to the point C of the rod *c z*, is fixed to the lower end *d* of the arch *d* Q. A weight X is also fixed at the end of the radius *d* C. Now when B is down at Z, X will have descended to *p*, and from acting at the end of a shorter lever, will be a less load upon the rod *c z* than when it had the position at X; that is, the additional weight which the bucket B has received from the increase of its chain is counterbalanced by the diminution of weight occasioned by the descent of CX into the position CP. Desaguliers remarks, that one hogshead falling 10 feet will raise very nearly one hogshead 10 feet, or one-fourth of a hogshead 40 feet.

### 9. *Description of the Scoop Wheel.*

The scoop wheel is intended to raise water through a height equal to its semidiameter. It is represented by WW in Fig. 1, and consists of a number of semicircular partitions, shewn in the Figure. These partitions are open at both ends, viz. at the circumference and at the centre of the machine. As the wheel is turned round in the direction WXW, either by the hand or by any other power, the scoops take up the water, which gradually descends during the rotation of the wheel, till it runs into its hollow axle, which again discharges it into a spout O. The scoop wheel is one of the forms in which the Persian wheel is generally described.

### 10. *Description of the Persian Wheel.*

The Persian wheel is a double water wheel, with floatboards on one side, and a series of buckets on the other, which are moveable about an axis above their centre of gravity. The wheel is placed in a stream, which puts it in motion, by acting upon its floatboards. As the wheel turns, the moveable buckets dip in the water, and ascend filled with fluid. But when they reach the highest point, their lower ends strike against a fixed obstacle, so as to make them empty themselves into a reservoir placed at the top of the wheel. See Ferguson's *Lectures*, vol. i. p. 180.

Another form of the Persian wheel is shewn in Fig. 2, where WW is a common bucket wheel, moving in the direction WOW. The buckets dipping in the water MN, rise filled with it, and discharge their contents into the reservoir O near the summit of the wheel. The wheel for draining the moss of Blair Drummond belongs to this class. It is driven by floatboards fixed on its periphery like the common undershot wheel, and a current of water is brought in at a side to fill buckets placed on the concave side of the rim.

### 11. *On Throwing Wheels, or Flash Wheels.*

A throwing wheel, which is commonly driven by a windmill, and used for draining fens, is nothing more than an undershot wheel, the floatboards of which push the water up a curvilineal plane, inclined from a lower to a higher level. One of these wheels is represented in Plate CCCXXIV. Fig. 3, where WW is the wheel, MN the inclined plane, N the water to be raised or pushed up the declivity MN, and M the drain which is to carry it off.

### 12. *On the Chain Pump.*

The chain pump, represented in Plate CCCXXV. Fig. 4, consists of an endless chain WWBA, passing round the wheel WW, and after entering the water to be raised, returning through the tube BA into the cistern MN. This chain carries a number of flat cylindrical pistons *a*, *b*, *c*, of nearly the same diameter as the tube AB, one half of each piston being received into openings in the circumference of the wheel. When the wheel is put in motion, the pistons enter the barrel BA, and pushing the water before them, raise it into the reservoir MN. When the wheel is turned with great velocity, the barrel is generally filled with water.

Pumps of this kind are frequently placed in an inclined position, and they raise the greatest quantity of water in this position, when the distance of the flat piston is equal to their breadth, and when the inclination of the barrel is about 24° 21′. The Spanish *noria* is the same as a chain pump, having a number of earthen pitchers placed between two ropes in place of a chain.

These machines are sometimes called *cellular pumps*, and when stuffed cushions are used in place of pistons, they are called *Paternoster pumps*.

Chain pumps are sometimes constructed without the piston *a*, *b*, *c*. In this case, the barrel AB is also removed, and they have the form shewn in Fig. 5, where W, W are two wheels with a set of buckets fixed to an endless chain, which passes round their circumference. By turning the upper wheel, the buckets dip into the water with their mouths downwards, and rising on the other side, convey the water into the reservoir at M.

### 13. *On the Hair Rope Machine of the Sieur Vera.*

The hair rope machine of the Sieur Vera is shewn in Fig. 6. It consists merely of a rope AB made of hair, passing round a wheel W, and kept stretched by going round a pulley P, fixed in the water. By turning the handle H, the rope rises loaded with the water that adheres to it, and when it reaches the top, it passes through a small tube which rubs the water from it, into a cistern. In a machine of this kind, where the wheel was three feet in diameter, the rope half an inch in diameter, and the well 95 feet deep, a labouring man could produce only 60 revolutions in a minute, and could not continue the exertion long. This raised 6 gallons in a minute. A great deal of water was raised when the wheel made 50 turns in a minute, but very little when it made only 30 turns. The rope soon decays if it is not made of hair. See Rozier's *Journal de Physique*, tom. xx. p. 132; and Cavallo's *Natural Philosophy*, vol. ii. p. 441.

### 14. *Description of Whitehurst's Engine.*

Mr Whitehurst, an ingenious watchmaker of Derby, appears to have been the first who entertained the ingenious idea of raising water by means of its momentum. A machine upon this principle was erected at Oulton in Cheshire, and was described in the Transactions of the Royal Society for 1775. This machine is represented in Plate CCCXXIV. Fig. 7, where AM is the reservoir of water, whose surface at M is on a level with B, the bottom of the reservoir BN. The main pipe AE is about 200 yards long, and $1\frac{1}{2}$ inches in diameter, and the branch pipe EF is of such a size that the cock F is about 16 feet below the surface of the water at M. A valve box with its valve *a* is shewn at D, and C is an air vessel into which are inserted the extremities *m n* of the main pipe, which are bent downwards for the purpose of preventing the air from being driven out when the water is forced into it. Now, when the cock F is opened, the water will rush out with a velocity of nearly 30 feet per second. A column of water, therefore, two hundred yards long and $1\frac{1}{2}$ inch diameter, is now put in motion, and must have a considerable momentum. Hence, if the cock F is suddenly shut, the water will rush through the valve *a* into the air vessel C, and condense the included air. This condensation will take place every time that the cock is opened, so that the included air being compressed, will press upon the water in the air vessel, and raise it into the reservoir BN. This simple and ingenious machine is obviously the same in principle as the hydraulic ram invented by Montgolfier, and which differs from it only in this, that the operation analogous to that of opening the cock F is produced by the motion of the water itself, as will be seen in the following description of this ingenious contrivance.

### 15. *Description of Montgolfier's Hydraulic Ram.*

This interesting machine was first constructed by Montgolfier about the year 1797, and has been brought to a very perfect state by a series of improvements which he has successively made upon it. The rams which we have represented in Plate CCCXXIV. Figs. 8, 9, 10, and 11, contain the improvements which have been made so late as 1816. The large pipe AB, called the body of the ram, passes through the side of the reservoir PQ, from which the fall of water is obtained. It has a trumpet mouth at one end A, and at the other end an opening HH, which can be closed by valves C or D. When these valves are open, the water will issue at HH with a velocity due to the height AP; but when the internal valve C is closed, as in the figure, the water is prevented from issuing. When the valve C opens, it descends into the position shewn by the dotted lines GG, being guided between three or four stems *g g*, which have hooks at the lower ends for supporting the valves. In this case the water has a free passage between these stems, and the width of the passage can be increased or diminished by the screws with which the stems are fixed. The valve C is made of metal, and has a hollow cup or dish of metal attached to its lower surface. The seat HH of the valve is wider than the diameter of the pipe AB. It consists of a short cylinder or pipe screwed by its flanch *h h* into the opening of the upper surface of the head R of the ram; and the cylinder is so formed as to have an inverted cup or annular space *i i* round the upper part of it for containing air, which cannot escape when it is compressed by the water. A small pipe *k l*, leading from this annular space to the open air, is furnished with small valves, *k*, *l*, one of which, *k*, opens inwards to admit the air into *i*, *i*, but to prevent its return, while the other valve, *l*, admits a certain quantity of air, and then shuts and prevents any farther entrance. The valve D is exactly the same as C, only it descends as in the figure when it shuts, and rises when it opens.

The upper part of the head of the ram at E is made flat, and has several valves which allow the water to pass freely from the pipe AB, but prevent its return. On each side of the head of the ram, at the part opposite to these valves, is a hollow enlargement, shewn by the dotted lines K, forming a circular basin, through the centre of which the pipe ABR passes. This part of the construction is shewn more distinctly in Fig. 9. which is a transverse section through LEZ in a plane perpendicular to that of the paper. The pipe is here made flat instead of circular, as seen at E, Fig. 9. for forming the seats of the valves, and the basin KK is covered with an air vessel FF. This air vessel communicates all round the pipe B, with the basin KK, and with the vertical pipe M.

The machine being thus constructed, let us suppose the pipe ABR full of water, and the valve C to be opened, the water will lift the valve D, and escape with a velocity due to the height of the reservoir. In a short time, the water having acquired an additional velocity, raises the valve G, which shuts the passage, and prevents the escape of the water. The consequence of this is, that all the included water exerts suddenly a hydrostatical pressure on every part of the pipe, compressing at the same time the air in the annular space *i i*, which by its elasticity diminishes the violence of the shock. This hydrostatical pressure opens the valves at E, and a portion of the water flows into the air vessel F, and condenses the air which it contains. The valves at E now close, preventing the return of the water into the pipe, and the water recoils a little in the tube with a slight motion from B to A, in consequence of the reaction or elasticity of the compressed air in *i i*, and also of the metal of the pipe, which must have yielded a little to the force exerted upon it in every direction. The recoil of the water towards A produces a slight aspiration within the head R of the ram, which causes the valve D to descend by its own weight, and prevents the water X which covers it from descending into the tube. The air, however, passes through the pipe *l k*, opens the valve *k*, and a small quantity is sucked into the annular space *i i*; but the quantity is very small, as the valve *k* closes as soon as the current of air becomes rapid. During the recoil towards A, the valve C, being unsupported, falls by its own weight; and when the force of recoil is expended by acting on the water in the reservoir PQ, the water begins again to flow along ABR, and the very same operation which we have described is repeated without end, a portion of water being driven into the air vessel F at every ascent of the valve C. The air in this vessel being thus highly compressed, will exert a force due to its elasticity upon the surface of the water in the vessel F, and will force it up through the pipe M to a height which is sufficient to balance the elasticity of the included air.

The small quantity of air which is drawn into the annular space *i i* through the air tube *l k* at each aspiration, causes an accumulation of air in the space *i i*: and when the aspiration of recoil takes place, a small quantity of air passes from *i i*, and proceeds along the pipe till it arrives beneath the valves at E, and lodging in the small space beneath the valves, it is forced into the air vessel at the next stroke, and thus affords a constant supply of air to the vessel. The valves make in general from 50 to 70 pulsations in a minute.

When the fall of water, or PQ, is five feet, and the pipe AB six inches in diameter and 14 feet long, a machine with its parts proportioned as in the figure will raise water to the height of 100 feet. It will expend about 70 cubic feet per minute in working it, and will raise about $2\frac{1}{3}$ cubic feet per minute to the height of 100 feet. Mr Millington observes, that one of these machines is said to have raised 100 hogsheads of water in 24 hours to the height of 134 feet by a fall of $4\frac{1}{2}$ feet.

The form of the ram represented in Fig. 10, is suited to the case where a current of foul water AB is employed to raise clean water from the well WW. This effect is produced by a bent pipe OPQ, containing a column of air from O to Q, and by another pipe T, with a suction valve *t*: The mode of action is precisely the same as in Fig. 8. When the valve C shuts, the sudden hydrostatical pressure forces the water up the bent tube at O, compresses the column of air OQ, which again presses, by its elasticity, on the surface of water at Q, and forces the clean water up through the valves into the air-vessel FF. The recoil of the water from B to A will produce a rarefaction in the column of air QO, in consequence of which the atmospherical pressure upon the water in the well will raise the valve *t*, till as much water is admitted as was driven into the air-vessel. Montgolfier proposes to substitute a straight pipe in place of OQ, and to place a piston, moving freely in the pipe, which will transmit the pressure from the foul water to the clean water, without allowing them to mix. We conceive that the same effect might be obtained more simply and with much less friction, by a very loose diaphragm fixed in the tube.

When the ram is employed to produce a current of air, it has the form shewn in Fig. 11. The air is expelled through the air-pipe *w m*, in consequence of the mass of water rushing into the air-chamber W, by the shutting of the valve C. The water in W is prevented from following the air by a hollow ball of copper *n*, which floats on the water, and shuts up the lower end of the pipe, when the water dashes into W. When things are in the state shewn in the figure, and all the air expelled from the chamber W, the air compressed in the annular space *p p*, (which serves the same purpose as *i i* in Fig. 8) produces a recoil of the water. The valve D shuts, C opens, the water quits the chamber W, and the valve *w* shuts, and prevents the admission of air. At the same time the valve *r* opens, and admits a fresh supply of air into the chamber; but when the water has descended below the float *e*, this float descends, and by its rod *e d* shuts the air-valve *d*. When the force of recoil is spent, the water flows again from A to B, and the operation which we have described is again repeated, so that there is a constant current of air in the pipe *w m*, which may be equalized by a water regulator, or any other contrivance. See the *Repertory of Arts*, Dec. 1816; Ferguson's *Lectures*, vol. ii. App.; and Brande's *Journal*, vol. i. p. 211. Lond. 1816.

16. *Description of the Chemnitz Fountain, or Hungarian Machine.*

The Chemnitz fountain is represented in Plate CCCXXIV. Fig. 12, where C is a collection of water, either in a mine or in a well, which it is required to raise to the reservoir B by means of a small head of water at A. In order to effect this, a pipe AFT, 4 inches in diameter, having a cock at M, enters the top of the copper vessel TD, $8\frac{1}{2}$ feet high, 5 feet in diameter, and 2 inches thick, containing about 170 cubic feet, and extends to D within 4 inches of the bottom. The vessel TD has a cock at N, and a very large one at P, and from its top proceeds a pipe TOG, 2 inches in diameter, with a cock at O, entering the top of the vessel KE, which is $6\frac{1}{2}$ feet high, 4 feet in diameter, 2 inches thick, and containing about 83 cubic feet. Another pipe EKHB, 4 inches in diameter, rises from E, within 4 inches of the bottom of the vessel KE, is soldered into its top at K, and rises into the reservoir B. The cylinder KE communicates by a tube with a cock at R, with the water C to be raised, and has a cock Q at its top. Let us now suppose that the cock M is shut, and all the other cocks open. The cylinder TD will contain air, and KE will contain water standing as high as the level of the water in the cistern C. Shut the cocks N, P, Q, and R, and open the cock M. The water from A will descend into the vessel TD, and after it rises above the mouth D of the pipe, it will compress the air in the vessel TD, in the pipe TOG, and in the upper part of the vessel KE. The action of this air upon the water in KE will force it up the pipe KH, till it is discharged into the reservoir B. This discharge into B goes on till the upper vessel TD is filled with water. As soon as this happens, the water is prevented from running into the pipe TO by a cork ball, or double cone, which hangs in the pipe TO by a brass wire, which is guided by holes into two cross pieces in the pipe. The ascent of the water into the mouth of the pipe at T pushes in this plug, and closes the pipe. The influx of water now stops; but the water still flows into B till the elasticity of the air in the lower vessel KE is no longer able to balance a column which reaches to H in the pipe KH. This cessation of the efflux into B generally ceases when KE is half full of water. When this takes place, the workman shuts the cock M, and opens the cock P, from which the water rushes with great velocity. Whenever $\frac{2}{3}$ths of the water in the vessel TD is discharged at P, which is measured in the vessel which receives it, the workman opens the cock R with a long rod, so as to fill the vessel KE with water. This drives the air out of KE through the pipe GO into the vessel TD, and consequently drives out all the remaining water. Every thing is now in the state in which it was at first, which is known to be the case when no more water flows out at P. The workman, therefore, shuts the cocks P and Q, and opens M, and the same operation is repeated. If the cock N be opened when the efflux has ceased at B, the water and air rush out together with prodigious violence, accompanied with hail and pieces of ice produced by the cold which attends the sudden expansion of air. It is usual to shew this sight to strangers, whose hats, when held opposite N, are sometimes pierced with the pieces of ice which are projected from it.

A considerable improvement upon this engine has been made by Mr John Whitley Boswell, who has added to it an apparatus which enables it to operate without any attending workmen. An account of this improvement will be found in Nicholson's *Journal*, 4to. vol. i. and 8vo. No. 5.

17. *Description of the Danaide invented by M. Mannoury Dectot.*

This machine consists of a cylindrical trough of tin-plate, nearly as high as it is broad, and having a hole in the centre of its bottom. It is fixed to a vertical axis of iron, which passes through the middle of the hole in the bottom, a vacant space being left all round to permit the water to escape. The axis turns with the trough upon a pivot, and is fixed above to a collar.

A drum of tin-plate, close above and below, is fixed upon the axis of the trough, and placed within the trough, so as to be concentric with it, and to leave only between the outer circumference of the drum and the inner circumference of the trough, an annular space not exceeding $1\frac{1}{2}$ inches. This annular space communicates with a space less than $1\frac{1}{2}$ inches, left between the bottom of the drum and the bottom of the trough, and divided into compartments by diaphragms fixed upon the bottom of the trough, and proceeding from the circumference to the central hole in the bottom of the trough.

The water comes from a reservoir above by one or two pipes, and makes its way into this annular space between the trough and drum. The bottom of these pipes corresponds with the level of the water in the trough, and they are directed horizontally, and as tangents to the mean circumference between that of the trough and of the drum. The velocity which the water has acquired by its fall along these pipes, makes the machine move round its axis, and this motion accelerates by degrees, till the velocity of the water in the space between the trough and drum equals that of the water from the reservoir; so that no sensible shock is perceived of the affluent water upon that which is contained in the machine.

This circular motion communicates to the water between the trough and drum a centrifugal force, in consequence of which it presses against the sides of the trough. This centrifugal force acts equally upon the water contained in the compartments at the bottom of the trough, but it acts less and less as this water approaches the centre.

The whole water then is animated by two opposite forces, viz. gravity, and the centrifugal force. The first tends to make the water run out at the hole at the bottom of the trough; the second, to drive the water from that hole.

To these two forces are joined a third, viz. *friction*, which acts here an important and singular part, as it promotes the efficacy of the machine, while in other machines it always diminishes that efficacy. Here, on the contrary, the effect would be nothing were it not for the friction, which acts as a tangent to the sides of the trough and drum.

By the combination of these three forces, there ought to result a more or less rapid flow from the hole at the bottom of the trough: and the less force the water has as it issues out, the more it will have employed in moving the machine, and of course in producing the useful effect for which it is destined.

The moving power is the weight of the water running in, multiplied by the height of the reservoir from which it flows above the bottom of the trough; and the useful effect is the same product diminished by half the force which the water retains when it issues out of the orifice below.

In order to ascertain, by direct experiment, the magnitude of this effect, MM. Prony and Carnot fixed a cord to the axis of the machine, which, passing over a pulley, raised a weight by the motion of the machine. By this means, the effect was found to be $\frac{7}{10}$ of the power, and often approached $\frac{75}{100}$ without reckoning the friction of the pullies, which has nothing to do with the machine. This effect exceeds that of the best overshot wheels. See the *Report of the Institute*, 23d August 1813; or Thomson's *Annals of Philosophy*, vol. ii. p. 412.

For farther information on Hydrodynamics, see ADHESION, BARLEY *Mill*, CAPILLARY ATTRACTION, PNEUMATICS, PUMPS, RIVERS, and WATERWORKS.

HYDROMETER. See HYDRODYNAMICS.

HYDROPHOBIA. See MEDICINE.

HYDROPHTHALMIA. See SURGERY.

HYDROSTATICS. See HYDRODYNAMICS.

HYDRUS. See OPHIOLOGY.

# GENERAL EXPLANATION

OF THE

# PLATES BELONGING TO VOLUME TENTH

OF THE

## AMERICAN EDITION

OF THE

# NEW EDINBURGH ENCYCLOPÆDIA.

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### PLATE CCLXXXIV.

Figs. 1, 2. Represent Mr Tappen's Method of constructing Groined Vaults.

Figs. 3, 4, 5, 6. Shew the Instruments used for forming Gun Flints.

Figs. 7, 8, 9. Represent the Masses of Flint in their different States.

Fig. 10. Represents the Eprouvette invented by Dr Hutton, for measuring the strength of Gun-powder.

Fig. 11. Represents the Ballistic Pendulum, invented by Mr Robins, for measuring the initial velocity of Projectiles.

### PLATE CCLXXXV.

Fig. 1. Represents Mr Forsyth's new Lock in the Priming Position.

Fig. 2. Represents the same Lock in the firing Position.

Fig. 3. Is a Section of the Magazine for containing the priming powder, and the Mechanism for inflaming it by Percussion.

Fig. 4. Is a Section of the Breach of the Gun, with the Roller screwed into it. See GUNMAKING.

Fig. 5. Represents the Indian Matchlock.

Fig. 6. Represents the European Matchlock or Harquebuss.

Fig. 7. Represents the Rest for the European Matchlock.

Fig. 8. Represents the Wheel Lock.

Fig. 9. Represents a modern Fowling Piece.

Fig. 10. Represents a Modern Spanish Lock.

### PLATE CCLXXXVI.

Figs. 1, 2, 3, 4. Are Diagrams for illustrating the mathematical principles of Gunnery.

Fig. 5. Is a Diagram for explaining Robins' theory of the explosive force of Gunpowder.

Fig. 6. Represents the Instrument invented by Mattei, for measuring the initial velocity of Projectiles. AB is a horizontal wheel, with a vertical axis CD turned by the weight Q, suspended to the rope GG, and raised by the winch N. AE, BF, is a circular drum about six inches high, formed of writing paper, fixed round the circumference of the wheel. The gun is fired at the distance of 20 feet, and pointed so, that the axis of the gun produced would pass along a diameter of the drum perpendicular to GG. A block of wood is placed two or three feet from the drum, to receive the balls. When the Machine was used at Turin, a little eccentric wheel IL was fitted to the axis CD, which with each revolution gave a vibrating horizontal motion to a tongue of wood, suspending a common pendulum, that was shortened or lengthened till its vibrations were isochronous to those of the tongue. The length of the pendulum will then shew how long the wheel is in making each revolution.

Fig. 7. Is a Diagram explaining one of Antoni's Methods of measuring the initial velocities of Projectiles.

Fig. 8. Is a Diagram for explaining Antoni's Method of determining the curve described by Projectiles, by firing the Guns from different heights.

### PLATE CCLXXXVII.

Fig. 1. Represents the Halo observed by Scheiner at Rome on the 20th March 1629.

Fig. 2. Is the Halo observed by Hevelius at Dantzic, on the 20th February 1661.

Fig. 3. Shews the Halo observed by Scheiner at Rome, in 1630.

Fig. 4. Represents the Paraselenæ seen by Hevelius at Dantzic, on the 30th March 1660.

Fig. 5. Shews the Parhelia seen by Hevelius, on the 6th April 1660.

Fig. 6. Shews the Paraselenæ seen by Hevelius, on the 17th December 1660.

Fig. 7. Represents the Halo seen in England, on the 8th April 1233.

Fig. 8. Is the Halo seen at Leyden, on the 14th January 1653, by Kechelius.

Fig. 9. Is the Halo seen by Dr Halley, on the 8th April 1702.

Fig. 10. Represents a very complicated system of Halos, which was seen at St Petersburg by M. Lowiz, on the 18th June 1790.

Fig. 11. Shews a Halo seen in Scotland, on the 18th February 1796, by Mr Hall.

Fig. 12. Is the Halo seen by Sir Henry Englefield at Richmond, on the 20th November 1812.

## PLATE CCLXXXVIII.

Figs. 1, 2, 3, 4, 5, 6. Represent the Harmonic Sliders invented by Dr Thomas Young.

Fig 7. Is an elevation of the Machine invented by Mr Thomas, for weaving Chip Hats.

Fig. 8. Is a Section of the same Machine.

Fig. 9. Represents the Apparatus used by M. Pictet, to illustrate the reflection of Heat. A and B represent the Concave Mirrors, C the heated Iron Ball, and D the Bulb of the Thermometer. The dotted lines mark the progress of the rays of heat which are emitted from the heated iron, impinge upon the Mirror A, then pass in straight lines to the Mirror B, and from this are reflected to the Focus D.

Fig. 10. Represents an Instrument invented by Dr Wollaston, and called the *Cryophorus*, for freezing at a distance.

## PLATE CCLXXXIX.

Figs. 1, 2, 3, 4, 5, 6, 7, 8, 9. Are Diagrams for explaining the new properties of heat discovered by Dr Brewster.

Fig. 10. Represents the Apparatus employed by Dr Brewster, in rendering visible the propagation of Heat downwards through Fluids.

Fig. 11. Represents the Apparatus employed by Professor Leslie in his experiments on Heat. A, is the concave elliptical Reflector; B, the differential Thermometer placed in one of its foci; C, the cubical Canister of block tin, placed on the other focus, and filled with hot water, whose temperature is ascertained by the Thermometer D, passing through an orifice in the upper side of the Canister, and having its Bulb in the centre of the Cubical Canister; E, is a Screen consisting of a light frame of wood, wider than the diameter of the largest reflector used. It has occasionally different thin substances attached to it.

Figs. 12, 13, 14, 15, 16, 17, 18, 19, 20. Represent the Apparatus used by MM. Delaroche and Berard, in their experiments for determining the specific heat of the Gases.

Fig. 12. Is a thin copper Cylinder, (called the *Calorimeter*,) 6 inches long and 3 inches in diameter, filled with distilled water, and traversed by a worm about 5 feet long, having 8 spiral turnings, the two ends of which open without the vessel. A regular current of gas, at a high and constant temperature, was made to pass through the worm, and the intensity of this heat was considered as proportioned to the excess of the temperature of the Cylinder AB (when it had become stationary) above that of the surrounding air. Hence, by repeating this experiment on each of the gases, each current will raise the temperature of the Cylinder AB above that of the ambient air, to a fixed point where it will be stationary; and, therefore, we obtain the quantity of heat given out by each current of gas. The relative specific heats consequently of the gases are obtained with great exactness.

Figs. 13, 14, 15, 16. Represent the Apparatus employed by Messrs Delaroche and Berard, to make a regular current of hot gas pass through the Calorimeter. In order to understand this, suppose a globular glass vessel A, Fig. 3. filled with water, and placed above a reservoir of glass or metal B, filled with any gas insoluble in water. Let these two vessels communicate by a vertical tube CD, which may be shut by a stop-cock E. Suppose, likewise, that the upper surface of the water contained in A is GH. It is evident, that if the stop-cock E is opened, the water will fall into the vessel B, and drive out the gas, which will make its escape by the mouth L, (the stop-cock M being open.) It is equally obvious that the force with which the water of the vessel A will run down, at first equal to the column of water HK, will diminish in proportion as the surface of the water GA sinks. But then, if the mouth F is shut exactly, and the communication of the vessel A established with the external air by the tube NO, open at its two ends, the air, in order to introduce itself into the vessel A, and fill up the place of the water that has run out, must overcome the pressure of the column of water HI. Of course, the water will only run into the vessel B, with a force equal to the column HK, minus HI, that is to say, the column IK, which is a constant quantity, as long as the surface of the water continues higher than OI. Now suppose the reservoir B be totally emptied of gas, and filled with water from the vessel A. Shut the stop-cocks EM, and introduce by the tube QR, which goes to the bottom of the vessel, a constant current of gas, coming from a similar gazometer. In these circumstances, if the stop-cock P is opened, to let out the water from the reservoir B, it is clear that this gas, in order to get into the reservoir B, is obliged to overcome a resistance represented by the column of water which this reservoir contains. On the other hand, it is attracted by an equal force, namely, the force with which this water tends to run out by the stop-cock P, and which is represented by the same column. These two forces being equal, and opposite, it follows that the regularity of the gas entering by the tube QR, will not be disturbed, and that the reservoir B will be filled with gas coming from the other gazometer, without having any effort to overcome. The stop-cock E remaining shut during the whole of this operation, there will be time to open the mouth F, and to fill the vessel A with water, in order to recommence the operation. It is easy to see that with two similar gazometers, we may make a certain quantity of gas pass from the one to the other as often as we please, without interruption.

When the gas which fills the reservoir B is not atmospherical air, when it is hydrogen gas, for example, if we pass it often from one gazometer to another, it will disengage the air contained in the water, and take its place, so that the purity of the gas will be injured. It would have been impossible to have produced a current of carbonic acid gas, nitrous oxide gas, or olefiant gas, in this manner, though they are but imperfectly soluble in water. This difficulty would have obliged them to renounce this kind of gazometer, if they had not found a method of obviating it. This method consists in putting only atmospherical air into the reservoir B, and in introducing the gas which is to circulate into a bladder V, Fig. 14. inclosed in a globular vessel M, communicating by the tube C with the reservoir B. If in this state of things we suppose a regular current of atmospherical air proceeding from the reservoir B to the vessel M through the tube C, as the vessel M is accurately shut, the air will press uniformly on the bladder, and there will issue out through the tube D a regular current of the gas contained in the bladder.

If, on the other hand, we suppose that the constant current issuing from the bladder V enters into another bladder V′, (Fig. 15.) which is empty, and placed, in the same manner as the first, in another globular vessel M′, which is full of air, and communicates with the reservoir B′ of the other gazometer, by the tube C′, which reaches down to its bottom. The reservoir B′ being full of water, and its stop-cock P′ open, the bladder V′ will become gradually filled with gas, and will drive the air of the globular vessel M′ into the reservoir B′, in an uniform current. It is now easy to form an idea of the apparatus which we employed, and of which we have given a vertical projection in Fig. 15.

B and B′ are the two lower reservoirs of the two gazometers. The reservoir B is supposed full of air, and B′ full of water. V is a bladder filled with gas, hydrogen gas for example, whose specific heat is to be determined. The corresponding bladder V′ is empty; *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, are the stop-cocks. Let us suppose *a*, *c*, *f*, *h*, alone open, if we make the gazometer B act, a regular current of common air will flow out of B, and pass into the globular vessel M. It will compress the bladder V, and force out a current of hydrogen gas. This gas will pass through the tube CDE, about forty inches in length, and which is surrounded by a larger tube FG. This last tube is kept filled with the steam of boiling water by means of a small boiler K, filled with water, and kept constantly boiling. The steam passes through the tube KF, into the tube FG, traverses the whole of it, and makes its escape by the tube GI. The part DE of the tube through which the gas passes is long enough to enable the gas during its passage to acquire very nearly the temperature of boiling water. The gas, when it leaves this tube, passes into the calorimeter L, where it gives out its heat, and then issues out by the tube NO, which conducts it to the bladder V′. It fills this bladder, driving the air of the vessel M′ into the reservoir B′, by a tube which plunges to the bottom of the reservoir.

When all the air has been driven out of the reservoir B, and water has been substituted in its place, then the bladder V is empty, and the vessel M full of air from the reservoir B. The bladder V′ is full of hydrogen, and the reservoir B′ full of air from the vessel M′. If we now shut at once the stop-cock *a*, *c*, *f*, *h*, and open *g*, *e*, *d*, *b*, and put the gazometer B′ into action; then the air issuing from the gazometer by the stop-cock *g*, will fill the vessel M′, press upon the bladder V′, and cause an uniform current of hydrogen gas to pass through the stop-cock *e* into the tube DE, where it will be heated. It will then pass through the calorimeter, and issuing out by the tube NO, it will pass through the stop-cock *d* into the bladder V, will fill it, and drive the air of the vessel M into the reservoir B. Thus matters will be brought to their primitive state, and we may commence the process as at first. With a bladder filled with hydrogen gas we may pass an uniform current as long as we please through the calorimeter; and we know, from experience, that notwithstanding the continual agitation given to this gas, by making it move so frequently through so long a circuit, it does not contain, after having circulated for six hours, three per cent. of impurities.

The greatest part of the apparatus which has been described is contained in the same room; but the calorimeter, the ends of the tubes DE, FG, and a part of the tubes GI, NO, are in another room, separated from the first by the door PQ, which has proper holes in it to allow the tubes to pass. This second room being but seldom opened, the air which it contains, and which surrounds the calorimeter, is seldom agitated, and its temperature scarcely varies.

Fig. 17. Represents a Horizontal Section of the Calorimeter AB, Fig. 12, through its lower part. This plate has fixed to its two extremities two rods, *b b*, *b′ b′*, six inches long, and cut half their length into the threads of a screw, upon which are fixed the nuts C, C′. The middle of this plate is pierced with a hole *d d*, which coincides with the orifice by which the inferior part of the serpentine opens outwards. Round the hole is a flat place *f f*, destined to receive a piece of leather.

Fig. 18. Represents the extremity of the Tube filled with vapour, which serves to heat the gases. This extremity is of copper. The plate EE, which terminates it, is pretty thick, and pierced in its middle with an opening II, communicating only with the interior tube, which contains the gas. This opening is surrounded externally with a flat place LL, which receives a round piece of leather. Immediately in the neighbourhood of the terminal plate is the tube RS, which opening into the inside of the vapour tube, allows the vapour and the condensed water to escape, and carries them to a distance from the calorimeter. It is the same tube that is represented by GI in the horizontal section of the apparatus, Fig. 16.

MM, NN, are two oval plates, pierced in their centre by a circular opening, which receives the vapour tube, to which they are firmly fixed. At each of their extremities is a hole, sufficiently large to give passage to the rods *b b*, *b′ b′*, fixed to the calorimeter, and represented in Fig. 17.

It is easy to see that when the extremity of the vapour tube is presented to the calorimeter, and the metallic rods are made to pass through corresponding openings in the wooden disks MM, NN, the opening II of the gas tube will be exactly opposite to the opening *d d* of the serpentine. If we interpose between the two openings a tube of glass of the requisite size, and such that its extremities, ground with care, press against the disks of leather which cover the flat faces *f f*, L L; and if, by means of the nuts C, C′ we force the extremities of the vapour tube to approach as near as possible to the calorimeter, then the tube of glass firmly fixed between the two disks of leather will establish a communication between the gas tube and the calorimeter, and will prevent all gas from escaping in any other direction.

Fig. 19. Represents the modification of the Apparatus for determining the specific heat of air subjected to different degrees of pressure. To the stop-cocks P and P′ was soldered a tube in the form of a Y reversed. The two branches of the Y united in a common tube HH, which, rising vertically, and passing through an opening in the roof of the room, opened above a tub X, placed in the room above. We carried to this room the cylindrical glass vessels A, A′, and formed the communication between them and the reservoirs B, B′, by the long tubes which passed down through the floor. In this apparatus the height HH, of the upper extremity of the tube H, above the mouth of the stop-cocks P, P′, determined the pressure to which the gas was subjected.

Fig. 20. Represents the Apparatus employed by the same Chemists for comparing the specific heats of the gases with that of water taken as unity.

In order to get a constant and regular current of water, they made use of a syphon of glass C, one of the branches of which passed through one of the mouths of a flaggon, with two mouths almost filled with water. On the other mouth was placed a globular vessel turned upside down, and full of water. The neck of this vessel was of such a length as just to reach the surface of the water in the flaggon. Hence it is evident, that whenever the water ran out through the syphon so as to sink its surface below the mouth of the globular vessel, the water which filled that vessel would fall down and supply its place; so that the height of the water in the flaggon would remain always nearly the same, and of course the water would flow through the syphon pretty equably. The bore of the syphon was capillary, in order to make the current of water very slow.

This current of water was heated in the same manner as the current of the different gases in the preceding experiments: but when a current of hot water circulates slowly in a horizontal tube, it is impossible to determine its temperature exactly by means of a thermometer placed in the centre of the tube, on account of the unequal temperature of the different strata of fluid which constitute the current. It was then ascertained, by experiment, that a thermometer, thus placed, indicated a temperature much lower than the true temperature of the current. To get rid of this uncertainty, the apparatus was disposed in the manner represented in Fig. 20.

The current of water which flows from the syphon C is received into the tube DD, which passes through a larger tube EE, kept continually filled with steam, by means of the small boiler R. The tube DD is soldered to another tube FF, about 0.3 inch in diameter. In this tube, placed, as will be seen, almost vertical, are disposed three thermometers, Nos. 1, 2, 3, in such a manner that the small spherical bulb of each is in the centre of the tube, and at the distance of 1.083 inch from each other. These thermometers served to determine the temperature of the current of water at its entrance into the calorimeter. The tube FF is cemented to the horizontal tube of glass GG, which is cut at its end G, very near the junction, so that the bulb of the thermometer No. 1, which must necessarily be in the vertical tube, that it may acquire the temperature of the current of water, is, notwithstanding, no farther distant from the calorimeter than the first thermometer is from the third. The tube GG is shut by a stopper H, that no water may escape, and it is ground at its extremity G, so that by pressing it, by means of two screws, against a piece of leather placed on the calorimeter, it is sufficiently tight to prevent any water from escaping in that direction. The water comes out of the calorimeter by the tube OOO, which is capillary at the extremity P, from which it falls, drop by drop, into a graduated tube, which serves to measure the rapidity of the current. The calorimeter was placed, as in the preceding experiments, in a separate room, that the temperature of the ambient air might be less variable.

## PLATE CCXC.

Fig. 1. Is a Perspective View of the *Heliostate*, a very useful Instrument, invented by S'Gravesande, for fixing in an invariable position a Beam of the Sun's Light, for the purpose of making optical experiments.

Fig. 2., Fig. 3., Fig. 4., Fig. 5., Fig. 7. } Represent different parts of the Instrument.

Fig. 6. Represents the *Placer* of the Heliostate.

Fig. 8. Represents a very simple Heliostate, proposed by Dr Thomas Young.

## PLATE CCXCI.

Fig. 1. Represents one of the *Galeæ Hastiludiales*, or Helmet of Tournaments.

Fig. 2. Represents the Seal.

Fig. 3., Fig. 4., Fig. 5., Fig. 6., Fig. 7. } Shew the different forms of the Shields on which arms are placed.

Fig. 8., Fig. 9., Fig. 10., Fig. 11., Fig. 12., Fig. 13., Fig. 14. } Shew the different Tinctures in Heraldry.

Fig. 15. Is the Fur called Ermine.

Fig. 16. Represents Contre Ermine.

Fig. 17. Represents the Fur called Vair.

Fig. 18. Is Contre Vair.

Fig. 19. Is another Fur, called *Murre*, *Vairy Cuppy*, &c.

Fig. 20. Shews the mode of dividing the Shield, and giving the divisions different names.

Fig. 21. A plain horizontal line.

Fig. 22. An angle.

Fig. 23. A Bevile.

Fig. 24. Escartele.

Fig. 25. Nowy.

Fig. 26. Arched, or enarched.

Fig. 27. Doublearched.

Fig. 28. Wavey or undé.

Fig. 29. Invecked.
Fig. 30. Ingrailed.
Fig. 31. Battled, embattled, or crenellé.
Fig. 32. Battled, embattled.
Fig. 33. Nebule.
Fig. 34. Potent.
Fig. 35. Indented.
Fig. 36. Dancetté.
Fig. 37. Patte, or dovetailed.
Fig. 38. Urdé.
Fig. 39. Rayed, radiant, rayonné, or ráyonated.
Fig. 40. Raguly.
Fig. 41. A Shield parted per fess.
Fig. 42. A Shield party per pale.
Fig. 43. A Shield party per bend dexter.
Fig. 44. A Shield party per bend sinister.
Fig. 45. A Shield parted per cross.
Fig. 46. A Shield parted per saltier argent and azure.
Fig. 47. A Shield girony of six.
Fig. 48. A Shield party per chevron.
Fig. 49. A Shield tierce, or tierce per pale.
Fig. 50. A Shield tierce per fess.
Fig. 51. A Shield tierce per bend dexter.
Fig. 52. A Shield tierce per bend sinister.
Fig. 53. } Shields divided into unequal parts.
Fig. 54. }

PLATE CCXCII.

Fig. 1. The Chief.
Fig. 2. The Pale.
Fig. 3. The Bend.
Fig. 4. The Bend sinister.
Fig. 5. The Fess.
Fig. 6. The Bar.
Fig. 7. The Escutcheon.
Fig. 8. The Border.
Fig. 9. The Orle.
Fig. 10. The Flasque.
Fig. 11. The Saltier.
Fig. 12. The Cross.
Fig. 13. The Cross patée.
Fig. 14. The Cross potence.
Fig. 15. The Cross avellane.
Fig. 16. The Cross furche.
Fig. 17. The Cross crosslet.
Fig. 18. The Cross botone.
Fig. 19. The Cross flory.
Fig. 20. The Cross patée fitched.
Fig. 21. The Cross pierced.
Fig. 22. The Cross moline.
Fig. 23. The Cheveron,
Fig. 24. The Fret.
Fig. 25. The Pile.
Fig. 26. The Giron.
Fig. 27. The Quarter.
Fig. 28. The Canton.
Fig. 29. The File or Label.
Fig. 30. The Lion Statant.
Fig. 31. Passant.
Fig. 32 Passant-gardant.
Fig. 33. Passant-regardant.
Fig. 34. Rampant.
Fig. 35. Rampant-gardant.
Fig. 36. Rampant-regardant.
Fig. 37 Salient.
Fig. 38. Sejant.
Fig. 39. Coward.
Fig. 40. Couchant.
Fig. 41. Dormant.
Fig. 42. Naissant.
Fig. 43. Issuant.
Fig. 44. Combattant.
Fig. 45. Lions endorsed.
Fig. 46. Lion demi-rampant erased. Lion's head coupé.
Fig. 47. Lions jambe erased.
Fig. 48. Lions tails erased.
Fig. 50. }
Fig. 51. }
Fig. 52. }
Fig. 53. } Are the Marks of Cadency.
Fig. 54. }
Fig. 55. }

PLATE CCXCIII.

Fig. 1. Is the method of impaling the arms of France and Navarre.
Fig. 2. }
Fig. 3. }
Fig. 4. } Shew different Methods of Impaling Arms.
Fig. 5. }
Fig. 6. }
Fig. 7. Represents the Arms of Sicily.
Fig. 8. Are the Arms of the Princes of Orange.
Fig. 9. Are the Arms of the King of Great Britain.
Fig. 10. Is another Method of Marshalling Arms.
Fig. 11. Shews the Ornaments of the Helmet.
Fig. 12. Is the Wreath.
Fig. 13. Is the Crest or Cimier.

PLATE CCXCIV.

Fig. 1. Is the Imperial Crown of England.
Fig. 2. Is the Prince of Wales's Crown.
Fig. 3. A Duke's Crown.
Fig. 4. A Marquis's Crown.
Fig. 5. An Earl's Crown.
Fig. 6. A Viscount's Crown.
Fig. 7. A Baron's Crown.
Fig. 8. Is the Cap of State.
Fig. 9. Is the Pope's Tiara.
Fig. 10. Is the Cardinal's red Hat.
Fig. 11. Is the Bishop's Mitre.
Fig. 12. Are the Arms of one of Napoleon's Dukes.
Fig. 13. Is the complete achievement of Scotland.
Fig. 14. Is the Funeral Escutcheon of the Duke of Athole.

PLATE CCXCV.

Fig. 1. Skeleton of a species of Tupinambis.
Fig. 2. The head of the same Animal. *a*, the intermaxillary bone; *b*, *b*, the two superior, or coronal maxillary bones; *c*, the nasal bone; *d*, one of the zygomatic arches; *e*, a supernumerary bone; *f*, *f*, the two sides of the frontal bone; *g*, the parietal; *h*, *h*, two bony arches forming the interior border of the temporal fossa; *i*, a small portion of the left basilar jaw; *k*, the bone with which this is articulated; *l*, *l*, the occipital bone; *m*, its condyle.
Fig. 3. The Jaws of the Nilotic Crocodile extended, shewing the mode of their articulation.
Fig. 4. Stomach of the common Land Tortoise.
Fig. 5. Stomach of the Gavial Crocodile, with a portion of the Intestinal Canal commencing at *a*, the pylorus.

Fig. 6. Stomach of the Nilotic Crocodile partly laid open; *a*, a pouch into which the aliments pass before proceeding out at *b*, the pylorus.

Fig. 7. Stomach and Intestines of the Chameleon; *a*, the *pylorus*; from *a* to *b*, the small intestine; *b*, the commencement of the large intestine.

Fig. 8. Part of the Intestines of the Land Tortoise; *a*, *b*, a part of the small intestine; *b*, the commencement of the large intestine.

Fig. 9. The *Rectum* of the Nilotic Crocodile insensibly commencing from the small intestine; *a a*, a valve between the two.

Fig. 10. *Rectum* of the Gavial; *a*, the termination of the small intestine; *b*, the rectum; *c*, a projection from the small intestine into the large for acting as a valve.

Fig. 11. Stomach and Intestines of the Siren; *a* the *pylorus*; *b*, the termination of the hepatic duct.

Fig. 12. The Heart of the Crocodile seen on its lower surface; *a a*, the right auricle; *c*, the common trunk of the right carotid and right brachial arteries; *d*, the common trunk of the same arteries on the left side; *e e*, the continuation of the right posterior *aorta*; *f f*, the left posterior aorta; *g h*, the left and right pulmonary arteries; *i k*, the pulmonary veins; *o*, the opening by which the right auricle communicates with the inferior compartment of the ventricle; *p*, an orifice by which this compartment communicates with the pulmonary cavity of the ventricle; *q*, *r*, two valves at the commencement of the left aorta; *s*, *t*, the trunks of the two arteries *c* and *d* laid open; *v*, the trachea; *x x*, its subdivisions into bronchi; *y y*, situation of the lungs.

Fig. 13. The Heart of the Crocodile viewed on its inferior surface, but a little more to the left side. Here the letters *a*, *c*, *d*, *e*, *f*, *g*, *h*, refer to the same parts as in the preceding Figure. *b*, the left or pulmonary auricle; *m*, a row of tubercles behind; *x*, *y*, the valves guarding the entrance of the left pulmonary artery; *z*, the communication between the inferior and pulmonary compartments of the ventricle.

Fig. 14. The Crocodile's heart seen on its upper surface; where the letters *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *k*, refer to the same parts as in the former Figures. *l*, the upper compartment of the ventricle laid open.

Fig. 15. The general appearance of the Ova of Frogs as extruded from the oviduct.

Fig. 16. The Tadpole of the Frog, when only a few days old.

Fig. 17. The Tadpole of the Surinam Frog in that stage called *Frog-fish*.

Fig. 18. Is the under surface of one of the Toes of the *Gecko Egyptiacus*, of the natural size.

Fig. 19. Is a Toe dissected, to shew the appearance of the pockets on its under surface, their serrated cuticular edge, the depth of the pockets, and the small muscles by which they are drawn open, the parts being highly magnified: *a a* are the two muscles which lie on the sides of the bones of the toe, with their tendons inserted into the last bone, close to the root of the claw. The muscles belonging to the pocket go off from these tendons.

## PLATE CCXCVI.

Fig. 1. *Chelonia Mydas*. Green Turtle.

Fig. 2. *Testudo Græca*. Common Land Tortoise.

Fig. 3. *Crocodilus Niloticus*. Crocodile of the Nile.

Fig. 4. *Dracæna*. Dragon Lizard.

Fig. 5. St Domingo Crocodile. This figure was engraved by mistake for the *Tupinambis Ornatus*.

Fig. 6. *Basiliscus Mitratus*. Mitred Basilisk.

Fig. 7. *Iguana Delicatissima*. Common Guana.

Fig. 8. *Draco Volans*. Flying Dragon.

## PLATE CCXCVII.

Fig. 9. *Agama Calotes*. Galeot Agama.

Fig. 10. *Stellio Brevicaudatus*. Short-tailed Stellio.

Fig. 11. *Chameleo Vulgaris*. Common Chameleon.

Fig. 12 *Gecko Egyptiacus*. Egyptian Gecko.

Fig. 13. *Anolis Bimaculatus*. Two-spotted Anolis.

Fig. 14. *Lacerta Lemniscata*. Laced Lizard.

Fig. 15. *Takydromus Sexlineatus*. Six-striped Takydrome.

Fig. 16. *Scincus Officinalis*. Common Scink.

## PLATE CCXCVIII.

Fig. 17. *Seps Pentadactylus*. Five-toed Eft.

Fig. 18. *Chalcides Tridactylus*. Three-toed Chalcides.

Fig. 19. *Hyla Bicolor*. Two-coloured Tree Frog.

Fig. 20. *Rana Paradoxa*. Surinam Frog.

Fig. 21. *Bufo Dorsiger*. Surinam Toad.

Fig 22. *Salamandra Terrestris*. Common Salamander.

Fig. 23. *Proteus Anguinus*. Common Proteus.

Fig. 24. *Siren Lacertina*. Lacertine Siren.

## PLATE CCXCIX.

Fig. 1. Is a section of Messrs Pollzapfell and Deyerlin's Machine for pressing Horn.

Fig. 2. Is an Elevation of the same Machine.

Fig. 3. Is a Roasting Jack, to be turned by the descending power of a weight.

Fig. 4. Is a Spring Jack.

Fig. 5. Represents a Smoke Jack.

Fig. 6 Represents the common hand Jack for raising weights.

Fig. 7. Is a Screw Jack for raising weights.

Figs. 8. and 9. Represent another Screw Jack in two views.

Fig. 10. Is a Jack constructed by Bramah on the hydrostatic principle discovered by Pascal.

## PLATE CCC.

Fig. 1. Represents a side view or profile of the going part *only* of the ancient striking Clock made by Vick. A is a heavy weight suspended at the end of a long cord, coiled or wrapped round a cylinder or barrel B, which is fixed on the arbor or axis, *a*, *a*, the small ends of which, called pivots, *b*, *b*, *b*, turn in holes made in the frame plates C, DD. These plates, in the early clocks, were of iron, and connected or put together by means of upright iron kneed pieces or pillars E, E, formed from one of the plates standing at right angles to them. The ends of these pillars being tapped, and having a shoulder, went through holes in the other plate, and the whole was kept together by screwed nuts, one of which is seen near D, and the other at upper D, thus forming what is called the *frame*. The action of the weight A tends necessarily to turn the cylinder or barrel B, and if it was not restrained, it would fall with an accelerated motion; but one of the ends of the cylinder carries a wheel F, having

teeth of the ratchet form, against the faces of which the end of a click is opposed, to prevent the barrel turning without bringing the great wheel GG along with it. The *click* is attached to the great wheel by a screw, and having a hole in it, it has liberty to move on a plane or cylindrical part of the screw; and when the weight A is winding up, the click is pressed down by a spring into the teeth of the ratchet wheel, in order to prevent any returning. The ratchet, with the click and its spring, are called the *click-work*, and without them there could be no security after winding up the weight. It may then be easily conceived that the action of the weight is transmitted to the toothed or great wheel GG, the teeth of which enter into the spaces or openings of the teeth, which are formed on the small wheel or lantern pinion *e*, and in such a manner that they compel it to turn on its pivots *f*, *f*. This kind of communication by the teeth of one wheel with those of another, or with a pinion, is called *pitching*. The wheel H H is fixed on the axis of the lantern pinion *e*; so that the motion communicated by the weight A to the wheel G G is transmitted to the pinion *e*, and consequently to the wheel H H, which pitches into the lantern pinion *g*, whose axis carries the crown wheel I I, which is by foreign artists called the *wheel of rencounter*, or of the 'scapement; and the action of the weight A is transmitted by the crown wheel I I to the levers or pallets *h*, *i*, formed on the vertical axis K K, which turns on its pivots the upper pivot at *l*; the lower one near to K turns in a stud fixed to the plate DD. It is on this axis that the regulator or balance LL is fixed: this regulator is suspended by a small cord M, and it can describe arcs of a circle round its pivots, going and returning alternately on itself, or vibrating. The alternate motion, or vibration of the balance, is produced here by the action of the wheel I I upon the pallets of the axis K K of the balance, whose planes may stand at an angle of 90 degrees or so, and with the axis form what is called, in technical language, the *verge*;* so that when a tooth of the wheel has drawn aside the pallet *h*, and has escaped, the other pallet *i* presents itself to a tooth of the wheel on that side which is diametrically opposite, and is in its turn drawn aside also; so that, by the wheel turning always in the same way, the balance going and returning on itself, forms vibrations which moderate and regulate the velocity of the wheel I, and consequently of the wheels H and G, whose revolutions serve to measure the time. The reciprocal action of the teeth of the wheel I, on the pallets *h*, *i*, carried by the axis of the balance, and of the pallets themselves on the teeth of the wheel serving to regulate as well as to restrain the motion of it, is what is called the *'scapement*. The wheel GG makes a revolution in an hour; the pivot *b b* of this wheel is lengthened a little beyond the outside of the fore plate, and carries a pinion *n*, which pitches into or leads the wheel N N, causing it to make one turn in 12 hours. The axis of this wheel carries the index or hand O, which marks or points to the hours on the dial-plate. We must now explain how a revolution of the wheel G is determined, so as to be made in an hour precisely. To produce this effect, it is necessary to know that the vibrations of the regulator or balance become slower if it is made heavier, or if its diameter is increased. We suppose here, that the regulator LL must make vibrations whose duration is exactly equal to one second, which is obtained by bringing nearer or farther from the centre the weights *m*, *m*, which hang upon it. We shall now proceed to show how, by means of the number of the teeth of the wheels and leaves of the pinions, we determine that the wheel G is to make its revolution exactly in an hour. In giving 30 teeth to the crown wheel I, I, it will make one turn in the time that the regulator shall make 60 vibrations; for at each turn of the wheel, the same tooth acts once on the pallet *h*, and once on *i*, which gives two vibrations for each tooth; thus, the wheel having 30 teeth, it will cause twice 30 vibrations to be made, and will consequently make a revolution in a minute of time: it is requisite, then, that the crown wheel I, I should make 60 revolutions in the same time that the wheel G makes one. Moreover, to determine the number of the teeth of the wheels G, H, and of their pinions, it must be observed, that a wheel gives as many more turns to its pinion, during the time it makes one turn, according as the number of the leaves of the pinion is contained a greater number of times in that of the teeth of the wheel: For example, the wheel G having 64 teeth, and the lantern pinion *e* 8, this pinion will make eight turns during the time that the wheel makes one. In like manner, the wheel H having 60 teeth, and the pinion *g* 8, it will cause this pinion to make $7\frac{1}{2}$ turns; but the wheel H, carried by the pinion *e*, makes 8 turns for one of the wheel G, the pinion *g* makes then 8 times 7 turns and a half, that is to say 60, during the time that the wheel G makes a turn; and we have seen that the wheel I, I, carried by the pinion *g*, makes a revolution in a minute; the wheel G makes then a turn in an hour. We see, from the same principle, that the pinion *n* carried by the axis of the wheel G, must make 12 turns during the time that the wheel NN makes one. When the cord which suspends the weight A is wholly uncoiled from the barrel, or when the weight A is run down, a handle or winding up key, is put upon the square part formed on the arbor of the lantern pinion *n'*, which pitches with the teeth of the wheel *n'*, fixed on the arbor of the cylinder or barrel B; and in turning the winding up key, the weight ascends. This wheel, and the ratchet wheel F, can turn separately from the wheel G, which remains immoveable during the time of winding. The retrograde motion of the barrel is obtained by means of the ratchet and click-work. The teeth of the ratchet are inclined on one side, which serves to raise up the click, so that during the whole time of winding up the weight, the ratchet F and barrel B turn along with the wheel, which are forced about by turning the pinion *n'*, and all turn independently of the wheel G; but as soon as the weight, after being wound up, is left to itself, it acts on the cylinder and on the ratchet, the faces or right side of whose teeth butt against the end of the click, which obliges the wheel G to turn with the cylinder; the click spring, as has already been mentioned, serving to push the click down among the teeth of the ratchet. In a plate wheel which is attached to the wheel NN, twelve

* In clock verges the angle of the pallets is considerably less than 90 degrees, and in Vick's clock it would be so too.

pins are fixed equally distant from one another, whose use is to raise an arm up, by the lifting of which another arm is raised; the fly pinion of the striking part is then discharged, and the hour is struck by the force of the striking weight acting on its barrel and train of wheels contained in the clock frame: By these the hammer is raised, and gives a blow on the bell, either by its falling from the force of gravity, or by its being impelled by the force of a hammer spring.

Fig. 2. Is the Crown Wheel and Verge 'Scapement, as mentioned in HOROLOGY, Chap. I. p. 473, the principle and mechanism of which is the same as that which has been described in Vick's clock. It was long applied to clocks and watches before the application of a pendulum to the former, or before the invention and application of the spiral or balance spring to the latter. This spring had originally been called the *pendulum spring*, which it still improperly retains, no difference being made here in the name, whether it is the spring which suspends the pendulum of a clock, or moves the balance of a watch: when applied to it, the *balance spring* appears to be the proper term. The crown wheel and verge 'scapement is still used in common pocket watches.

Fig. 3. Is a side view of an Alarm Clock, the alarm part of which is nearly the same as the going part in Vick's clock. The iron frame of the alarm clock is formed much in the same manner as Vick's clock, only it has a bar or plate in the middle of the frame which serves to make it a double frame; one division of which, CD contains the going part, while the other, NO, contains the alarm part. H is the great wheel of the going part, carrying on its arbor a pulley, in the groove of which is fixed a few short steel points, serving to enter a little way into the texture of a cord wove either of silk or cotton. At one end of the cord is hung the going weight F; and at the other the counter weight G. This pulley with its socket and ratchet are fixed together, and turn freely on the arbor of the great wheel H. The ratchet click and click spring are upon the wheel H, so that, on pulling down the counter weight G, the weight F ascends. The old click and ratchet work consisted of a circular kind of steel spring, pinned down by one side against the bottom of the jagged and moveable pulley. The spring having a step made on it, acted both as click and spring, the arms or crosses of the wheel serving as a ratchet, the step of the spring stopping against them. The weight when wound up was kept there, and exerting its force on the pulley and wheel H, put the going part in motion. The first wheel H makes its revolution in an hour; its axis, which is also that of the pulley, has the fore pivot *b* prolonged outside of the fore plate C. This pivot carries a socket, on the end of which is the minute hand fitted by means of a square. On the lower end is fixed a wheel *c*, which pitches with the wheel *d* of the same diameter and number of teeth; the axis of the wheel *d* carries the pinion *e*, which leads the wheel *f*; this makes a revolution in 12 hours, and on its socket the hour hand is fitted spring tight.—The wheel H, which has 64 teeth, pitches into the pinion *g*, which has eight. The arbor of this pinion carries the wheel I, of 60 teeth. This again pitches into the pinion *h*, which makes 60 turns for one of the wheel H; it makes then a turn in a minute, and the hand *i*, carried by the long pivot from the axis of the pinion *h*, marks the seconds on the seconds circle of the dial. The axis of the seconds pinion *h* carries also the contrate wheel K, which has 48 teeth; it pitches into the pinion *k* of 12 teeth or leaves. The axis of this pinion carries the crown wheel, or wheel of rencounter L, of 15 teeth. This wheel makes 'scapement with the pallets *i*, *r*, carried by the axis of the balance MM, which is the regulator of this machine. At each revolution of the crown-wheel L the balance makes twice 15 or 30 vibrations, and this wheel makes four turns for one of the contrate or seconds wheel. Thus the balance makes 120 vibrations in a minute, and 7200 in an hour. Each of the vibrations is then equal to half a second of time; the seconds hand consequently gives half a second on the seconds circle. The mechanism of the alarm part, which is very simple, is contained in NO, the second division of the frame connected with that which contains the wheel-work of the going part of the clock. The crown-wheel P carries on its axis the jagged pulley Q, over which is laid the cord which supports the weight R, which puts the alarm part in motion, the counter-weight S being on the other end of the cord. The teeth of the crown-wheel P makes 'scapement with the pallets *n*, *o*, formed on the vertical axis or verge TV, the kneed or bent arm of which *p p*, *q q*, at the top of the figure, forms with *g x* the alarm hammer. This hammer has the form of a small cylinder, and carries two ends or buttons *x*, which strike alternately on the inner edges of a bell, which is not represented here. The alarm or crown-wheel P carries on its circumference a pin, which serves to stop the alarm, after having drawn up the alarm weight. This stopping is made by means of a detent at *p*, fixed into an arbor *p*, *q*, whose pivots run, one in the dial, the other in the back frame plate O of the alarm part. To discharge or set off the alarm, there is placed on the socket of the hour wheel another socket, which carries the small dial *t* for the hours of the alarm, and a counter spring *s*, in which is fixed a pin, which serves to raise the arm *r*, fixed on the same arbor *p*, *q* in which the detent is fixed, so that when the pin in the counterspring *s* raises up the arm *r*, the detent is raised up at the same time from the wheel P, and the pin which it carries getting disengaged, the alarm part immediately sets off, and the hammer strikes the bell with force and precipitation. In order that the alarm should set off at the precise hour that is required, or at which we wish to be awakened, it is only necessary to turn the small dial *t*, so as the number of the hour required is placed under the tail of the hour hand. If it is required that it sets off at four hours and a half, the tail of the hour hand will stand between the figures 4 and 5.

Fig. 4. Represents a Side View of Huygens's Clock, with the cycloidal cheek-pieces, which were put for the purpose of causing the long and short vibrations of the pendulum to be performed in equal times, a double and flexible silk thread, by which the pendulum was suspended, applying itself on the inner sides of these checks more or less, according to the extent of the arc described by the pendulum. A perspective view of the cheeks and of the double thread is seen in Fig. A. The brass frame plates of this clock as seen at AA, BB, placed vertically, 6 inches in height, and 2 inches and a half broad, are

connected by four brass pillars, turned and placed near the angles of the plates, their height being about one inch and a half: The pivots of the arbors of the principal wheels run in holes made for them in the plates. The first wheel marked CC has eighty teeth, and is two inches and a half in diameter. It carries on its arbor a pulley D; the bottom of the groove, being a very little convex, is furnished with steel points, to prevent the cord which goes over it from slipping, to which cord two weights are attached, as will be afterwards explained. The wheel CC deriving its motion from a weight, communicates it to the pinion E of eight leaves, and of consequence also to the wheel F of forty-eight teeth, having the same axis as the pinion. The wheel F conducts the pinion G and the contrate wheel H both upon the same axis. The contrate wheel has 48 teeth. It is from this last wheel that the pinion I, and the crown wheel K on the same vertical axis, receive their motion. The pinion I has 24 teeth or leaves. The crown wheel K carries 15 teeth, inclined as the figure represents. Two bridges are fixed on the top of the plate BB, the extremities of which carry the pivots of the axis LM, and the jutting out part Q of the bridge NQ has two holes pierced in it, through one of which the axis LM goes, and in the other, the upper pivot of the arbor of the crown wheel K runs. The same axis LM (which passes also through the plate BB) carries two pallets, which must be raised up alternately and in a contrary direction by the teeth of the wheel K. The part M of the axis LM, which goes beyond the frame plate, carries the fork MS, between two branches of which passes the rod VV of the pendulum VX, suspended by means of two threads between the two cycloidal cheeks, which are distinctly seen in Fig. A. With regard to the curve formed on the cheeks, we will speak of it more at length afterwards; at present let us attend to the movement of the clock. It is evident at first, that the pendulum having been drawn aside from the perpendicular and then left to itself, this will not only allow the teeth of the wheel K to pass successively, but the motion impressed by the force of the weight will cause the teeth of the wheel K to act on the pallets of the verge LM, and by this means and that of the fork restore to the pendulum that motion, which friction, or the resistance of the air, would insensibly take away from it; and although in ordinary clocks the wheel K does not always act with the same force, the curve that has been given to the cheeks, on which the threads of the pendulum must apply themselves, subjects the pendulum to make its oscillations all in the same length of time so long as its length remains the same, determines the teeth of the wheel K to pass only in equal times, and consequently gives uniformity to all the other parts of the clock, since their motions are proportional: So that, whatever fault there might be in the construction, whatever difficulties in the motion of the wheel-work, occasioned by change of temperature in the air, provided that the motion of the clock is not wholly interrupted, there will no inequality result from it; the clock will always measure time exactly, or it will not measure it at all. *g g* is a third plate, parallel to the two former, and distant about a quarter of an inch from the plate AA. In the centre of the dial which is traced on this plate, the arbor of the wheel CC prolonged comes through. On this dial are traced two concentric circles, the one divided into twelve, the other into sixty parts. On the arbor of the wheel CC, and outside of the plate AA, is put spring-tight the cannon or socket of the wheel *a*. This cannon is prolonged or carried out near to *e* through the plate *g g*, and turns with the wheel CC, and can also be made to turn independently of it when it is necessary; this is when setting the hands. It is at the point *e* that the minute hand is placed. With regard to the wheel *a*, it conducts a wheel *b* of the same number of teeth with itself, and whose axis carries a pinion of six leaves, whose pivots on the one part run in the plate AA, on the other in the cock or bridge *c* fixed to the same plate. Finally, this latter pinion conducts or leads the wheel *d* of 72 teeth, the socket of which goes on that of the wheel *a*, terminates under *e*, and passes like it through the plate *g g*. The extremity of this socket carries the hour hand, which is made a little shorter than that of the minute hand. With regard to the seconds, to avoid confusion, the axis of the wheel H, which is prolonged nearly as far as the plate *g g*, carries a small dial *f f* divided into 60 parts, which turns in the same time as the wheel H, and an index *g*, fixed to the upper part of an opening made in the plate *g g*, marks the seconds, according as the divisions pass the index. Let us examine now, if the number of teeth that we have assigned to the wheels agrees with the revolutions which we require of them. There results from these numbers, that at each turn of the wheel C, the wheel F will make 10 turns, the wheel H 60, the wheel K 120; and as this last has 15 teeth which raise up alternately the pallets LL, that is to say, that during one revolution of the wheel K, each tooth will raise up the two pallets during the time of this same revolution, the pendulum will make 30 vibrations, and consequently it will make 3600 during one turn of the wheel C, each being equal to one second. The wheel C will then make its turn in an hour. The same will be done by the wheels *a* and *b*; and as the pinion of the last conducts the hour wheel* *d* twelve times more in number than itself, it will then cause it to make, as well as the hand placed on its socket near to *e*, a revolution in twelve hours. Then as the wheel H makes, as we have said, 60 turns for one turn of the wheel C, which it does in an hour, the small dial *f f* will make a turn in a minute. The weight of the pendulum is three pounds, and is made wholly of lead, covered over with very thin brass. But to avoid the effects of the resistance of the air, it is not enough to use too heavy a pendulum; some attention must be paid to its outward form. It is for this reason that we have given it the figure of a cylinder standing the wrong way, the ends of which are finished off to a point. However, if this clock were to be employed at sea, a lenticular form would be preferable.

We see in Plate CCCIV. Fig. 6. the manner by which the going weight of Huygen's clock is suspended, so that the motion of the clock shall con-

* This wheel has, in the language of workmen, been always called the *hour wheel,* although it takes twelve hours to make one revolution.

tinue even at the time while this going weight is winding up; a thing which had not hitherto been thought of, and which deserves some consideration. The cord which is used here is continuous, that is to say, the two ends of it are joined together in such a way as to have no appearance of being joined. This cord being passed over the pulley D of the clock, Fig. 4. Plate CCC. represented here by A, from whence it descends and takes in the pulley by which the main weight P is suspended. From this pulley it is carried up and passed over the pulley H, moveable on a stud fixed to one of the frame plates. This pulley, like that of D in Fig. 4 is furnished with points in the bottom of the groove to prevent the cord from slipping, and has also teeth cut in the ratchet form, in such a way, that it can turn when we draw down one of the cords from H, and cannot turn the contrary way by action of the weight P, being kept back or restrained by the end of a click which comes against the right side or face of the ratchet wheel teeth. From this ratchet pulley the cord comes down, and takes in the pully to which the small counter weight $p$ is hung, whose purpose, along with that of the ratchet, is to prevent the main weight P from descending in any other way than by making the pulley D of the clock turn, carried by the first wheel C, and represented by A, Fig. 6. It is obvious, that by this arrangement the main weight P employs always the half of its force to turn the wheel work, and the effort of this force is not suspended during the time of the weight being wound up, so that no time is lost, the clock continuing to go during the time of winding up the main weight P. Certain rules cannot well be given to determine the quantity that the main weight P should have; but it may be said in general, that a clock has been so much the better contrived and executed, the less the weight shall be that is required to keep it going. In the best that has been made, according to the principles which we have given, this weight was about six pounds; that of the pendulum ball being three. These clocks, suspended or placed about the height of a man, would go for about thirty hours.

Fig. 5. of Plate CCC. Represents the Anchor 'Scapement, an invention claimed by Dr Hooke, as well as by W. Clement, a clockmaker in London. The 'scapement wheel SW being flat, and having saw or ratchet-like teeth, has a different appearance from that of the ancient crown wheel; the pallets P, P supply the place of the pallets or verge used with the crown wheel. The properties of the anchor 'scapement are taken notice of in p. 476. of our article Horology. The crown wheel and verge 'scapement gave a considerable recoil to the wheels, which was lessened in a small degree in the anchor one. From what has been said respecting the number of vibrations given by the crown wheel of 15 teeth and its verge, it will be seen, that since the ratchet kind of wheel in the anchor 'scapement has 30 teeth, and since each tooth acts on both pallets, then, as the motion of one pallet is equal to one vibration, one revolution of the wheel will be equal to 60 vibrations, and with a pendulum of the proper length will be equal to one minute. Objections having been made to the principle of the recoiling 'scapement, one of a contrary nature was contrived by the celebrated George Graham, and got the name of the *dead beat 'scapement*.

Fig. 6. Is a representation of Graham's *Dead Beat 'Scapement*. SW is the 'scapement wheel, or swing wheel, being so called from the swinging of the pendulum by the motion communicated to it by the wheel. P, P are the pallets, which have a small portion made circular, by taking their length as a *radius* from the centre of the arbor on which they are fixed, to the place where the teeth of the wheel rest on them, and describing small portions of circles on the piece of steel from which the pallets are to be formed. It is by the wheel teeth resting on the circular parts of the pallets during a part of the motion of the pendulum, and however more or less this may be, yet no motion can be given to the wheel teeth either forward or backward; at this time the seconds hand appears still or *dead*. The time of rest is on the inside circular part of the right hand pallet, and on the outside circular part of the left one, in the figure a tooth here seen on this side, after giving, by means of the left hand flanch, impulse to the pendulum, is just escaped from the pallet, another tooth at this instant gets on the right hand pallet, where, after resting on the inside circular part, it gets on the flanch, and in its turn gives impulse, and so on.

Fig. 7. Represents an improvement on Graham's Dead Beat 'Scapement, made by Lepaute. The first piece of this 'scapement is an arbor, placed horizontally in F, and bearing in the two plates of the clock frame to which it is perpendicular. The ends of this arbor terminate with pivots. On this arbor are two levers, bent in or crooked at one end FA $e$, HB $d$, and are twisted pretty firmly on the arbor, in such a way that they can be opened from one another more or less, so as to put them at pleasure to the angle necessary for the effects which they are required to produce when 'scaping. The parts RI, LS of the levers are arcs of the circle, whose centre is in the same plane with the wheel and at the axis F, but they are finished by the inclined planes I $e$, L $d$. The lever F A $e$ passes behind the wheel, whilst the lever HB $d$ is on the front side of it. On the surface or flat sides of the wheel, pins are placed perpendicular to the flat sides. The pins $x$ and $y$ (left white) are on the front side of the wheel. The pins $m$, $n$ placed alternately with the others, are on the opposite side. The wheel advancing by the motive force from $u$ towards $x$, the pins of the front side meet the inclined plane L $d$, and push it towards B. By this motion, the lever FA $e$, which is on the opposite side of the wheel, advances under the next following pin. At the time when the pin V has escaped from the point $d$, and the lever or pallet continuing to recede by the force of the impulsion impressed on the pendulum, the following pin $u$ finds itself on the concave circular part RI, which is the arc of repose or rest. The levers being returned or brought back from the side A by the descending oscillation of the pendulum, the pin which was resting or sliding on the arc RI, immediately meets with the flanch or inclined plane I $e$, on which it acts as the former did, but in a contrary direction, in pushing the levers from $e$ to A, until the following pin comes to find itself on the constant arc LS, to fall from it again on the inclined plane L $d$, and so on. The pin teeth of this wheel are thirty in number on each side, and are placed in such a manner that the inside diameter of the pins on the hinder side shall

coincide with the outside diameter of those on the front which impel the front pallet; the other set impel the pallet behind the wheel: the pins are cut one half away on the side length, in order to allow the pallets to drop off when at the extremity of the diameter of the pin. Lepaute's 'scapement has been made for pocket watches, and in place of such length of levers as are at the pallets of a clock 'scapement of this kind, those in a watch are formed into a short kind of crank which connects the pallets together.

Fig. 8. Represents the wheel and pallets of the recoiling 'scapement, nearly such as it is made at the present day. P, P, are the pallets; S, W, the swing wheel; the front or right side of the teeth follow the curved part. In the dead beat 'scapement wheel of Graham's, the right side of the tooth leads or goes first; this difference is to give the pallets in each way freedom to come down between their corresponding teeth.

Fig. 9. Is a side view of the 'Scapement contrived by Mudge for his marine time-keepers. BB represents the balance seen edgewise. AA, the balance wheel, formed somewhat in the manner of the ancient crown wheel, only the space between the teeth are more enlarged, to give room for the falling in of the pallets. F, the pendulum or balance spiral spring, the inner end of which is attached to the axis of the balance; the outer end to the stud G, which is screwed on the cock: it is by this spring that the time keeper is regulated. H, the pendulum or spiral spring which is acted upon by the compensation pieces: The inner end of this spiral is attached also to the axis of the balance; the outer end is fixed in the stud I, which is screwed to the upper plate. CC is a double kneed piece or crank, which connects the balance and its upper pivot with the lower one, or foot pivot as it is commonly called. D and E are two separate arbors, whose pivots run into cocks which are not represented here, neither are those which support the crown wheel pinion. Each of these arbors have a curved kind of pallet made of some fine hard stone, having a nib or detent at the edge on which the crown wheel teeth stop, after having so far raised up the pallets. *i* and *k* are screws which fix the pallets to their arbors. It is easy to conceive that the force of the crown wheel is derived from the main spring through the intervention of the wheels in the movement. From each of the arbors D, E, small arms *a*, *b* proceed or project; the upper one *a* takes hold of a pin *c* on the outside, which is fixed to the upper knee of the crank; the lower arm *b* takes hold likewise on the outside of the pin *d*, which is fixed on the inside of the lower knee of the crank; *e* and *f* are small spiral springs, whose inner ends are fixed to the arbors D and E, and the outer ends to the studs *g* and *h*. The pallets are not seen in the Figure; for if they had been represented, it would have given obscurity to the other parts. From what has been said, it is however expected, that all the parts of the 'scapement may easily be comprehended, and we shall now describe the way in which they act. For example, let a tooth of the wheel be at liberty to raise up the upper pallet which is on the arbor D; in doing which, the course of the wheel, when acting in its proper direction on the pallet, tends to carry away or turn the arm *a* from beyond the crank pin *c*; when the pallet is raised up, the tooth of the wheel stops on the nib, and gets no farther for the present; the pallet on the lower arbor E is allowed at this time to come down, and falls between the teeth. In its course this way, the balance being on the return from one of its vibrations, it makes the crank pin *c* come against the side or near the end of the arm *a*, carrying it on a little way; at the instant of the pin *c* meeting with the arm *a*, the crown wheel teeth get disengaged from the nib or detent of the pallet, and at the same instant the pallet on the arbor E is raised up, and the wheel stops; in the mean time the balance, making its excursion, carries the arm *a* with it, and consequently bends up a little more the small spiral *e*. After the force of the balance is spent, it returns again by means of the action of the small spiral spring, which makes the arm *a* press against the pin *c*, and in this way the motion of the balance is kept up. Near the end of this return, the crank pin *d* carries away the arm *b*, the wheel gets unlocked and raises the upper pallet, and so on. There is certainly great ingenuity displayed in the contrivance and principle of this 'scapement, so far as regards the keeping up the balance to a constant arc of vibration, and making it, as it were, totally independent of any inequality or irregularity that might arise from the mainspring and pitching of the wheels. Those time-keepers, with this 'scapement, which were executed by Mudge himself, seem to have performed well; but notwithstanding this, they failed in the hands of others; and it must be allowed, that the 'scapement is too complex and operose for the execution of any artist.

## PLATE CCCI.

Figs. 1, 2. Represent a Clock 'Scapement by Mr Thomas Reid.

Figs. 3, 4, 5. Represent another Clock 'Scapement by Mr Reid.

Figs. 6, 7, 8. Represent Harrison's Clock 'Scapement without oil.

These Figures are fully described in Horology, p. 477, 478, 479.

## PLATE CCCII.

Fig. 1. Represents a general view of a Watch Movement, which is fully described in Horology, p. 482.

Fig. 2. Represents a Frame, containing a 'Scapement contrived by Huygens. The object of the inventor was to give great arcs of vibration to the balance, or rather to make it have a few revolutions. AB is the frame; CC, the balance, and *a a* its spiral spring. EE is the crown wheel, with its pinion placed in the frame where the contrate wheel is usually put, the teeth 'scaping with the verge *f e*. On the verge, as an axis, is put a contrate wheel DD, which is placed where the crown wheel and pinion are commonly put, the teeth of the wheel DD acting on a pinion *d*, whose arbor carries the balance CC. The action of the pallets *f*, *e* upon the crown wheel EE, will cause a considerable portion of the wheel DD to turn, and consequently to give a few revolutions to the pinion, which will depend in some degree on the number of its leaves. This

sort of 'scapement is called by the French artists, *échappement à pirouette*.

Fig. 3. Is a perspective view of the Horizontal or Cylinder 'Scapement of Graham, which has been long and successfully used in pocket watches. F with its pinion is the 'scapement or balance wheel, the teeth of which are shaped like a wedge or inclined plane, as seen at *a*, *b*, *c*, and act on the edges of an opening made in a cannon A of steel well hardened, which is called the cylinder. Copper plugs are put in at each end of the cannon, and in these are inserted pieces of well tempered steel, from the ends of which the pivots 1, 2, of the balance B are formed. The balance is rivetted on the upper copper plug. The inclined planes of the teeth in the cylinder 'scapement are made on the wheel to facilitate the extent of the vibrations of the balance, which can describe a whole revolution nearly. Therefore, the inner diameter of the cylinder being equal to the length of a tooth, can be made to turn round the tooth nearly a whole turn; and as the cylinder is concentric with its pivots, the wheel, remains at rest during the time that the point of a tooth is stayed, or dwells on the cylinder, whether it is on the inside or outside of it.

Fig. 4. Contains two views of Debaufre's 'Scapement. WW is a front view of the balance wheels, which are seen edgewise in the other view. AB is the balance, on the verge or axis of which, CD, is put the pallet E; the flat end or base of which is uppermost, and is a little more than a semicircle, having a flanch made below and opposite to it. The body of the pallet behind the flanch is rounded down, and narrowed conically towards the lowest end of the flanch, which is here not a point, but in form a little round, somewhat resembling the curve of an inverted parabola. When a tooth of any of the two wheels passes down on the flanch, this gives impulse to the balance, causing it to turn or give a vibration. The tooth having escaped the flanch, a tooth of the other wheel falls on the semicircular base of the pallet, where it remains at rest during the going and returning of the balance, when this tooth in its turn gets on the flanch, and gives impulse to the balance in a direction opposite to that given by the teeth of the other wheel, and so on.

Fig. 5. Represents a 'Scapement by the Abbé Houtefeuille. The teeth of the wheel A are made to 'scape with the pallets B, which have somewhat of the anchor or recoiling form. On the same arbor with the pallets is fixed a rack or small portion of a toothed circle *b*, the teeth of which work or pitch into a small pinion *a*, not properly seen in the Figure. On the arbor of this pinion the balance CD is rivetted; the teeth of the 'scapement wheel urging the pallets, first on one side and then on the other, gives a small circular motion to the rack backward and forward, which makes the pinion and balance to have one, two or more turns likewise backward and forward; the turns are according to the radius of the rack and number of leaves in the pinion. In the drawing, the balance wheel and balance seem as if they were on the same arbor and centre, with the design of having the figure more compact. The middle of the small dark circular space near E may be considered as the place for the pinion or balance arbor; and the dark arm from the pallets that of the rack whose teeth work into the pinion. The faces, or acting parts of the pallets, are in general set with some fine hard stone, such as ruby or sapphire.

Fig. 6. Represents Dutertre's 'Scapement for a Watch. The toothed wheels, or balances A and B, are of equal diameter and pitch with one another. They are placed outside of the upper plate, as well as the double ratchet, consisting each of five teeth; the arbors on which these are fixed are supported each by a cock. The pallets D and E are fixed on an arm of their respective balances, and the arbors of the balances have each a notch in them to allow the teeth of the great ratchet to pass through them. They act in this way. When the point of a tooth of the great ratchet meets with the notch in the arbor of the balance B, it passes. The tooth 3 of the small ratchet strikes the pallet D, and makes the balances to vibrate. On the tooth 3 escaping, the tooth 4 of the great ratchet is detained by the arbor of the balance A; the return of the balance causes the notch to present itself to the tooth 4; it then passes, and the tooth 3 comes and strikes on the pallet E. After having escaped the point 5 is detained by the arbor of the balance B, and so on successively. Under one of the balances B is placed the spiral. These balances cannot vibrate without the spiral spring.

Fig. 7. Represents Dutertre's clock 'scapement. AB is the wheel of *arréte*, or repose; CD the wheel of impulse; both having the same number of teeth, but differing greatly in their diameters. E is the pallet seen on its arbor, in which is a notch to allow the teeth of the wheel of *arréte* to pass; at the instant of this taking place, the teeth of the lesser wheel give impulse to the pallet, and having escaped it, a tooth of the larger wheel falls on the circular part of the pallet arbor. See Horology, p. 487.

Fig. 8. Is the Duplex 'Scapement, of late much used in watches, the principle of which is obviously the same as that of Fig. 7. as a slight inspection of the Figures will show. WW is the balance-wheel, the long teeth of which serve as a wheel of repose, or *arréte*, which takes place at the time of their coming on to a very small ruby cylinder, fixed on the lower part of the pallet arbor. On this wheel, the teeth of impulse are formed, and stand a little up from the plane of it. A section of them is seen at the letters *a*, *b*, *c*. That of *a* may be supposed impelling the pallet AB, one of the teeth of the wheel of *arréte* having previously left the small ruby cylinder, which is represented by the dotted broken circle under the pallet AB, both of which as well as the balance, are on the same arbor. For a farther description of this 'scapement, see Horology, p. 488.

Fig. 9. Is a kind of perspective view of the 'Scapement known to workmen *formerly* by the name of that with the tumbling pallets. WW is the common crown wheel, and A, B, two semi-cylindrical pallets, formed on the verge or axis of the balance. For other particulars regarding it, see Horology, p. 488.

## PLATE CCCIII.

Fig. 1. Contains two views of what has been called Kendal's 'Scapement; one of which may be properly so called, as being an alteration of that of the crown-wheel and verge with semi-cylindrical pallets. The crown-wheel of the first is represented at AB, and a plan of it is seen at CD. *t* may be supposed to give a view of both the pallets; the light part be-

ing the upper pallet ; and the shaded, or dark part, the lower one. The action of the teeth and pallets of this 'scapement is the same as that of the tumbling pallets, or semi-cylindrical verge. When a tooth has escaped from the upper pallet, that on the opposite side of the wheel falls on the cylindrical part of the pallet below, and does not get on the face or flat part of it until the going and returning of the vibration of the balance; at the instant when the tooth gets on the face, it gives impulse to the lower pallet ; and so on. Mr Kendal, as has been formerly mentioned, put two crown-wheels on the same pinion arbor, and used one pallet only. A part of the wheels *w*, *w*, and the pallet *p p*, are seen at Fig. 1. The wheel on the right side of the pallet is represented as just on the escape from the flat part of the pallet. This being made, the other wheel has a tooth which falls on the circular part, where it rests until the return of the balance from that side, to which the tooth of the right hand wheel gave impulse ; then the wheel on the left will give impulse in its turn on the face of the same pallet ; and so on.

Fig. 2. Represents the Detached 'Scapement as made by the late Mr Arnold, and by his son the present Mr Arnold, for box chronometers. The 'scapement or balance-wheel A having 12 teeth, is calculated to have a train of 14,400; and by the seconds hand, half of a second will be marked at every step by it on the seconds circle on the dial. The acting part, or face of the tooth, is partly in the form of a cycloidal curve, and stands above the plane of the wheel, as represented in the edge view given of it; in the plan, the shaded or dark part of the tooth may be supposed either the upper end or top, or a section of it; the other two sides are flat, or bounded by right lines, the longest of which, with the cycloidal curve, form an angle ; and on this angle the wheel is locked by the spring detent CD, in which is set a small bit of fine stone, either of ruby or sapphire, for the purpose of the wheel being locked on it. This bit of stone may be supposed to be put into the spring detent, so as to stand near the point of the adjusting screw *b*, or nearly where the letter *a* is. It is by the screw *b* that the detent piece can be made to have more or less hold of the angle on the tooth. The end of the detent stone piece must be of such a length or height as to be quite free from the inside bottom of the wheel. R, is the main pallet or roller, having an opening or notch in it, the lower end of which being what is called the face of the pallet, in which is set a piece of precious stone, as seen at *c*. It is on it that the curved part of the tooth acts. As represented in the Figure, the tooth 1 has carried the pallet so far on, by a distance equal to that between tooth 2 and the point of the adjusting screw. Concentric with the main pallet R is a small lifting pallet *d*, whose use is to unlock the wheel, by pressing on the side end of the lifting spring D, and carrying it so far inwards, takes the detent and its spring along with it; the detent piece of stone by this means getting free of the angle of the tooth at *a*, the wheel gets forward, and the tooth 1 gives impulse to the main pallet R. During the first part of the impulse, and before the impelling tooth gets so far on as is here represented, or it may not take place till the tooth gets a little farther on, the end of the lifting spring parts with the lifting pallet *d*, leaving the detent and its spring at liberty; the detent then, by means of its spring, comes quickly to its place at *a*, and before tooth 1 has escaped, is ready to receive tooth 3, and lock it. On the balance returning from the vibration given by this impulse, the pallet *d*, meeting with the end of the delicate lifting spring, carries it so far outwards, and then parts with it, to complete its vibration on this side. It is evident that the point of the adjusting screw opposes the detent being carried that way, although the lifting spring is, and is at the same time connected with the detent spring, but extends so far beyond the end of the detent spring, that the lifting pallet *d*, whether going or returning, cannot touch it, but cannot pass either way without meeting with the side ends of the lifting spring, and working on it. The detent spring is screwed to one of the frame plates by the paume or sole, near to which it is made very thin and weak ; and at this place the centre of motion of the detent piece may be supposed to lie. The lifting spring is pinned by one end to the side of the detent spring, which may be called the outside of it. It is easy to perceive that the unlocking is made by carrying the detent spring inwards, or towards the centre of the wheel. When this takes place, the cycloidal part of the tooth falls (not on the point, but a little within it,) on the blunted edge, or nearly so, of the face of the pallet; having given impulse, and escaping, the wheel is again locked ; and so on. The wheel is unlocked at every alternate vibration of the balance, or 7200 times in an hour, or 120 times in a minute; hence half seconds are marked out on the dial by the seconds hand. The diameter of the main pallet R may be made at the option of the 'scapement maker, in any proportion to that of the wheel, but it must always stand, when the wheel is locked, free between the teeth; and the impulse given by the wheel to it will be so much more direct, the less the difference of the diameters. And in this experience is the best test; but it requires long and reiterated trials.

Fig. 3. Shews the Detached 'Scapement made by Mr Earnshaw for his box chronometers. The balance wheel ABCD is plain or flat, made of steel and sometimes of brass, the teeth have somewhat of the ratchet form, and are considerably undercut on the face, the number of teeth in it being 12, and calculated so as to give half seconds by the steps of the seconds hand on the seconds circle, in the same way as we have mentioned in Arnold's. The steel roller or main pallet MSK has an opening in it, the face of which is also much undercut, having a piece of some fine stone, such as hard ruby or sapphire set into it, as seen at *l h*, for the purpose of making the points of the teeth work smoothly on it, and preventing any wearing from their constant action. A stud G is fixed to the potence plate ; and to this stud the detent spring FF is screwed, and made very slender and weak near the stud. It is by the yielding at this place that any motion can be given to the detent on which the wheel is locked ; and here is its centre of motion. The tooth D of the wheel is supposed to be locked on a flat side of the stone detent, which is fixed in a thick part of the detent spring, by means of which it presses against the inside of the head of the adjusting screw *m*, which works in a fixed stud *a* P, so that when it is screwed into this stud the detent will have less hold of the tooth, and *vice versa*. Y is a delicate spring attached to the

inner side of the detent spring, and which is called the lifting spring. The end of the detent spring is bent a very little, so that the free end of the lifting spring may bear only on the inward bent point at *o*. Concentric with the main pallet is the small lifting pallet *u*, which is flat on the face or lifting side, and tapered or rounded off on the opposite side. Its position in the Figure represents it coming with its face against the lifting spring, which it would carry away with it; but this cannot have place without taking along with it the detent spring, and consequently the detent is carried out from locking a tooth of the wheel at D. By this time the main pallet has got so far forward as to be in the way of receiving impulse from the tooth B, and before it can escape, the lifting pallet parts with the end of the lifting spring, and leaves the detent and detent spring immediately to resume their place. The detent will then be ready to receive the tooth C, by which the wheel is again locked. The balance having performed this vibration by the impulse given, returns, and with it the lifting pallet *u*, the tapered side of which will press the lifting spring inwards, but cannot carry the detent spring with it, this being prevented by the inside part of the head of the adjusting screw *m*; after passing the lifting spring, it goes along with the vibration of the balance, on whose return the face of it will again meet with the lifting spring; unlocking then takes place, and so on. The unlocking here is performed by carrying the detent outward from the centre of the wheel, which is locked by the extreme points of the teeth. Mr Earnshaw gives as a rule for making the inclination of the faces of the teeth and main pallet, that they should be in a line drawn from the points of the teeth as a tangent to a circle, whose diameter is half of that of the wheel; and the same rule is used for the face of the pallet, which is shewn by the dotted lines and circle in the figure. As the detent stone piece on which the tooth D is locked, being set into that side of the detent spring lying undermost in the Figure, it cannot therefore be well represented here. The points or dots at the letters *k* and *a*, shew the relative positions of being locked and unlocked. The flat part of the stone detent goes a very little way in, as at *k*, to receive the point of the tooth A, on the opposite side of the wheel when locking is supposed; and at unlocking, the dot at *a* may be supposed to be the utmost extent of the detent, when carried out by the detent and lifting springs at that time. The detent spring lies above, and clear of the wheel; and the detent stone piece may be either a semi-cylinder or an angular piece. A flat side is, however, in either way, requisite for the tooth of the wheel to lock on it; and the height or length of this stone should be a little below the under side of the wheel, so that the teeth may at all times have a sure hold on it. Mr Earnshaw has stated, that he makes the diameter of his roller or pallet larger than that of Arnold's, which will no doubt allow the teeth of the wheel to give a more direct impulse on it; the diameter of the roller, however, if carried too far, would lessen the hold of the teeth on the pallet. Where a wheel of 12 teeth is used, it will give scope for getting in a pallet of considerable length. If the drawings in the specifications are correct, the proportion between the diameter of the balance-wheel and of the roller seems to be the same, or nearly the same, in Arnold's and Earnshaw's 'scapements.

Fig. 4. Is a contrivance of Mr Owen Robinson's, for a detached or free 'scapement, where the unlocking should be easier effected than it is done, either in Arnold's or Earnshaw's. AB, AB is a view of the balance wheel, both in plan and edgewise, being somewhat similar to the wheel in the duplex 'scapement, that is, the upright teeth are those which give impulse to the pallet, while the long teeth in the plane of the wheel are those which lock on the detent; R is the roller or pallet, the acting face of which may be supposed to have a piece of fine stone inserted there, as in the two former 'scapements; *d s*, the detent spring screwed to the potence plate, and made rather weaker at a place between *s* and the sole than any where else. It is at this place only where it will readily bend or yield, which becomes, as it were, a centre of motion to the detent. At the thick part *d* the stone for the detent is inserted; the white part at *d* may be supposed the upper end of it, and a tooth of the wheel locked on the flat side next the centre of the roller; *l l* is the lifting spring attached to the inside of the detent spring. A part of both these springs lying under the roller cannot properly be represented. The extreme or free end of the lifting spring goes a little beyond that of the detent spring, so that the lifting pallet can never pass without touching it, but while passing, it never can touch the end of the detent spring: The lifting pallet is not easily seen, but is of the same form as that in Fig. 3. where the adjusting screw and stud is the same as may be supposed for Fig. 4. although not drawn there. The face of the lifting pallet is just on the eve of touching the lifting spring; carrying it on a little way would unlock the wheel, and the pallet face being brought to a part where its edge, as seen in the Figure, would be ready to receive impulse from one of the upright teeth. The action of this 'scapement is quite the same as that of the others; the great difference of radius in the diameter of the wheel of impulse, and of the locking wheel, causes this to press with less force on the detent than those which have been mentioned; the unlocking is outwards, or receding from the extremity of the points of the teeth; and when locked, the roller stands free between the teeth of impulse.

Fig. 5. Is a view of a free or detached 'scapement, contrived by Mr Mudge, and which may be said to be the first of the kind where any ingenuity was displayed, or from which any utility was derived. It gives impulse at each vibration, whereas those which have been described give an impulse at alternate vibrations. The 'scapement, or balance wheel AB, and pallets *a*, are nearly like those in Graham's dead beat 'scapement. When the point of the tooth escapes the flanch of the right hand pallet, the point of another tooth is ready to fall on the outside circular part of the left hand pallet, just within the edge formed by the flanch and circular part; here it rests during the going and returning part of the vibration of the balance from the impulse received or given. Fixed on the same arbor with the pallets is a long arm, on the end of which, and near to the arbor of the balance, a forked piece is put or fixed, between the prongs of which a small pallet works; this pallet being on the

axis or arbor of the balance, returns with it, and getting within the prongs, carries the right hand one a little more to that side, this setting the main pallet on the left hand away from its state of rest, and being carried a little more to the same side, by which the wheel is unlocked getting forward, it gives impulse by the tooth that had just now been reposing from its action on the flanch of the pallet, and which is communicated to the small pallet by the left hand prong impelling it on the opposite side to that by which it unlocked the wheel. After the tooth has escaped from the main *pallet* on the left hand, another tooth will fall on the inside circular part of the right hand one, and repose there until the return of the balance from its course of vibration, when the unlocking of the wheel again takes place, by the small pallet carrying away to a side the prong on the left; that on the right following, gives new impulse on the small pallet, by the force of the wheel tooth on the flanch of the main pallet on the right hand, and so on. In order that no external or any sort of motion shall make the main pallets recede from their state of rest, which might happen, and would derange the 'scapement if there was no provision made against accidents of this sort, a small roller, having a notch in the edge of it, is fixed on the arbor of the balance, and a pin on the long arm from the pallets remains on the outside of the roller during the time of rest by the wheel teeth; the edge of the roller prevents by this means the unlocking, until the return of the small pallet; and to prevent the pin getting away in an opposite direction, two pins in the potence plate limit the excursions *that way*, by confining the long arm connected with the main pallets: when they are in their relative situation to the pin outside of the roller, these pins are represented white, and seen near the end of the arm; the fork, and the parts of action connected with it, are seen at *b*. When the balance vibrates freely and independently of every part, it is at the time when the teeth rest on the circular part of the pallets either inside or outside. The arm in this drawing is rather longer than in the original drawing of Mudge's, and was taken from a 'scapement of this sort in a watch made by Emery for the late M. le President Sarron in France, which is said to have performed extremely well. The spiral and stud, shewn by dotted lines, will easily be recognised as the pendulum or balance spring, whose inner end is fixed to the axis of the balance, and the outer end to the stud.

Fig. 6. Shews the wheels and pallet of Mr Kendal's 'scapement, which the late Mr Howells made into a detached one. AB, AB are two crown wheels, fixed on *p*, *p*, the balance-wheel pinion arbor; the pallet is a semi-cylindric one, to a collet on the axis of which the balance RR is rivetted; *h* is the axis or centre of motion to the long forked arm, and its counterpoise the lowest *d*; the highest *d* is a detent on both sides of the arm; the two screws *b b*, are screwed into fixed studs, (not represented here) for adjusting the quantity of holding of the teeth on the detents *d* of the long arm, which has a fork and pin at the end of it. On the lower end of the arbor of the balance is fixed a notched roller, and an unlocking or locking pallet, for it serves both purposes, which gets occasionally for this purpose between the prongs of the fork, and the pin gets either at one edge or other of the roller, passing the notch with it; the screws *b*, *b*, serve not only as adjusting screws for the detents, but also as a sort of banking, as it may technically be called, to keep them in their places of locking. For example, the outer arm in the Figure is close by the screw on the right hand, and the pin at the end of the other arm is at the same time on the left edge of the roller; the wheel AB on the left being now locked, the arms cannot turn either way on the pivots of the axis at *h*, until the return of the balance, and with it the unlocking pallet, as at this time it may be so called, which, getting in between the prongs of the fork, carries away the arm and detent *d* from the locking of the wheel; so soon as the tooth has escaped the detent, the semicylindric pallet by this time is in the way of being impelled by a tooth of the wheel on the right; and before the tooth has escaped from the pallet, one of the detents *d* is in the way ready to receive, and lock a tooth of the wheel on the right hand; the arm going in between the wheels, locks those teeth at a place which stands nearly at right angles to those which give impulse to the pallet. During the time the wheels are locked, either on the one detent or the other, the balance vibrates freely from any thing that could impede its motion, and it gets an impulse at every vibration. The sole use of the fork here, is for leading the detents to lock or to unlock the wheels, no impulse being given by it to the pallet which works between the prongs, as was the case with the fork in Mudge's 'scapement. The impulse given by the teeth of the wheels here is very direct, and of course with little friction, and this will depend on the distance of the tops of the teeth of the wheels from each other, which determines the diameter or face of the semicylindric pallet. Indeed it is of little consequence here whether the face of the pallet has a semicylinder behind it or not, which, in Kendal's way, was absolutely necessary; it may, however, as well be semicylindrical as otherwise. From what has been said here, and in our article Horology, p. 134, we hope the nature of this detached 'scapement, and the manner of its action, will be understood.

## PLATE CCCIV.

Fig. 1. Is a perspective view of the balance, the compensation and other parts connected with it, in M. P. Le Roy's marine timekeeper, tried by order of the King of France, in a voyage on board the Lively frigate, in the year 1768. From its good performance, a prize was awarded to him by the Royal Academy of Sciences. The balance or regulator *v v v v* of this timekeeper was steel: It was four inches in diameter, weighed five ounces, and was fixed on an arbor AA, about five inches long. A brass frame or mounting *x x x x x*, to which the movement is fixed, keeps the balance horizontally suspended by the upper end of its arbor, by means of F, a very fine harpsichord wire, to which it is attached; the length of the wire is three inches or so, forming one vertical right line with the axis. The movement cannot well be seen here, being behind the upper part of the brass mounting; the dark shade is part of the dial. The timekeeper goes 38 hours, and has no equalizing for the mainspring by means of a fusee. The ba-

lance-wheel is a star of six radii or teeth, and extremely light; it gives impulse to a pallet on the upper side of the rim of the balance at every alternate vibration; and the 'scapement is a free or detached one. In order that the balance may turn freely on its axis, each of its pivots is retained with proper play, between four rollers turning freely in two small frames *c c*, *c c*, one for the lower pivot, fixed to the under part of the brass mounting; the upper pivot runs in the uppermost frame, fixed to the brass mounting also, at a little distance from the lower end of the harpsichord, or suspending wire. The whole is arranged with the necessary precautions, so that the wire and the axis of the balance may form always one vertical right line. The balance thus suspended would make vibrations, each of which would take about twenty seconds of time, by means of the elasticity of the wire of suspension. Two spiral springs *s s*, *s s*, like those which serve as main-springs to common watches, are adjusted to the lower end of the balance arbor, by means of their collets or virrels, like what the spiral or pendulum springs have in ordinary watches, and are placed opposite each other in a centre of equilibrium absolutely at rest, so as to cause the vibrations to be made in half a second. The sliding cocks *d d*, serve to adjust to any position the pendulum springs, whose outer ends are fixed to these cocks. To regulate the timekeeper, there is placed near to the lower end of the balance-arbor, a small plain circular crossed wheel G G; on the upper side of which, and diametrically opposite, two studs are fixed, through which the two screws *z* G, *z* G pass, in such a manner that turning them by the hand will make them come equally nearer or farther from the arbor. These screws, by their mass, which can be diminished at pleasure, according to the exigency of the case, can be made to describe a great space, and allow the machine to be regulated in the nicest manner. If the effects of heat and cold were of short duration, the inconveniences that have been exposed might be neglected; but as the machine may be placed so as to undergo such trials of temperature for six months at a time, it is obvious that the vibrations of different extent of the regulator, having then no longer the isochronism required, the causes which might be able to vary the largeness of the vibrations, would considerably alter the regularity of the time keeper. "Convinced of the principle," says Le Roy, "that I have just established to compensate the effect of different temperatures on my machine, I took quite a new way. I adapted to the balance several small bars of brass and steel, disposed in such a manner, that by their lengthening in heat, or shortening in cold, they brought nearer to or farther from its centre, two considerable parts of its mass, placed each at the extremity of a lever, and diametrically opposite.* By the calculation which I had made of it, it appeared that the whole mass of the balance approached to or receded from the centre of the balance about one thirteenth of a line, to compensate a variation in heat, which would have produced one second out of fifteen in an hour in the going of the watch. The inconvenience of the preceding method made me soon give it up; the play of the levers or bars, and the want of solidity of the balance, produced errors greater than those which I wanted to compensate; this made me have recourse to a method, which afterwards answered my utmost expectations. It consists in the application to the balance of two small thermometers *t t t t*, *t t t t* made each of a glass tube, bent, and open at one end, and having a ball at the other. These thermometers, composed of mercury and spirit of wine, would have formed each an exact parallelogram, if the upper side which carries the ball wherein the spirit of wine is contained, and partly on this side of it, had not been a little inclined. Both these thermometers are adjusted firmly to the axis of the balance, and in opposition to each other, in such a manner, that the axis of their tubes and that of the balance meet in the same plane which intersects the balls in the middle. It must be understood, previous to explaining this compensation, that the mercury fills the lower side of the tube, and about half way up the side parts of it. It will easily be conceived how this construction produces the compensation required. The thermometers, making part of the regulator or balance, when the spirit of wine by its expansion pushes a part of the mercury of the outward branch of the tube *t t* towards that which is near the axis of motion, a portion of mercury, as part of the mass of the regulator, passes then from its circumference towards its centre. At the mean of temperature, for example, the mercury occupies the tubes half way up in each side, whereas in extreme cold, when the thermometer of Reaumur is 15°, or that of Fahrenheit is 33.75° below the freezing point or —1.75°, the outward branch of the tube is filled with mercury, whilst its inward corresponding branch is empty. And as the mass of the balance resists, in the ratio of the square of its distance from the centre, there evidently follows from this a compensation. If the chronometer goes slow, from a loss in the elasticity of the springs, and from the expansion of the balance by too great a heat, it is compensated by less weight or mass at the circumference of the regulator; and, *vice versa*, in the passage to cold, this effect is so much the more sure, as there is no shake or play to be apprehended here; besides, the expansion of spirit of wine by heat, and its contraction by cold, are constant effects, as has been found by experience with thermometers of this liquor, which had lost nothing of their exactness at the end of thirty years. From the calculation made for these thermometers, it was found necessary to have them in the form represented here, by bringing the balls near to the centre of the balance, in order to diminish that resistance of the air to its motion, which it would have experienced had the balls been placed at or near the circumference.

Fig. 2. and 3. Are two views of Berthoud's different modes of compensation for correcting the effects of heat and cold on the going of his watches, and of his marine time-keepers. In one of them, Fig. 2. BB is the upper or potence plate, and 1, 2, 3, and 4, the ends or pivots formed on the pillar tops, by which the potence plate is pinned down with the pillar plate. CC is the balance. DE is the cock for supporting the balance, and for the arbor which

* This method, or something like it, was once used by the late Arnold, which is the same nearly as has been noticed in our article Horology, p. 493.

carries a double arm *a b*, on one end of which at *a* are the curb pins; the sole D is screwed to the potence plate; the small cock E screwed to the main one DE, and is that which carries one of the pivots of the arbor of the arm for the curb pins, the other pivot running in the main cock a quarter of an inch below the cock E. The arbor for the arm of the curb pins is hollow, and through it the balance arbor comes, the upper pivot of which runs in a jewelled hole in E, and the end supported by a diamond piece, which will be the lower end when the watch is in its case and the dial uppermost. GH is a potence or bridge screwed to the plate, having chops at H to receive one end of the compound bar of brass and steel, the other end has a thick part to receive the adjusting screw *c*, acting on the shorter arm *b*. A very delicate spring is screwed to the plate at lower *d*, serving to press the arm *b* against the end of the screw *c*, which is in a thick part of the compound bar; screwing it in will, by bringing the arm *a* with the curb pins to a greater distance from the small stud, make the watch go faster, and *vice versa*. The brass part of the compound bar of brass and steel is on the left hand, (the steel being on the right hand side,) will expand with some degree of heat, and become a little convex outside, bending as it were, and causing the screw *c* to press the arm *b* a little to the right, which would make the watch go fast, and the same degree of heat will weaken the powers of the pendulum spring; but these are compensated by the motion of the compound bar of brass and steel. An opposite degree of temperature would make the brass to contract, the motion of the screw would then be the reverse, and the curb pins would approach nearer to the small stud, and give a greater length beyond the curb pins for the action of the pendulum spring, to counteract the effects of cold on it. The compensation bar can be made to act with more or less effect according as it is moved in the chops H, where there is a screw for fixing it at whatever distance the screw *c* may be brought from the centre of the balance. It is obvious that the nearer it is to this centre, the greater will be the effect of any motion given to the arm *b*, and *vice versa*. It is by the screw *c* that the watch is regulated to mean time.

Fig. 3. Is another contrivance adopted by Berthoud, the compensation being on the balance itself. B is the circle of the balance, on the plane of which, and inside of it a contrate rim is formed or raised up, for the purpose of fixing to it at *a*, *b*, and *c*, the ends of the compound blades or laminæ of brass and steel *e d*, *e d*, *e d*; the ends of the blades are fixed by screws at *e* to the parts *a*, *b*, *c*, of the contrate rim reserved for this purpose, the rest of the rim being taken away. The free ends of the blades carry the masses of compensation C, D, E. These masses are fixed to the blades each by a screw and two steady pins. By this disposition of the balance, when the masses have a proper weight for regulating the watch, the balance being in equilibrium, if the compound blades are well executed, the balance will preserve this state of equilibrium, although the masses recede or come nearer the centre of the balance by the effect of different temperatures, making the equilibrium of such a regulator as invariable as if the balance was a simple one. The circle of the balance carries three small masses *d*, *d*, *d*, which are destined to regulate the machine to the nearest time, by giving them more or less weight. The blades or laminæ of steel and brass, which are either pinned, soldered, or melted together, have the brass outwards: Hence if we suppose any degree of heat that is greater than the medium temperature takes place, it will weaken the elasticity of the pendulum spring, and make the machine to go slow; but the same cause will operate on the laminæ of brass and steel, but with greater effect on the brass one, which will make it bend as it were inward, and force the laminæ of steel with it, and the masses C, D, E being also carried inward, will compensate the effects of heat on the pendulum spring, by their less resistance to motion, as well as by the effect of their gravity being lessened; when an opposite degree of temperature takes place, the masses will be carried outwards, and the same cause will strengthen the elasticity of the pendulum spring; hence the compensation will keep pace with the changes of temperature.

Fig. 4. Represents Arnold's Compensation Balance, both in plan and edgewise. The circular part *a*, *b*, and the cross or diametrical arms are steel, as well as the parts carried beyond the circle, to the extremes of which the circular laminæ of brass and steel are fixed: It is into these parts also that the screws *d*, *d*, for adjusting the chronometer to mean time, turn, bringing them out making the chronometer go slow, and putting them in makes it go fast. On the circular part are three small masses of brass, one of which is seen at *a*, no letters of reference being to the other two; they can be made to slide back and forward on the circular ring *a*, *b*, and serve to adjust for positions. A part of the steel lamina is left a little thick at the outer end, which is tapped, to receive the masses of brass *c*, *c* which are screwed upon it; bringing them out gives a greater scope for the laminæ to have more effect in compensating, and screwing them farther home a less effect; the small screws *e*, *e* not only serve for this purpose, but also for more minutely altering the going to mean time. The lamina of brass being outward, and the steel one inward, the masses of brass *c*, *c* are carried out and in according to the change and degrees of temperature, compensating the effects of temperature on the pendulum spring, in the same way as we described it in Berthoud's balance.

Fig. 5. Represents a view in plan, and also an edgeview of the Compensation Balance by Earnshaw. It is composed of a bar or two steel arms, at the middle of which it is rivetted on the verge or balance-arbor; at the ends of these arms, a part is raised up to which the laminæ of brass and steel are fixed, or rather are made to proceed from; it is also in these ends that the screws *a*, *a* turn out or in, so as to adjust the chronometer to mean time; the compensation brass masses *d*, *b* have a groove turned in them, by which they can be made to slide farther or nearer the ends of the laminæ, when adjusting for compensation, and the masses can be fixed any where to the laminæ, by the small screws *c*, *c*. The steel part of this balance is formed by turning a thick and flat piece of steel outside, so as the diameter shall be that of the steel part of the compensation, and brass is melted on the turned edge of the steel to form the brass part; the steel being afterwards hollowed out, a contrate sort of rim is formed

from it as well as the brass, a great part of which is then taken away: The remainder, with the masses attached to the free ends, makes the compensation against the effects of heat and cold on the pendulum spring, acting in the same way as has been described for the other compensation balances. There is a facility in adjusting the compensation here, by the easy sliding of the masses, which cannot be obtained in Berthoud's balance, in consequence of his masses being fixed with steady pins as well as a screw. Arnold's screwing and spring-tight masses have, in some degree, the disadvantage also of Berthoud's method.

Fig. 6. Represents the Machinery for going in time of Winding, used in Huygen's Clock, and invented by that celebrated philosopher. See p. 759, col. 2. where it is already described.

Fig. 7. Represents a view of some wheels adapted for an Equation Clock, so as to make a hand representing the sun give solar time, while the minute hand gives mean time as in common. *m* is one of the minute wheels of 56 teeth, fixed to the minute pinion arbor, the upper pivot of which runs in the cock C screwed to the fore-plate of the clock frame, the lower pivot turns in a hole made inside of the bevelled wheel *c*, and in the end of its arbor the bevelled wheel *b*, of 38 teeth, and the flat wheel above it of the same number, have one common socket, and turn on the minute pinion arbor, independent of it and the minute wheel. The three bevelled wheels *b*, B, and *c*, are all of one number, and pitch with one another; the arbour of the wheel *c* turns in the cock A, screwed on to the inside of the pillar plate, and independent of the minute pinion arbor; the lower pivot of it runs in the cock K, screwed to the back of the pillar plate. The wheel W of 32 teeth is by its socket pinned fast with the arbor of the bevelled wheel *c*. W is the wheel which leads the toothed rack, the arbor of which at the opposite end carries the tail which bears on the elliptical plate, and this causes the variation necessary to show the equation of time. For farther particulars, the reader is referred to p. 497. of our article Horology.

Fig. 8, 9. AA is a view of the Month Wheel in the Equation Clock; AA, in Fig. 9. is a view of it seen edgewise; BB in both figures is a segment of a circle of three teeth, which is pumped up and down on the socket of the month wheel, by means of the fork, which takes hold of a round groove or pulley, seen near the lower end of the socket in Fig 9; the pillars *b*, *b*, fixed to C with the pulley, and to the segment BB, move up and down on the socket of the month wheel, and on the small ends of the pillars *a*, *a*, which are rivetted below to the month wheel; *d* is a kneed piece fixed to the month wheel also, a pin from which is that which in common shifts the day of the month ring; the teeth of the segment serve for this purpose when the month has 30 or 28 days. See p. 501 of Horology, for more particular information regarding the mechanism of shifting the day of the month.

## PLATE CCCV.

Fig. 1.—7. Represent a repeating Clock with an Anchor 'Scapement. For the description, see p. 504. of our article Horology.

## PLATE CCCVI.

Fig. 1.—9 Represent a repeating Watch with Grahame's Horizontal 'Scapement. See the description of it, p. 505. of our article Horology.

## PLATE CCCVII.

Fig. 1. Represents the Mercurial Pendulum improved by Reid.

Fig. 2. Gridiron Pendulum.

Fig. 3. Ellicott's Pendulum.

Fig. 4. Cumming's Improvement upon it.

Fig. 5. Smeaton's Compensation Pendulum.

Fig. 6. Reid's Compensation Pendulum with a zinc tube and steel rods.—We have said in Horology, p. 516, that the zinc tube pendulum had not easily the means of adjusting for compensation. This objection, however, has since been removed by the contriver of it. Let a brass socket be made, about three or four inches long, whose outside fits easily the inside of the zinc tube, and the inside of the socket fits easily the centre steel rod, at the lower end of it. Let two holes be put through the zinc tube, brass socket and steel rod, one of the holes being about one inch or so above the lower end of the tube, and the other hole two or two inches and a half above the lower end of the zinc tube, two pins being pretty well fitted to them. Should the compensation, after trial, be found rather defective, release or take away the pin in the uppermost hole; and should the pendulum be still found defective in its compensation, let the other pin be taken away, and the zinc tube will now be operating its compensation by means of both ends; in the case of the pins, this was effected by the length of the tube from a pin to the upper end of it. This is a very easy way of rectifying the compensation, and it may soon be brought to the greatest nicety. For this and other reasons we are of opinion, that it will be found to be the most complete and convenient of any compensation pendulum that has yet been applied to a clock.

Fig. 7. Reid's Compensation Pendulum with a glass tube.

Fig. 8. Apparatus for Ditto.

Fig. 9. Troughton's Tubular Pendulum.

Fig. 10. Ward's Pendulum.

Fig. 11. Reid's Pendulum with a Wooden Rod.

## PLATE CCCVIII.

Contains several Figures illustrative of the method of transferring tunes to the barrels of Musical Clocks.

## PLATE CCCIX.

*Modes of Grafting.*

Fig. 1. Tongue Grafting.

Fig. 2 Cleft Grafting. *a*, The graft placed in the cleft. *b*, The graft separate, to shew the wedge-shape of its extremity.

Fig. 3. Side Grafting.

Fig. 4. Inarching, or Grafting by Approach. *a*, The stock, placed in a flower pot, so as to be *approached* to another tree or shrub. *b*, The spring or branch of that other tree, to be engrafted on the stock.

Fig. 5. Budding, (figures of natural size.) *a*, The bud as cut from the tree. *b*, The bud dressed and ready

for being inserted. *c*, Transverse and longitudinal incision in the stock, for receiving the bud. *d*, The bud placed in the incision in the stock, and ready for being tied.

## PLATE CCCX.

*State of Hot-houses at Dalmeny Park.*

Fig. 1. Ground Plan. A, B, C, Peach-houses. D, Double Peach-house. E, F, G, Grape-houses. H. Mushroom-house.
Fig. 2. Elevation of the Suite.
Fig. 3. Section of the Grape-house.
Fig. 4. Section of the Mushroom-house H, and of the Peach-house A.
Fig. 5. Section of the double Peach-house A. *a*, *a*, *a*, in Figures 3, 4, and 5, shew the situation of the weights and pullies for moving the upper sashes.
Fig. 6. Cock, pipe, and director, for watering and washing the trees, &c. *a*, the brass cock ; *b b*, the leathern pipe ; *c*, the brass director.

## PLATE CCCXI.

*Pine-stoves designed by Mr Hay for Dalmeny Park Garden.*

Fig. 1. Ground Plan. A, First Succession-pit. B, Second Succession-pit. C, Fruiting-pit. DDD, Nursing-pit. *a a*, *c c*, Small openings for the passage of heated air. *b b*, *d d*, Openings for the same purpose, furnished with covered dampers.
Fig. 2. Elevation.
Fig. 3. Section (on an enlarged scale). The line *e f g h i* shews the declivity of the ground, *k* is a moveable gangway.

## PLATE CCCXII.

*Plan, Section, and Elevation of a Hot-house proposed by Sir George Mackenzie, Bart. the glazing being a segment of a sphere, &c.*

Fig. 1. Elevation of the Hot-house.
Fig. 2. Section.
Fig. 3. Ground Plan. A, A, A, &c. Sliding shutters in the low wall, to admit air. B, (in the section,) Shutters along the back wall, to open and shut on pivots with a cord, or in any other manner. There are also hatches in the roof. C, Half the plan of the glass cover, formed of hammered iron. *x x x x*, Iron rods for supports, if necessary. D, Half the plan, shewing the flue F going round to E, and out at the vase at top. G, Treillage for vines, with an opening in the centre to allow a person to pass. H, Iron astragals glazed.
Fig. 4. Section of a wrought iron rib for the glass frames, (full size.)

Since the engraving has been thrown off, Mr T. A. Knight has hit upon a very neat contrivance for obviating the inconvenience of the rapid contraction of the bars near the top. He proposes that every alternate pair of astragals shall be joined as in the annexed cut, when the contraction comes to be 6 or 5 inches. Thus the greatest possible quantity of light seems to be admitted by this form of hot-house.

Fig. 5. Blanching Pots for Sea-cale.
Fig. 6. Averuncator.
Fig. 7. Pruning Shears. *a*, Opposite side of the nail, with the groove in which the nail moves, by which means the cutting blade makes a *drawing* cut.

## PLATE CCCXIII. No. 1.

Fig. 1. Represents the earlier form of the Clepsydræ or Water Clocks.
Fig. 2. Is another Clepsydra of a more ingenious construction.
Fig. 3, and 4. Represent the Clepsydra invented by Ctesibius.

## PLATE CCCXIII. No. 2.

Contains various Diagrams illustrative of the principles of Hydrostatics.

## PLATE CCCXIV.

Fig. 1. Represents Fahrenheit's Hydrometer
Fig. 2. Deparcieux's Hydrometer.
Fig. 3. Jones' Hydrometer.
Fig. 4. Nicholson's Hydrometer.
Fig. 5. Mr Adie's Statical Hydrometer.
Fig. 6. Dr Brewster's Capillary Hydrometer
Fig. 8, and 9. The Hydrostatic Balance.

## PLATE CCCXV.

Contains several Diagrams illustrative of the Doctrines relative to the Equilibrium and Stability of Floating Bodies.

## PLATE CCCXVI.

Contains Diagrams illustrative of the Doctrines of Capillary Attraction.
Fig. 3. Represents Gay Lussac's Instrument for measuring the ascent of Fluids in Capillary Tubes.

## PLATE CCCXVII.

Figs. 1, 2. Represent the Hydrostatic Paradox.
Figs. 3, 4, 5. Hydrostatic Bellows.
Fig. 6. Shews an Experiment for illustrating the quaquaversus pressure of Fluids.
Fig. 7. Is the Experiment of the Cartesian Devil.
Fig. 8. Apparatus for illustrating the Doctrine of Specific Gravities.
Fig. 9. Dr Hooke's Semicylindrical Counterpoise.
Fig. 10. The Common Syphon.
Fig. 11. An improved Syphon.
Fig. 12. Explains the Phenomena of reciprocating Springs.
Fig. 13. Represents a Vessel from which the Water escapes when it reaches a certain height.
Fig. 14. Is a Vessel which retains water when it is upright, but discharges it when it is inclined.
Fig. 15. Is another Vessel for the same purpose.
Fig. 16. Is a Machine in which all the water thrown into a basin from a jet d'eau appears to be drank by a bird.

## PLATE CCCXVIII.

Contains Diagrams illustrative of the Theory of Hydraulics, and of the Experiments of Bossut, Venturi, &c.

## PLATE CCCXIX.

Figs. 1—8. Are illustrative of Bossut's Experiments on the Motion of Fluids.
Fig. 9. Illustrates the Doctrine of the Resistance of Fluids.
Fig. 10. Is Bossut's Apparatus for measuring the Resistance of Prows.
Fig. 11. Is the Apparatus employed by Coulomb for measuring the Resistance of Fluids by the principle of Torsion.
Figs. 12, 13. Illustrate the Doctrine of the Oscillation of Fluids.
Fig. 14. Illustrates the Doctrine of the Undulation of Waves.
Fig. 15. Represents the common Overshot Water Wheel.
Fig. 16. Shews the form of the Buckets recommended by Dr Robison.
Figs. 17, and 18. Explain the advantages of a new form of the Buckets.
Fig. 19. Represents the Double Buckets invented by Mr Burns.

## PLATE CCCXX.

Fig. 1, and 2. Represent two Overshot Wheels as constructed by Smeaton.
Fig. 3. Is an improved Overshot Wheel with a new Regulating Shuttle.
Figs. 4, and 5. Shew an Overshot Wheel without an axle, invented by the late Mr Burns.
Fig. 6. Is a Double Bucket Wheel.
Fig. 7. The common Undershot Wheel.
Fig. 8. Proper form of the Mill Course.
Fig. 9. A Horizontal Water Wheel, with inclined Floatboards.
Figs. 10, 11. Represent a horizontal Wheel with concave Floatboards.
Figs. 12, 13. Is another horizontal Tide Wheel, invented by Mr Robert Leslie.

## PLATE CCCXXI.

Fig. 1. Represents Smeaton's Breast Wheel.
Fig. 2. Improved Breast Wheel.
Fig. 3. Dr Barker's Mill, moved by the reaction of water.
Fig. 4. Improvement on Barker's Mill by M. Mathon de la Cour.
Figs. 5, 6, 7, and 8. Represent the Sluice Governor for regulating the admission of water upon water wheels.

## PLATE CCCXXII.

Fig. 1. Represents Archimedes's Screw for raising Water.
Fig. 2. Represents the same Engine, as erected at the Hurlet Works near Paisley.
Fig. 3. Represents a Section of Double Screw Engine invented by M. Pattu.
Figs. 4, 5, and 6. Shew different modes of applying it for different purposes.
Fig. 7. Shews the Form of Archimedes's Screw, as recommended by Daniel Bernoulli.

## PLATE CCCXXIII.

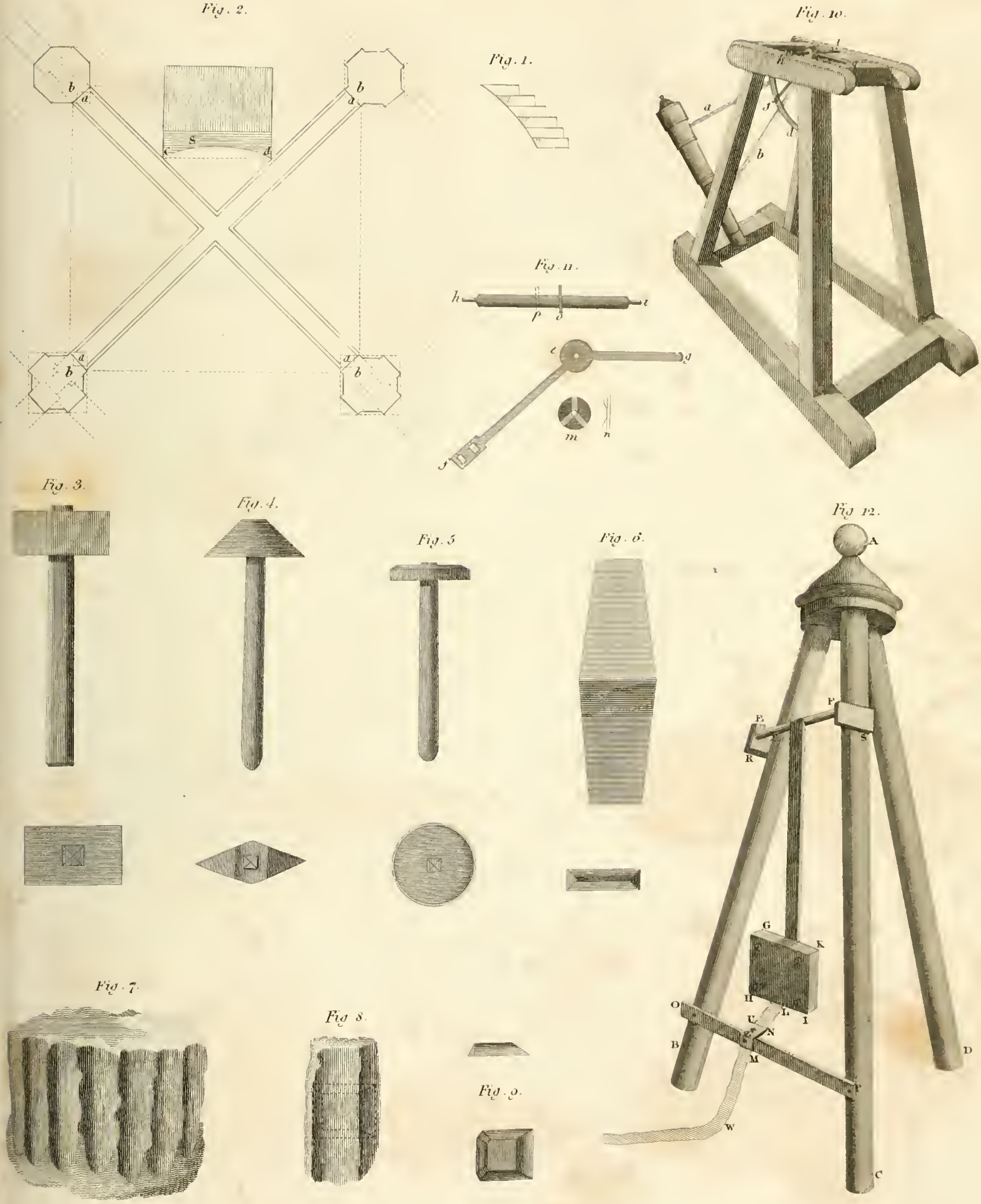
Fig. 1. Shews the Spiral Pump, or Zurich Machine.
Fig. 2. Represents the Form given to the same Machine by Daniel Bernoulli.
Fig. 3. Is Pitot's Bent Tube for measuring the Velocity of Water.
Fig. 4. Shews the Hydraulic Quadrant for the same purpose.
Fig. 5. Is a Floating Tube for obtaining an uniform Discharge from a variable Head of Water.
Fig. 6. Is a Floating Syphon for the same purpose.
Fig. 7. Is a Floating Cone for the same purpose.
Figs. 8, and 9. Represent the Water-blowing machine.
Fig. 10. Represents the Machinery for raising Water, called the gaining and Losing Buckets.

## PLATE CCCXXIV.

Fig. 1. Is the Scoop Wheel.
Fig. 2. Represents the Persian Wheel.
Fig. 3. Is the Throwing, or Flash Wheel.
Fig. 4. Shews the Chain Pump with Plugs.
Fig. 5. Is the Chain Pump with Buckets.
Fig. 6. Is the Hair Rope Machine of the Sieur Vera.
Fig. 7. Represents Whitchurst's Engine for raising Water by its Momentum.
Fig. 8, 9, and Fig. A, represent the Hydraulic Ram, invented by Montgolfier.
Fig. 10. Is the same Machine for raising Clean Water by a current of Foul Water.
Fig. 11. Is the same Machine employed to furnish a Blast of Air.
Fig. 12. Represents the Chemnitz Fountain.

END OF VOLUME TEN.

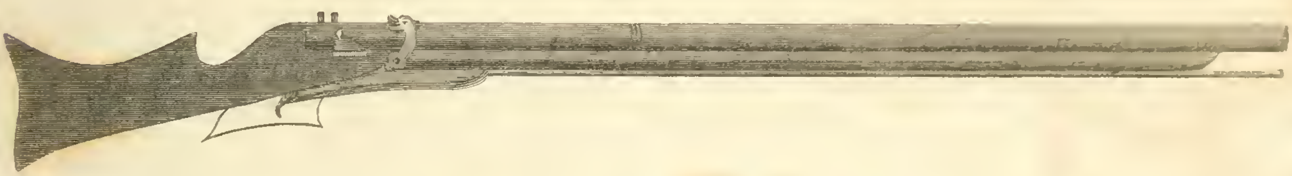
William Brown, Printer, Philadelphia.




*Engraved by H. Anderson*

*Fig. 5.*


*Fig. 6.*



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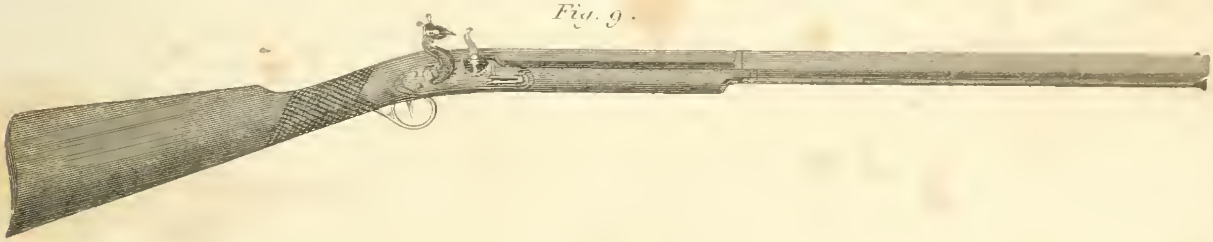
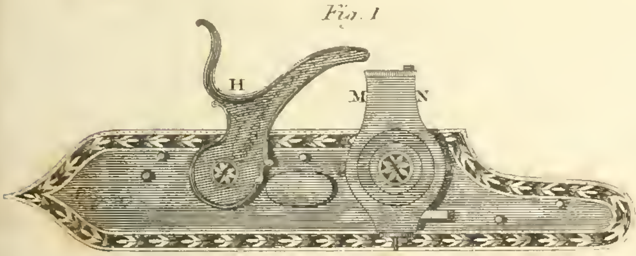


*Fig. 7*

*Fig. 1*

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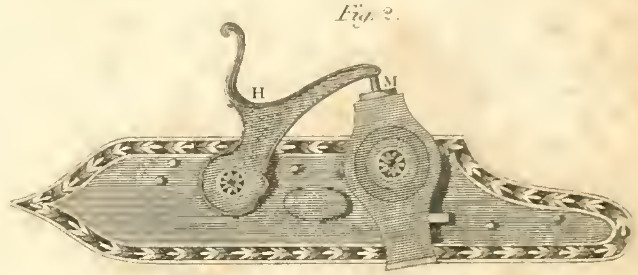


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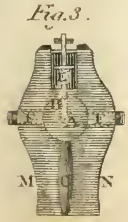


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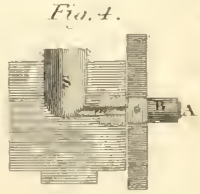
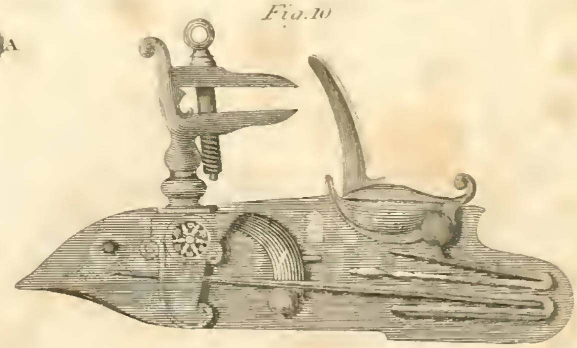



*Fig. 10*



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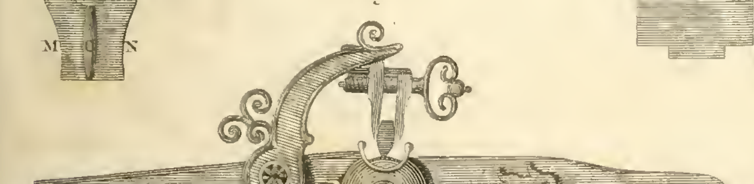
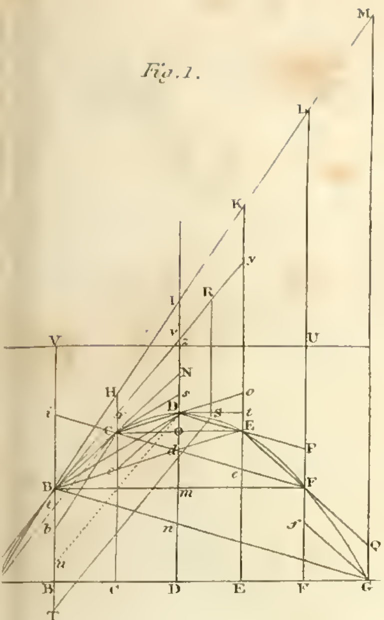


*W. Charles Sc.*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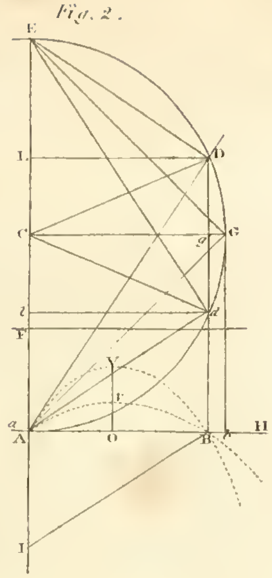
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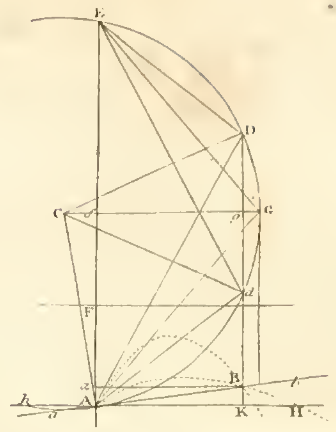
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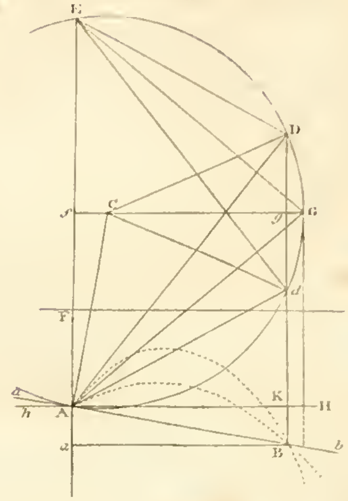
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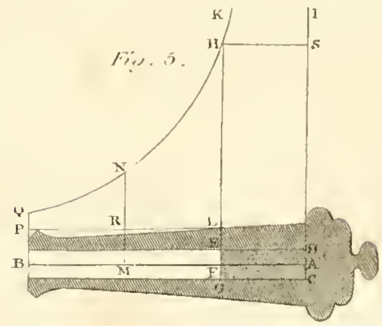
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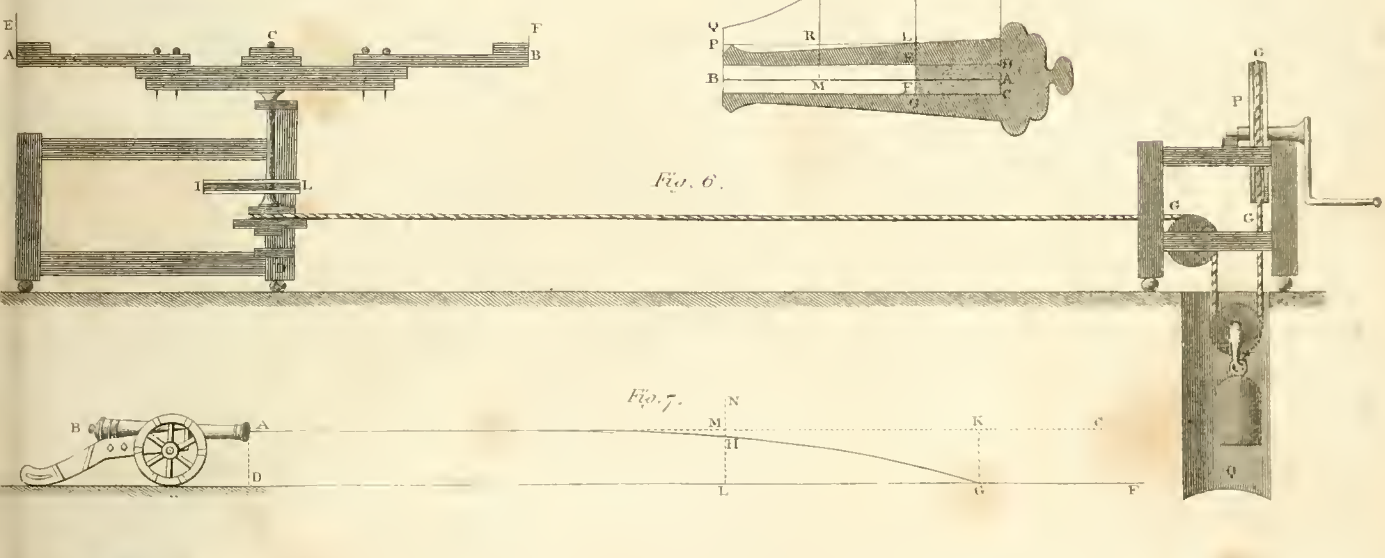
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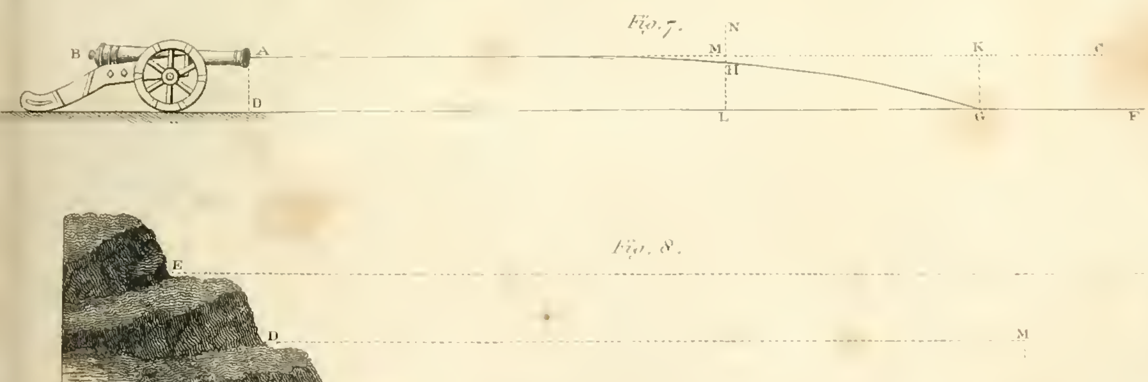
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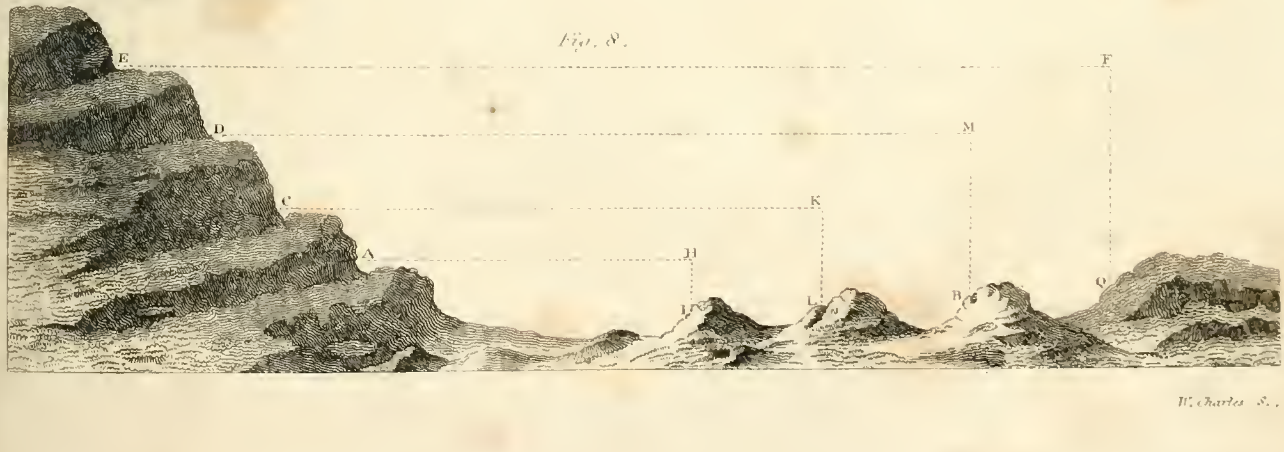


Fig. 8.

W. Charles S.

Fig. 1.

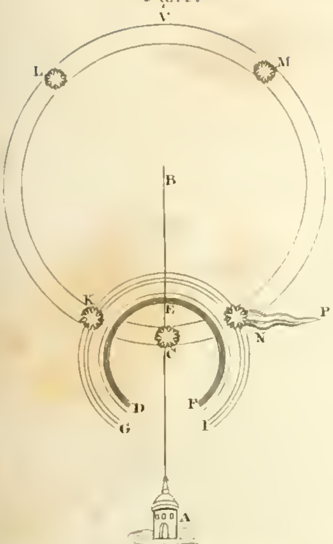
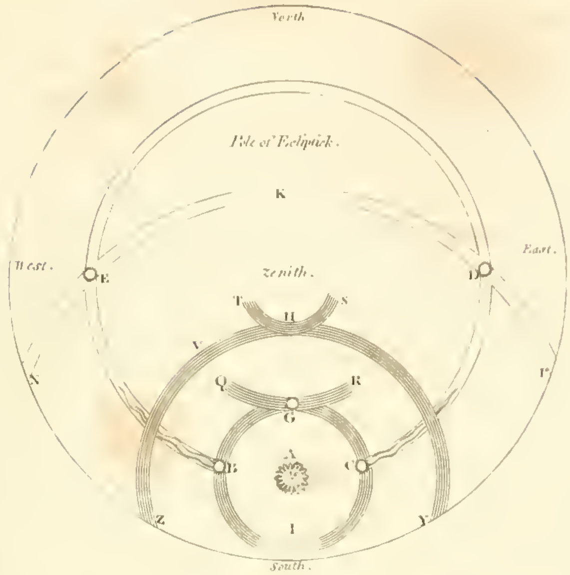



Fig. 2.

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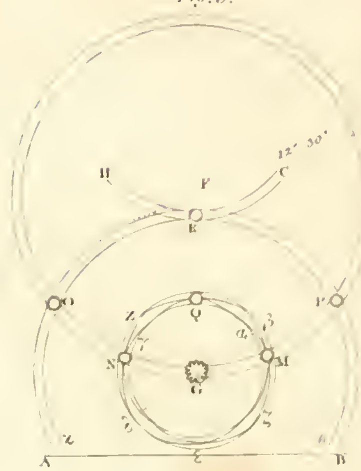
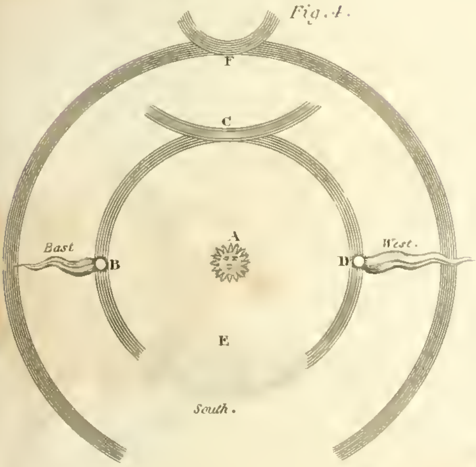



Fig. 4.

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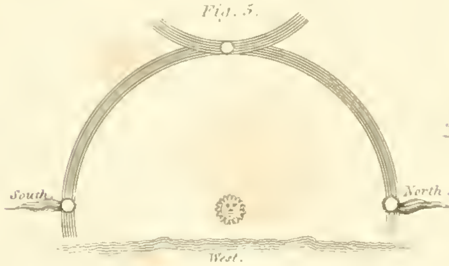


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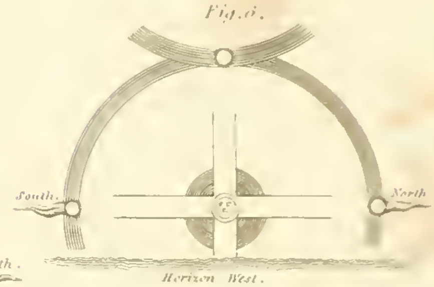


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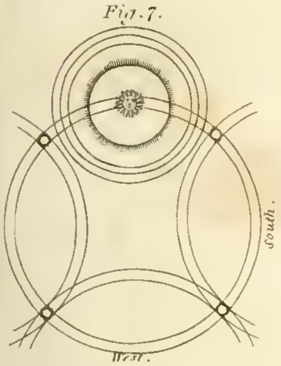


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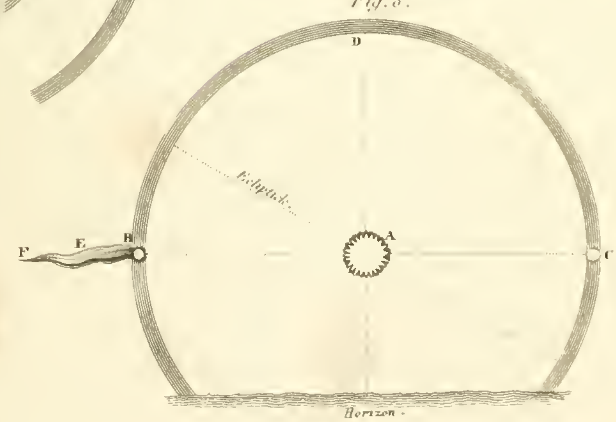


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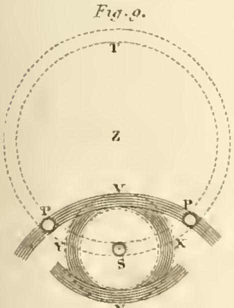


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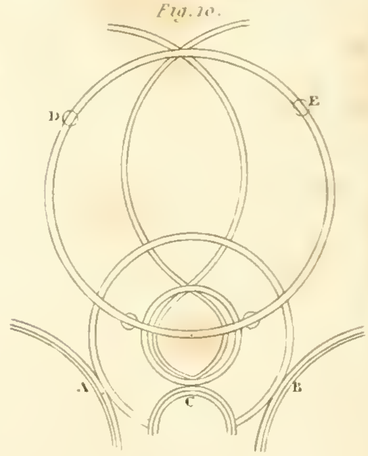


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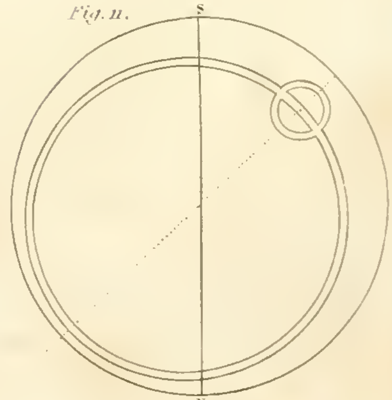
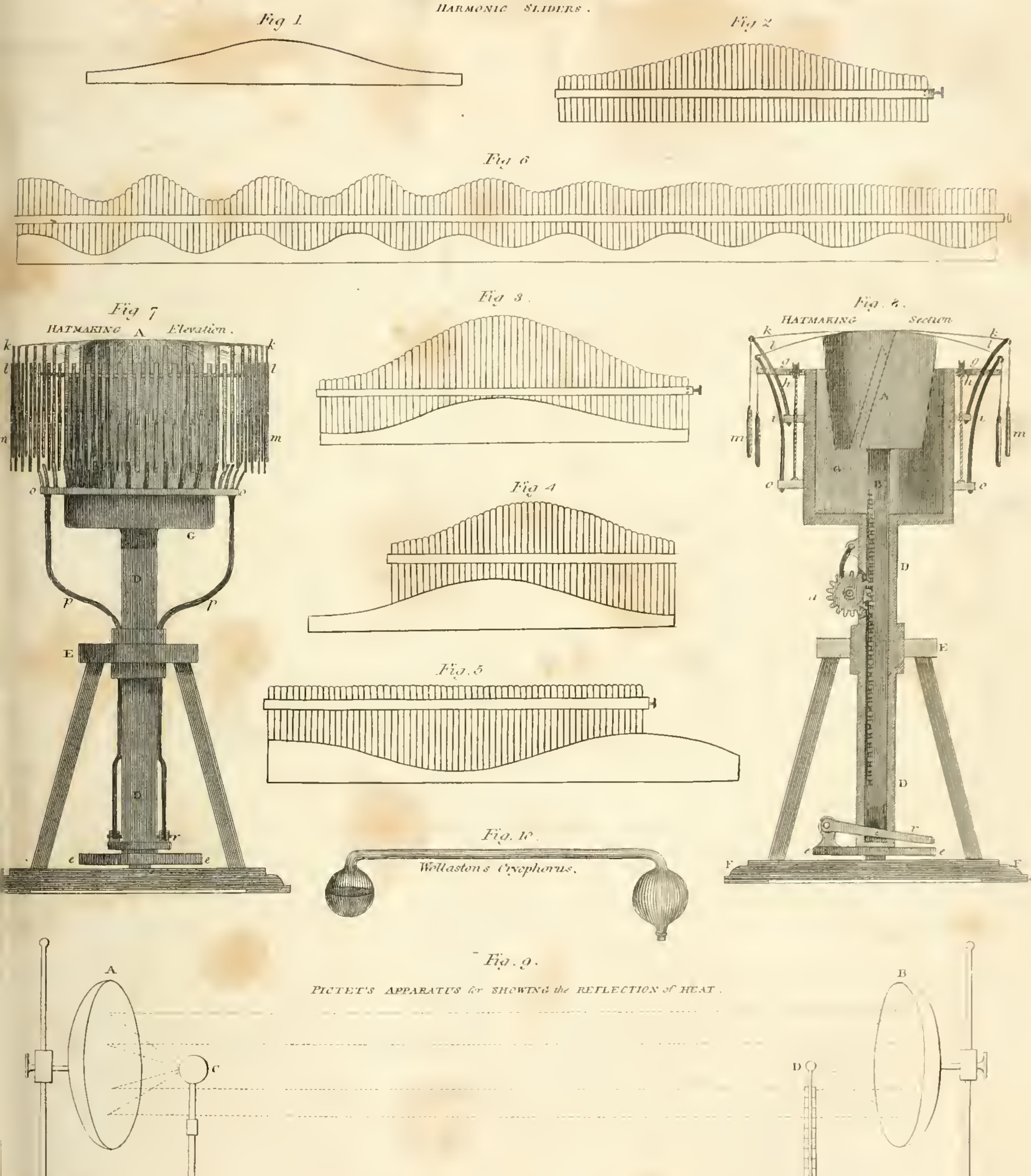



Fig. 12.


Engraved by H. Anderson.

# HARMONIC SLIDERS, HATMAKING, &c. *PLATE CCLXXVIII.*




W. Charles Sc.

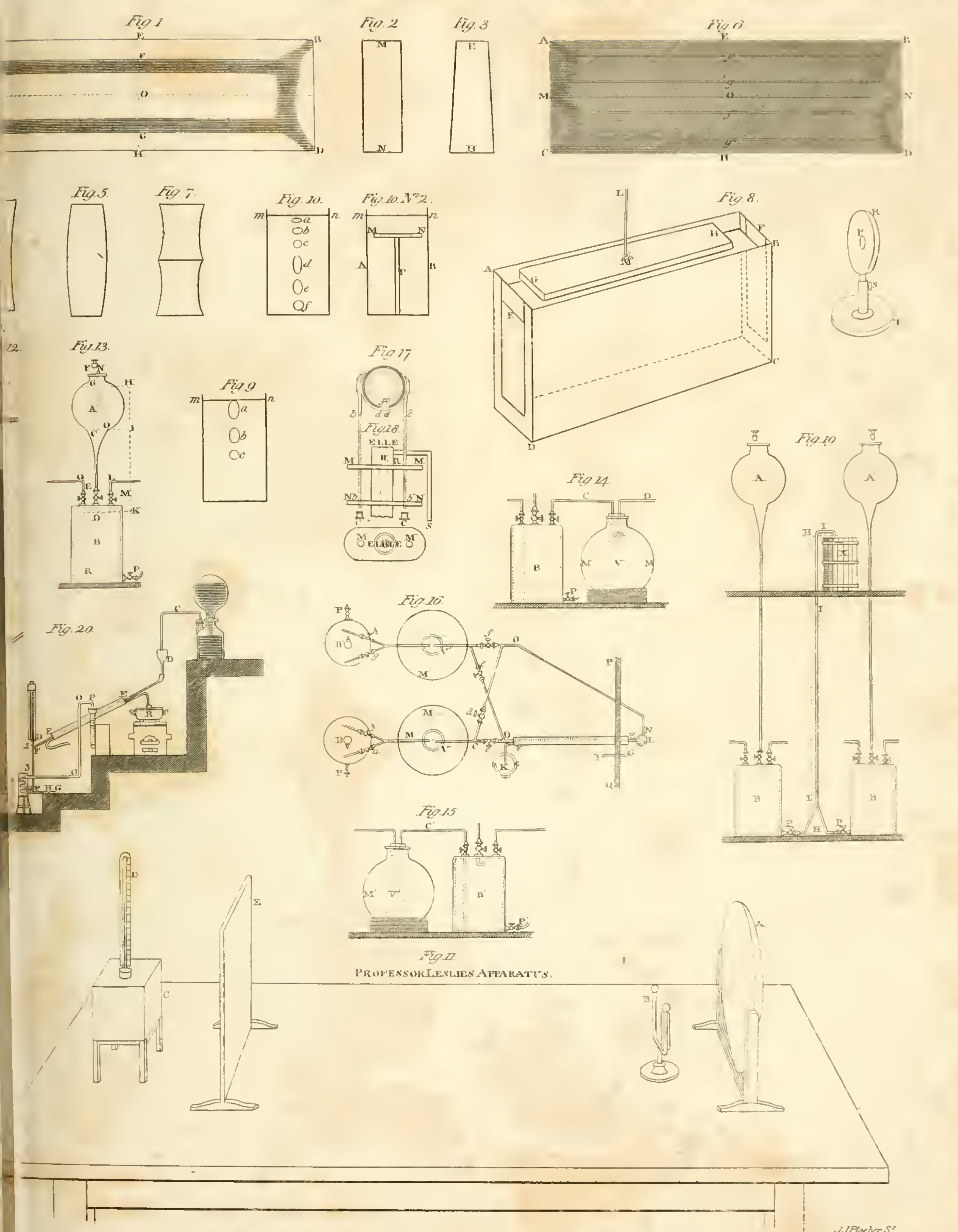
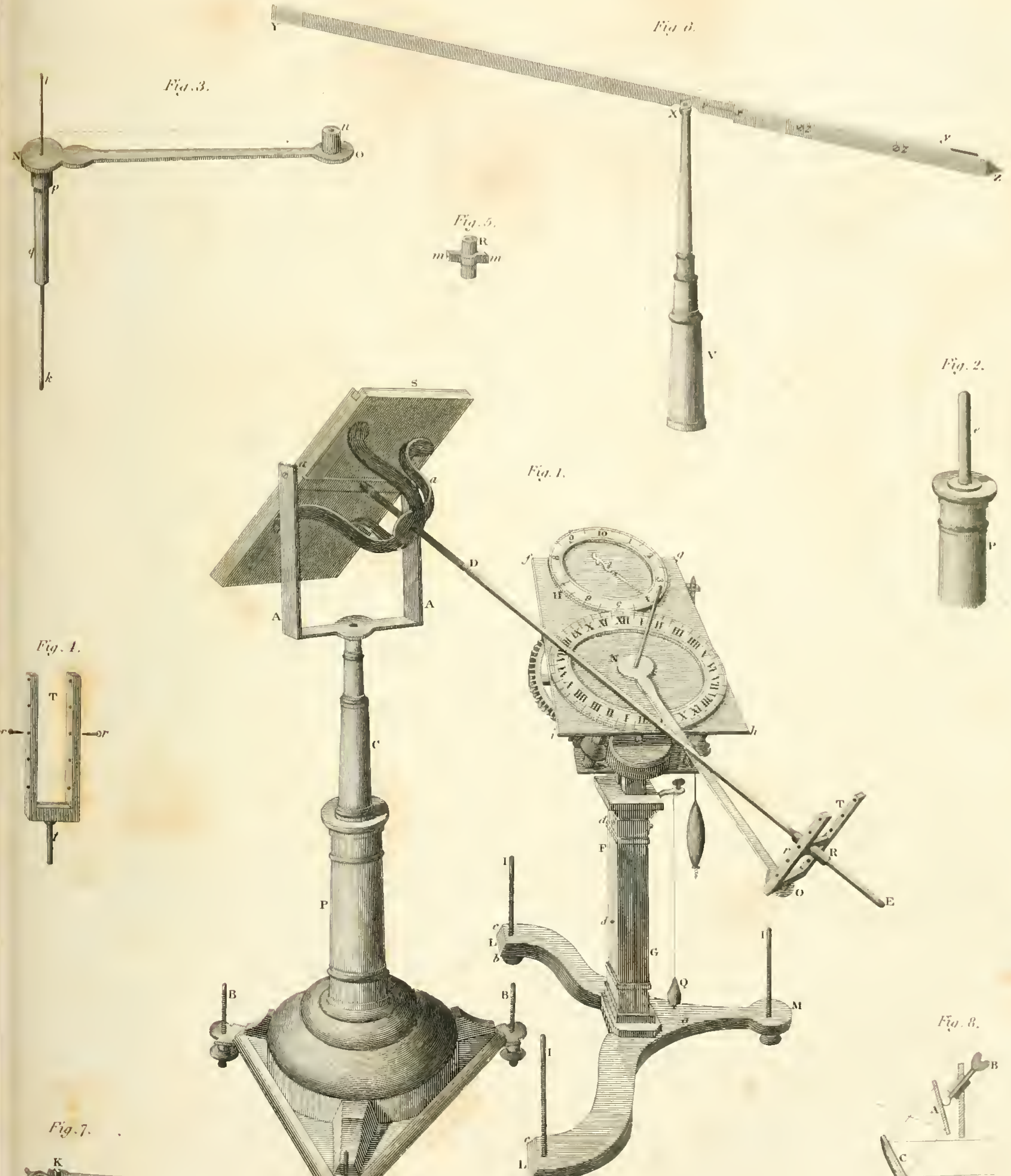


Fig. 1
Fig. 2
Fig. 3
Fig. 6
Fig. 5
Fig. 7
Fig. 10.
Fig. 10. N°2.
Fig. 8.
Fig. 13.
Fig. 17
Fig. 9
Fig. 18.
Fig. 19
Fig. 14.
Fig. 20.
Fig. 16.
Fig. 15
Fig. 11.
PROFESSOR LESLIE'S APPARATUS.
J.J.Plocher Sc.

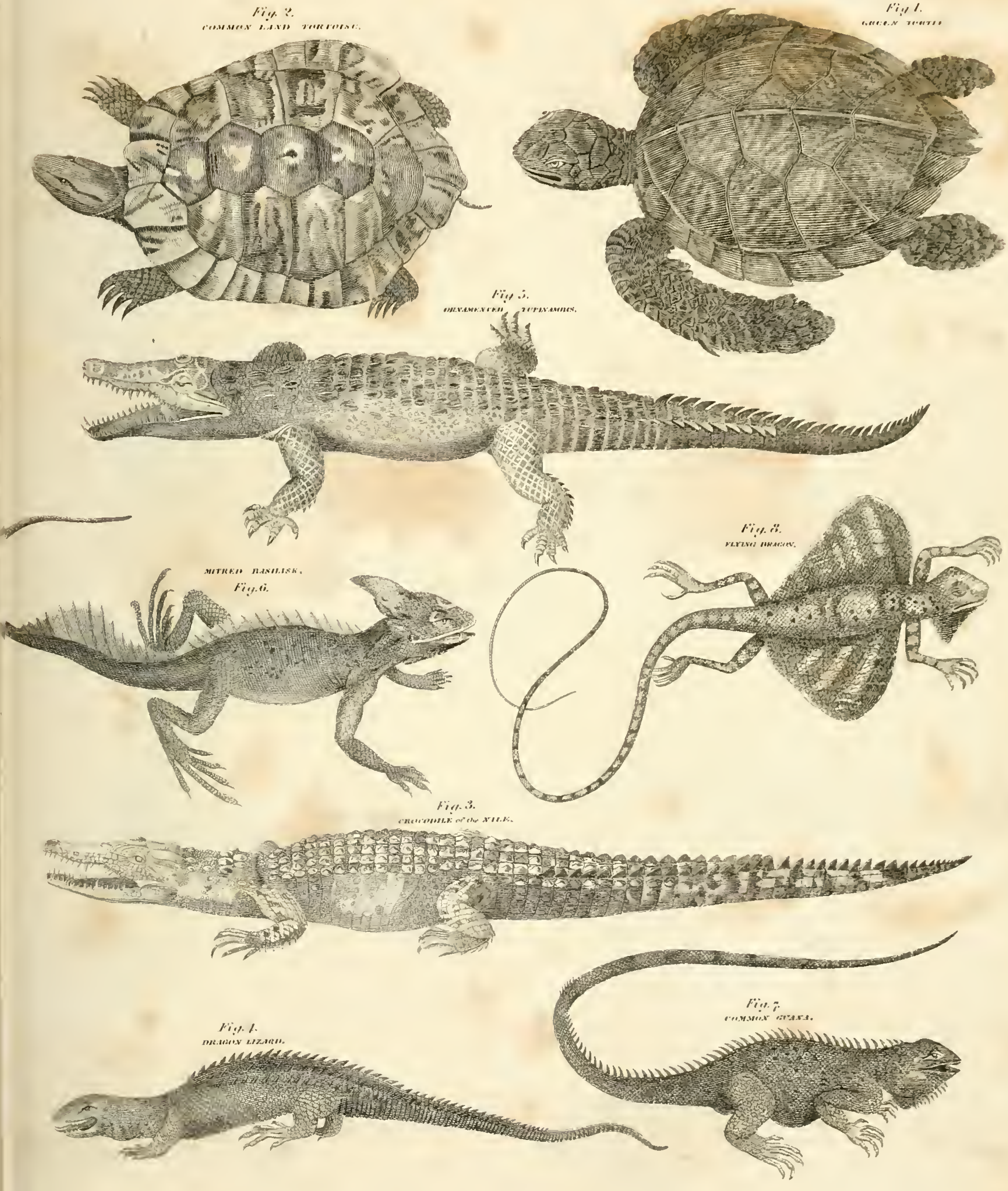
# HELIOSTATE.

PLATE CCXC.




H. Anderson Sc.

# HERPETOLOGY. *PLATE CCXCII.*



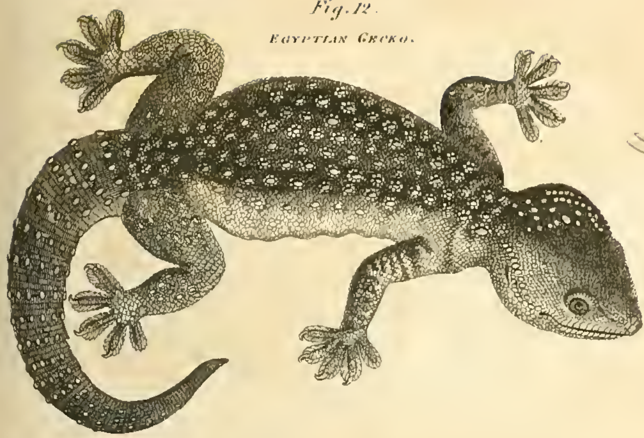


*Fig. 12.*
EGYPTIAN GECKO.

*Fig. 11.*
LACED LIZARD

*Fig. 11.*
COMMON CHAMELEON.

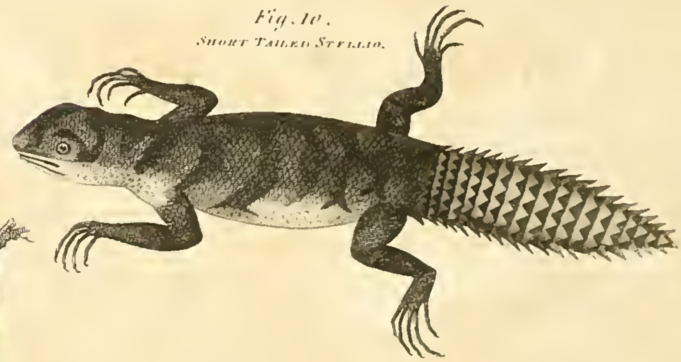


*Fig. 10.*
SHORT TAILED STELLIO.

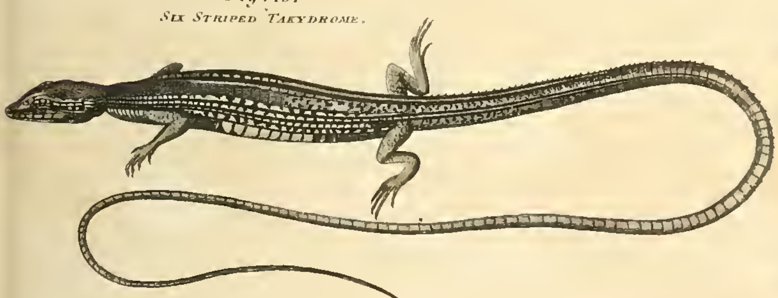


*Fig. 15.*
SIX STRIPED TAKYDROME.

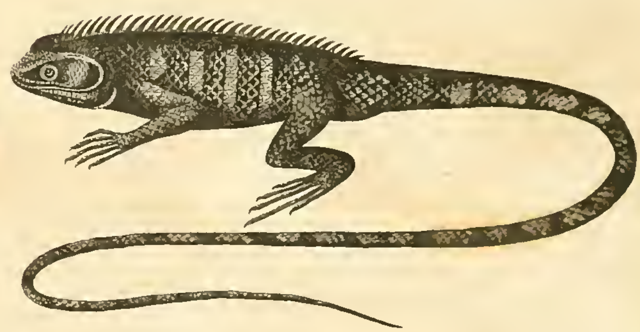


*Fig. 9.*
GALEOT AGAMA.

*Fig. 13.*
TWO SPOTTED ANOLIS.

*Fig. 16.*
COMMON SCINK.

Thurston

## HERPETOLOGY. PLATE CCXCVIII.

*Fig. 17.*
FIVE-TOED EFT.

*Fig. 24.*
LACERTINE SIREN.

*Fig. 21.*
SURINAM TOAD.

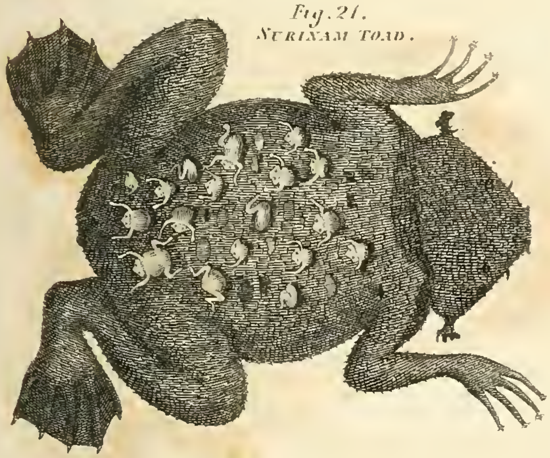


*Fig. 20.*
SURINAM FROG.

*Fig. 19.*
TWO-COLOURED TREE FROG.

*Fig. 22.*
COMMON SALAMANDER.

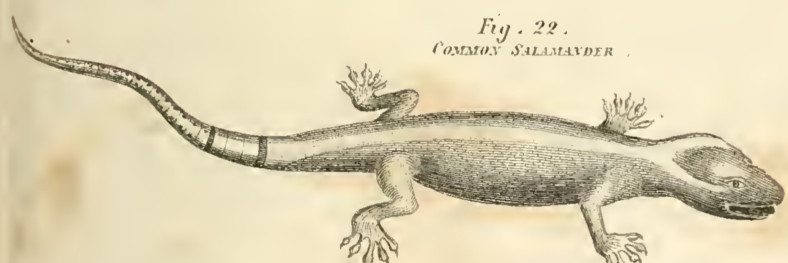


*Fig. 23.*
COMMON PROTEUS.

*Fig. 18.*
THREE-TOED CHALCIDES.

P.E.Hom Sc

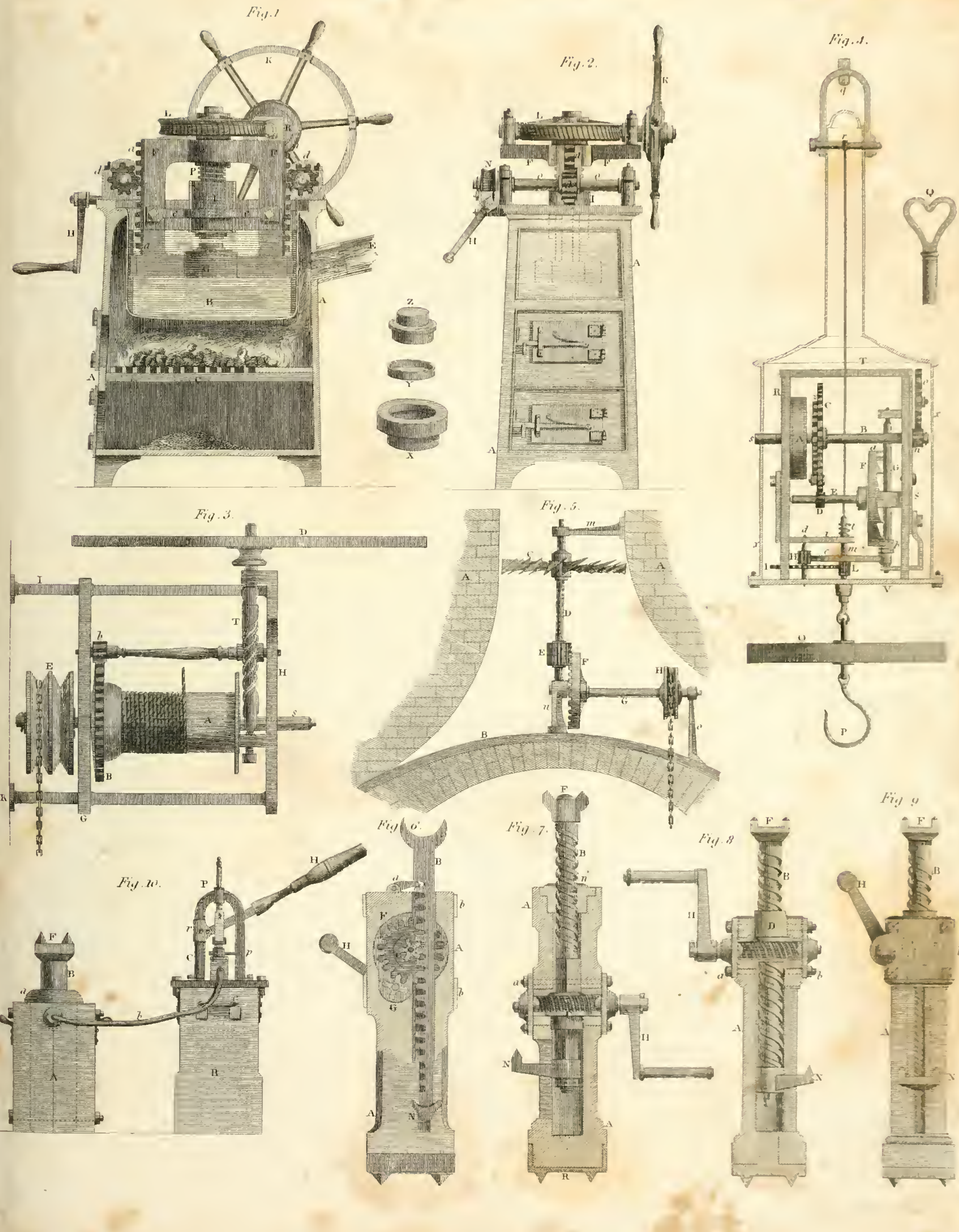
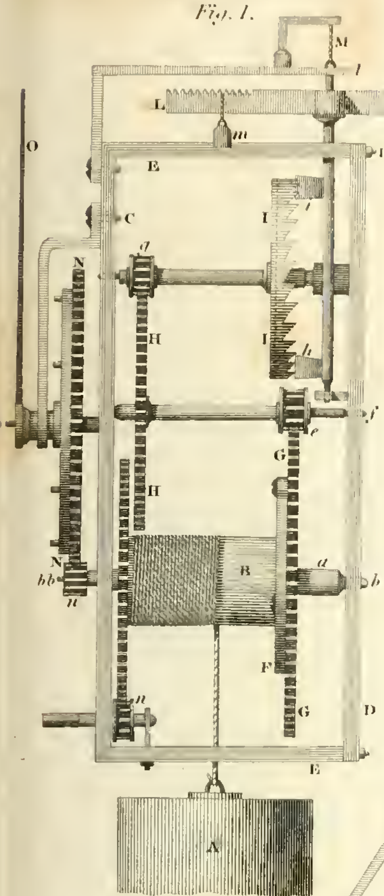


Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5
Fig. 6
Fig. 7
Fig. 8
Fig. 9
Fig. 10

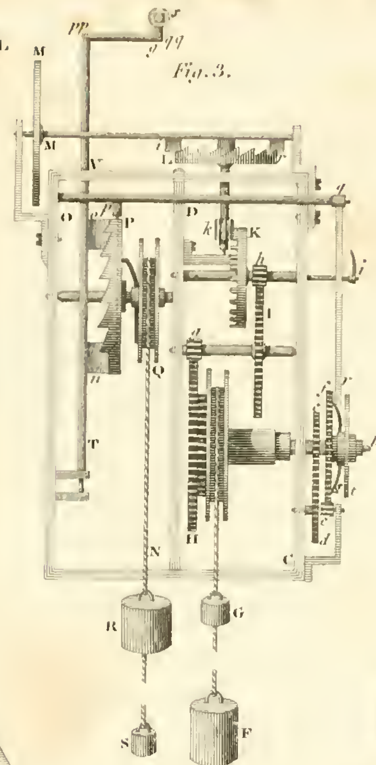
AN ANCIENT CLOCK BY VICK

*Fig. 1.*



ALARM CLOCK

*Fig. 3.*



HUYGHENS CLOCK

*Fig. 1.*

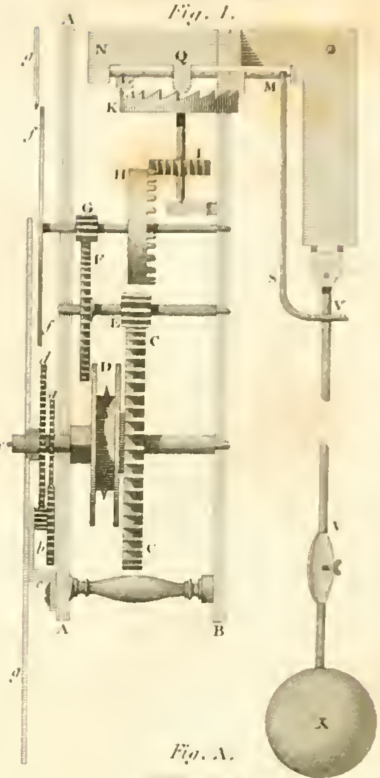


*Fig. 6.*

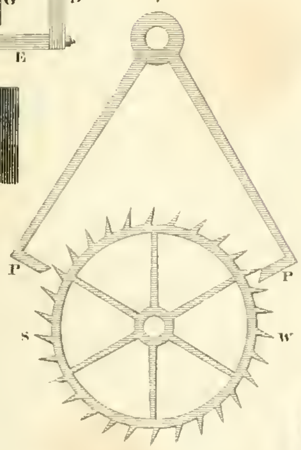


*Fig. 8.*

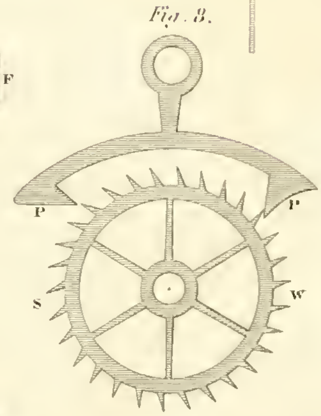


*Fig. A.*

*Fig. 5.*

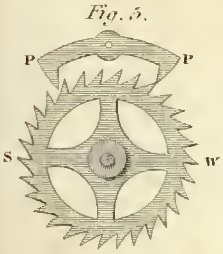


*Fig. 7.*

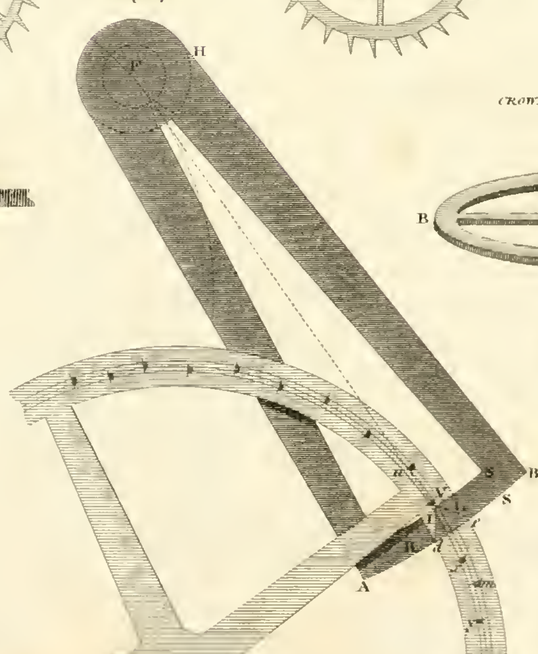
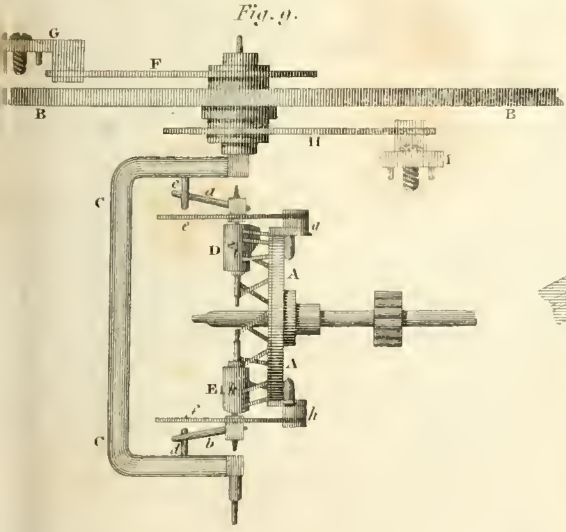
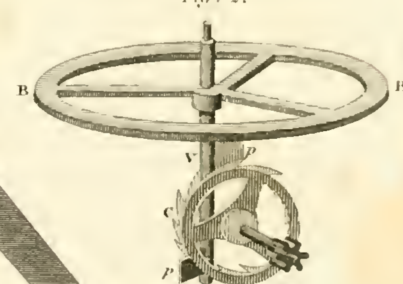


*Fig. 9.*



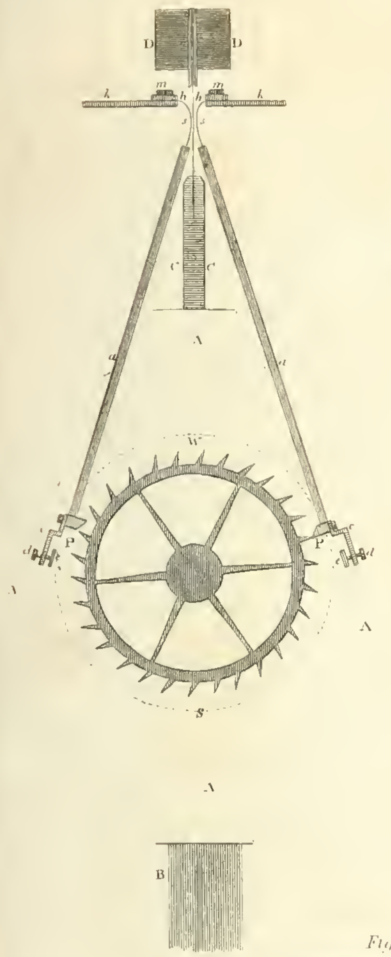
CROWN WHEEL & VERGE SCAPMENT

*Fig. 2.*



Engraved by D. Haines

Fig 1



Harrisons Pallets.

Fig 6

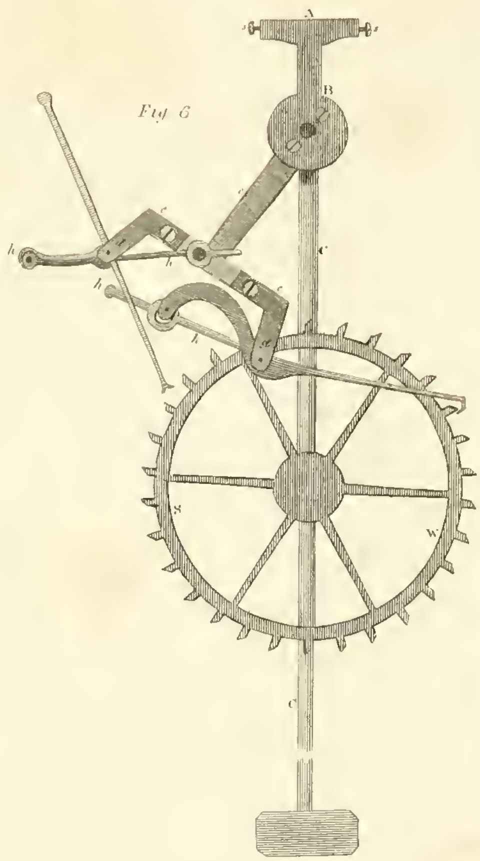


Fig 2

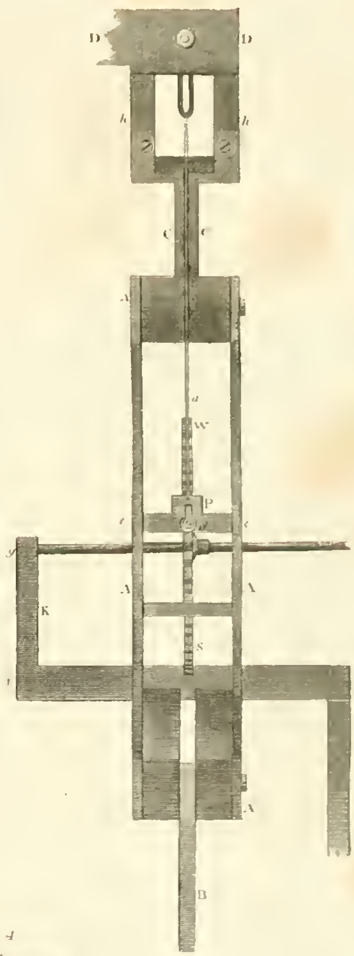


Fig 5

Fig 3. Mr Reids Scapement

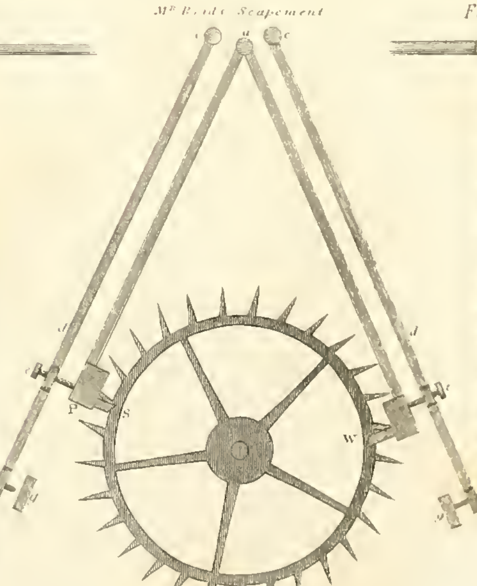


Fig 4

Fig 7

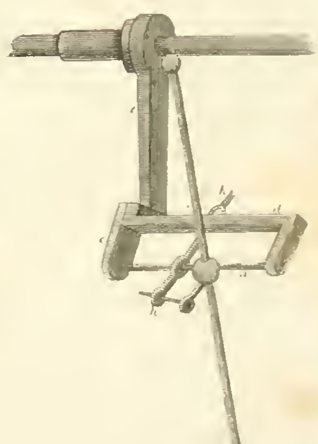
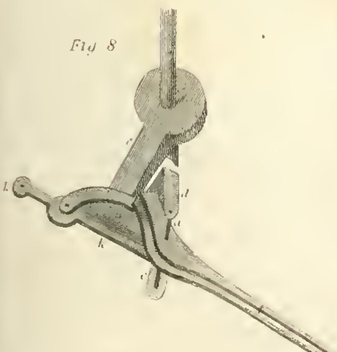
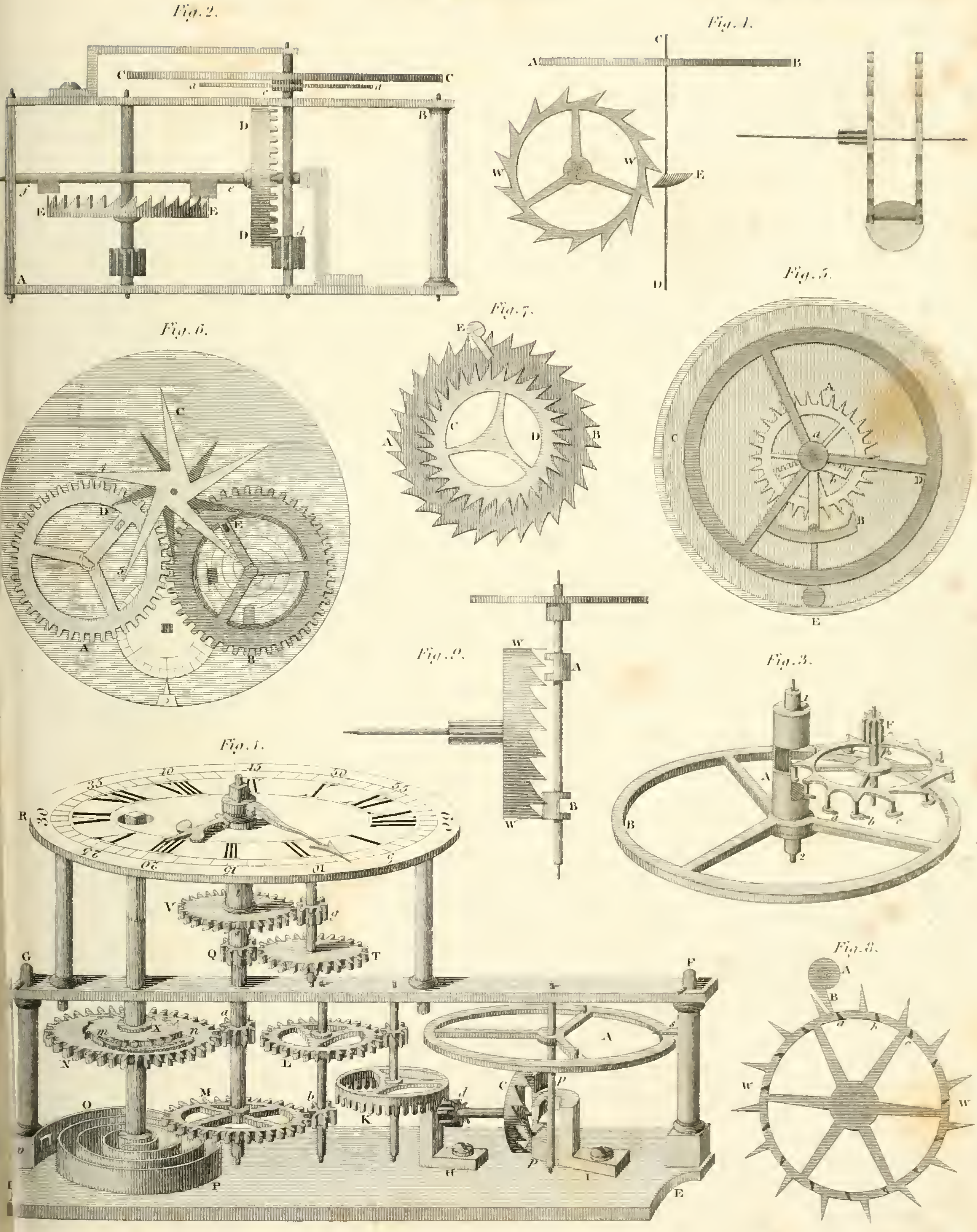


Fig 8



# HOROLOGY. *PLATE CCCII.*




*Engraved by Davies*

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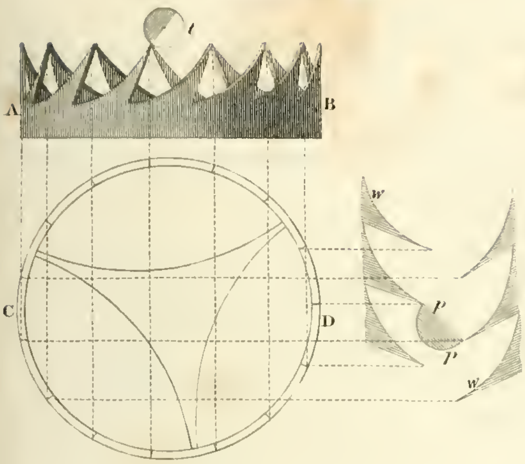



Fig. 3.

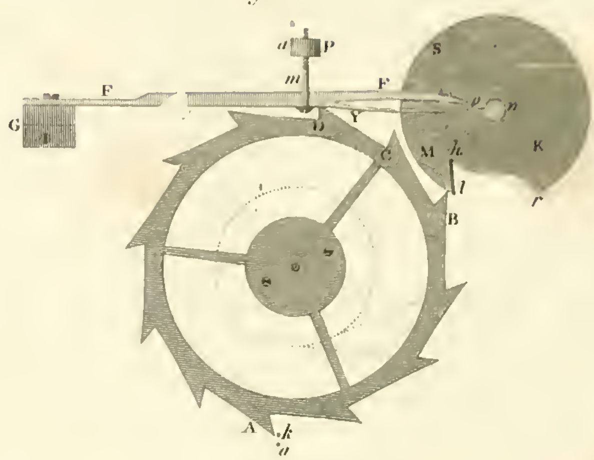
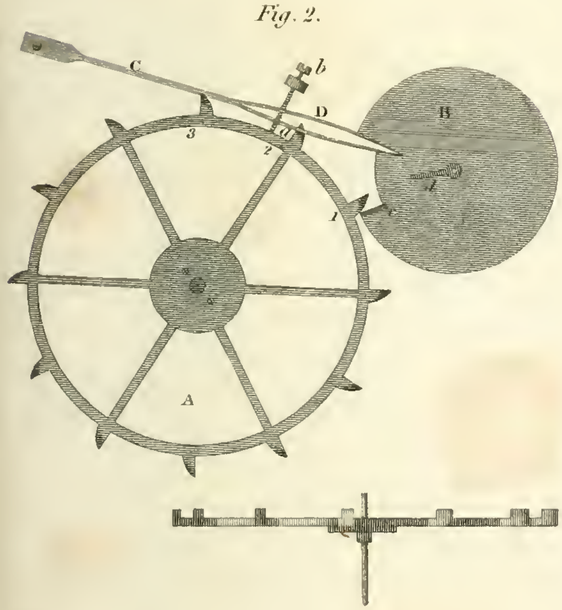



Fig. 2.

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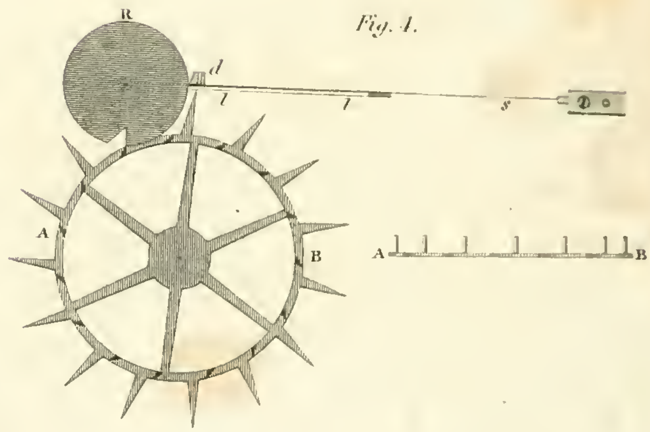



Fig. 6.

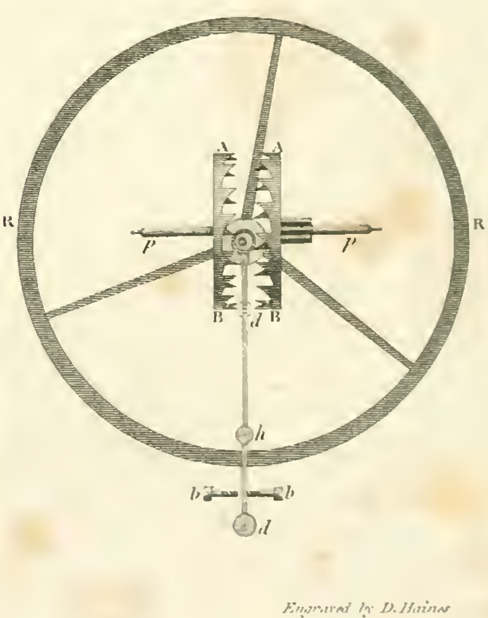
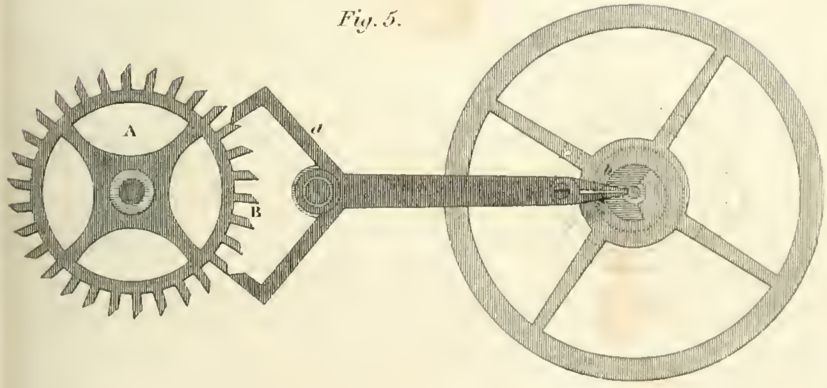
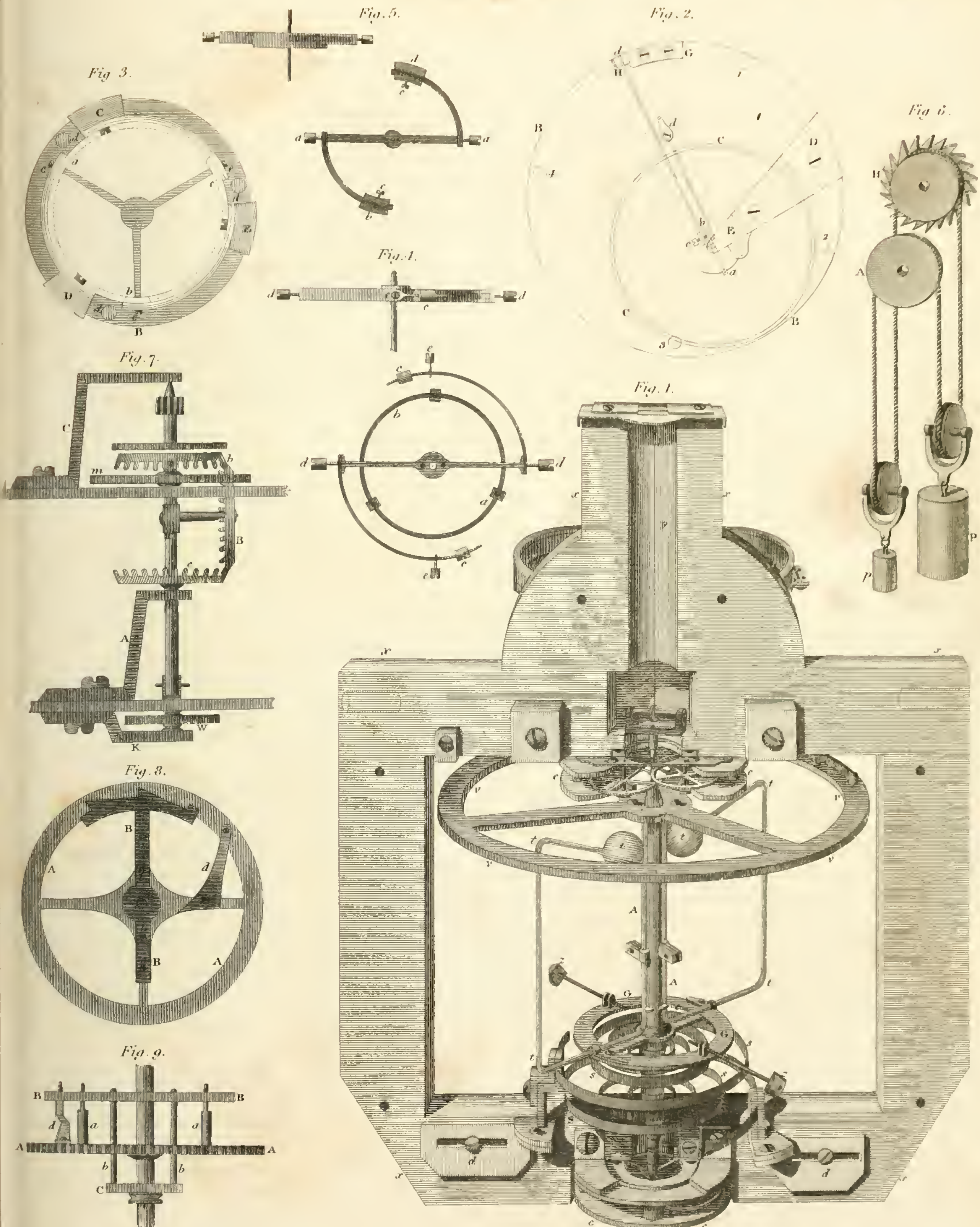



Fig. 5.




Engraved by D. Haines




R. Anderson sc.

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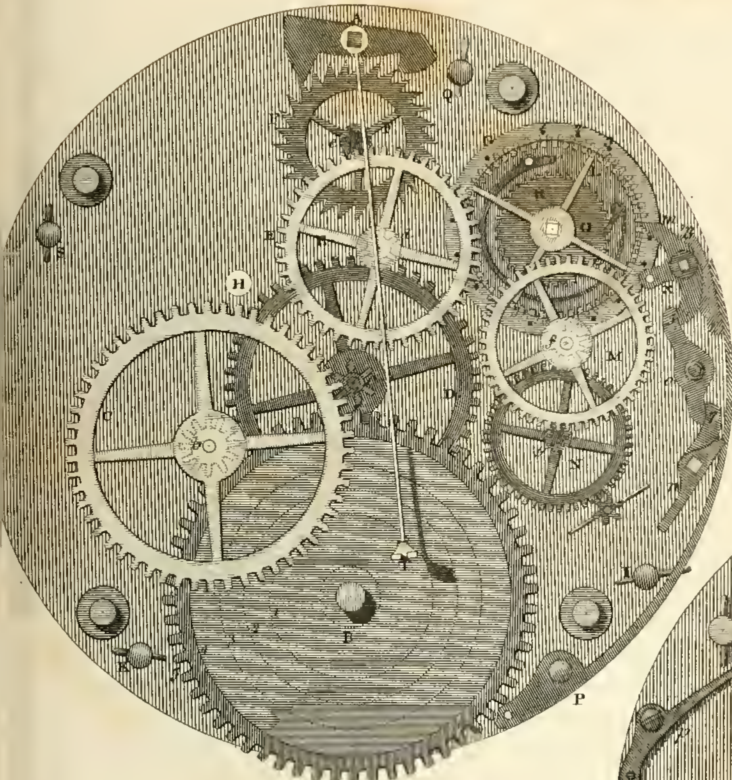


Fig. 5.

Fig. 4.

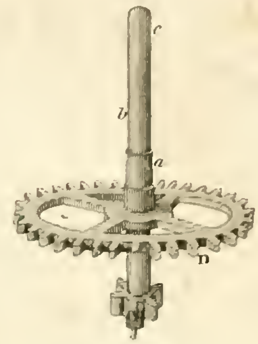


Fig. 2.

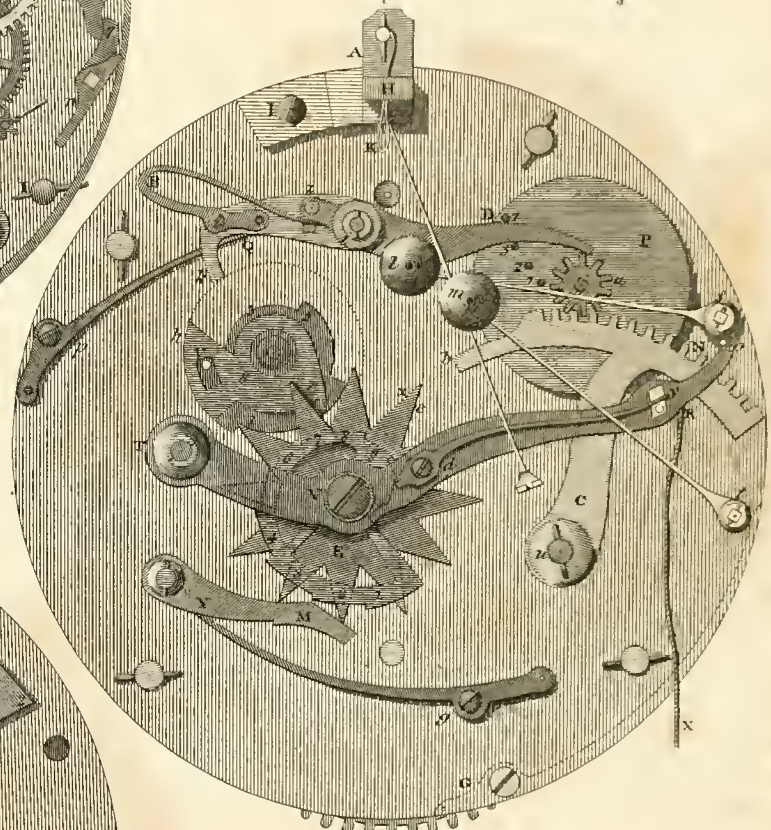
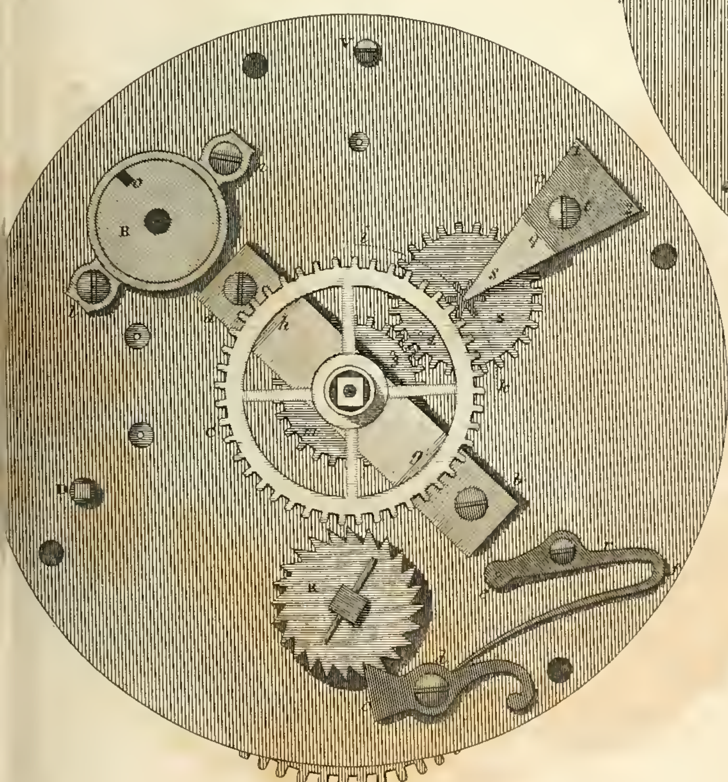


Fig. 3.



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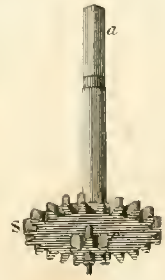

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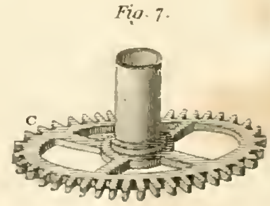


H. Andrews sc.

Fig. 2.

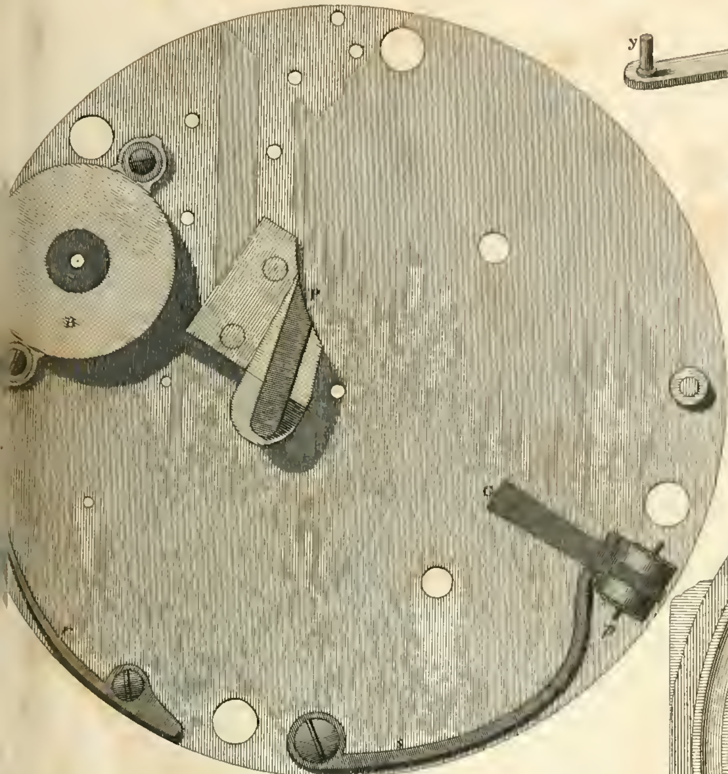


Fig. 4.

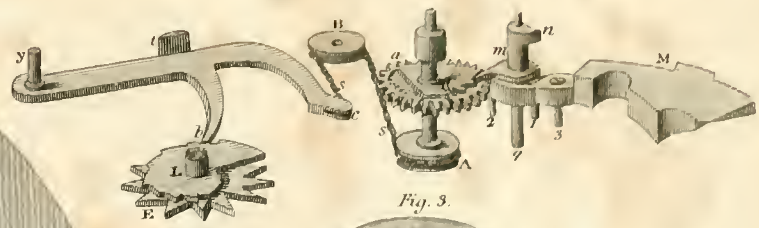


Fig. 3.

Fig. 1.

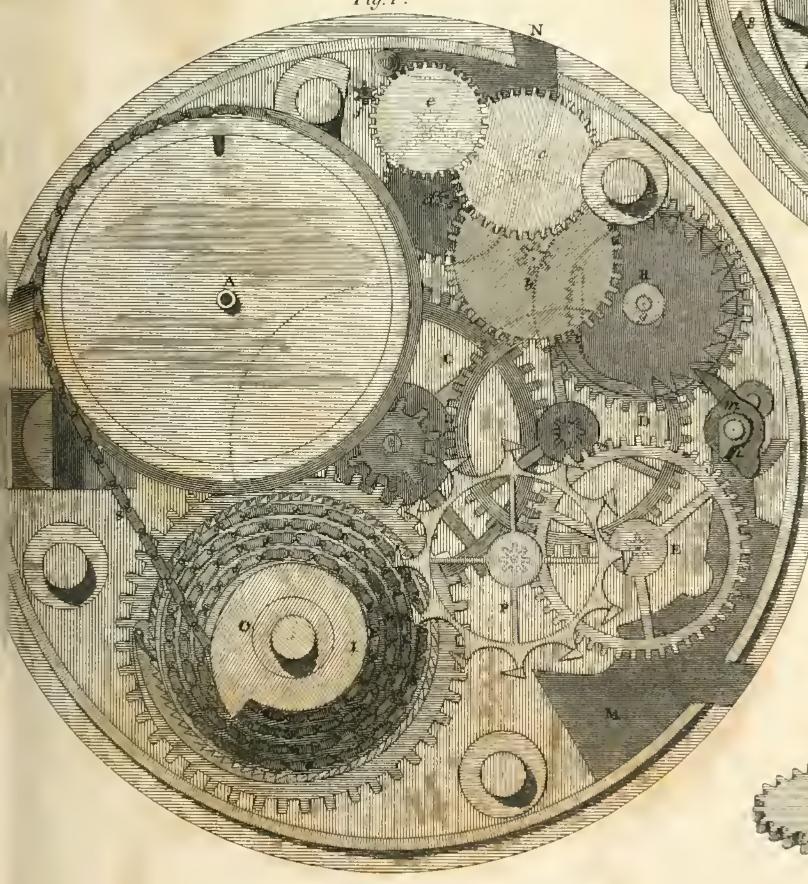
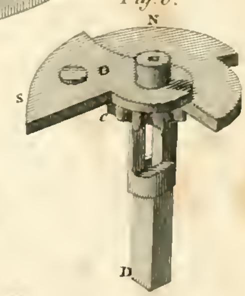


Fig. 6.



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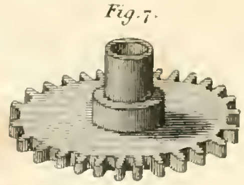

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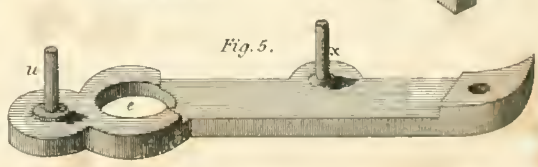


Fig. 8.

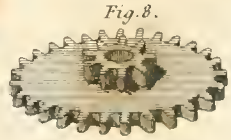


Fig. 9.

H. Andersen sc.

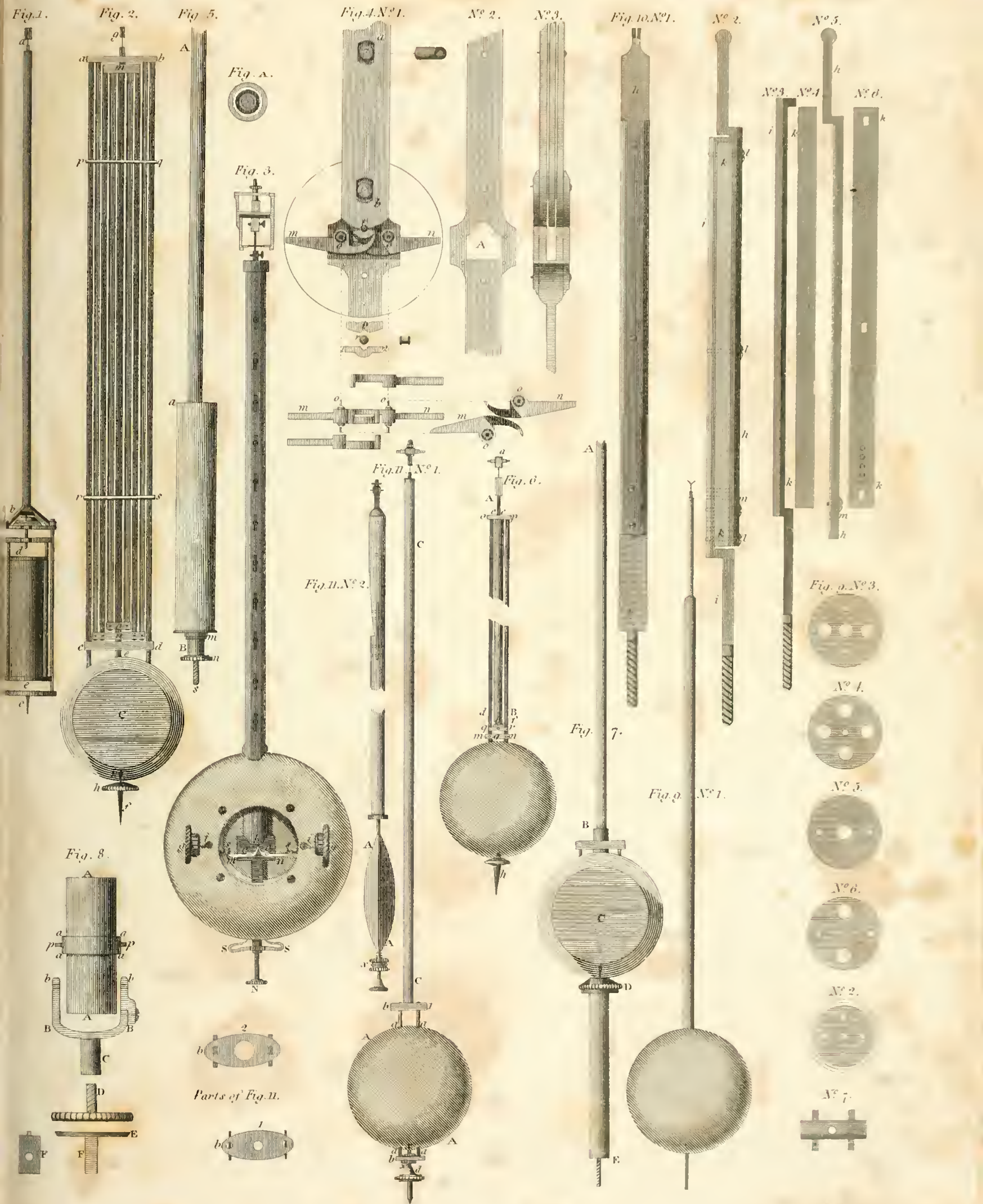


Fig. 1.
Fig. 2.
Fig. 5.
Fig. A.
Fig. 3.
Fig. 4. Nº 1.
Nº 2.
Nº 3.
Fig. 10. Nº 1.
Nº 2.
Nº 3.
Nº 4.
Nº 5.
Nº 6.
Fig. 11. Nº 1.
Fig. 11. Nº 2.
Fig. 6.
Fig. 7.
Fig. 9. Nº 1.
Fig. 9. Nº 3.
Nº 4.
Nº 5.
Nº 6.
Nº 2.
Nº 7.
Fig. 8.
Parts of Fig. 11.

CHIMES

Fig 3.

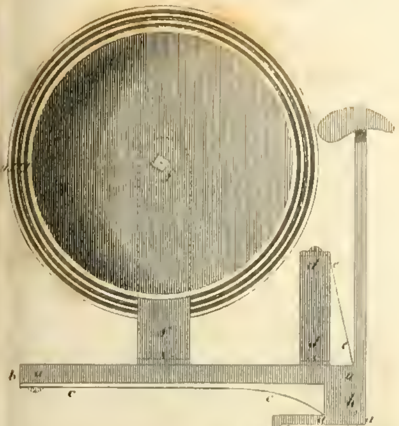


Fig 4.

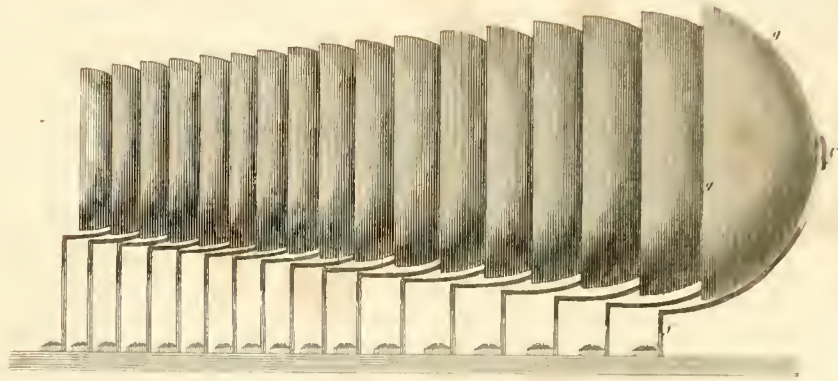


Fig 2.

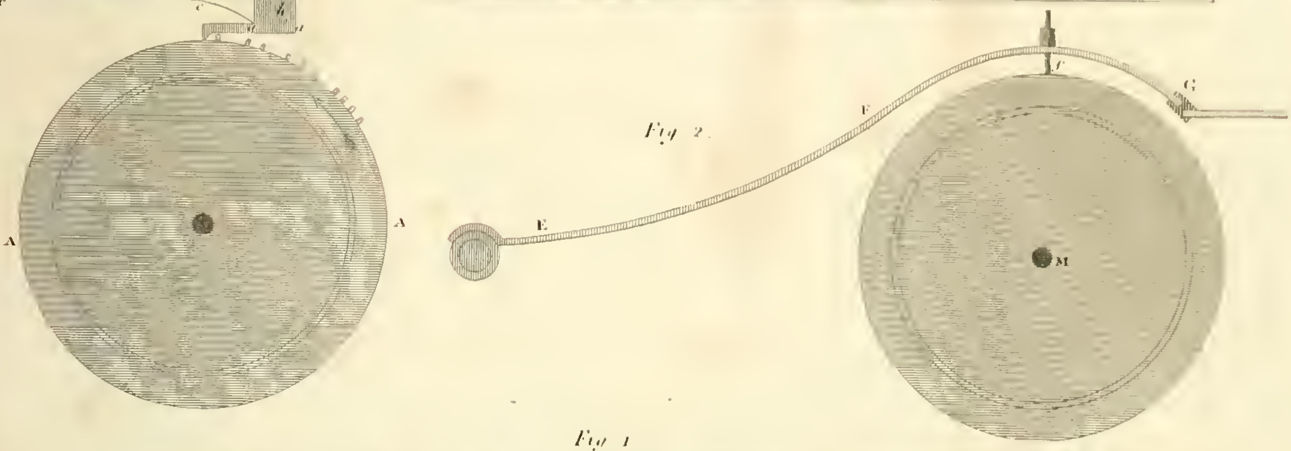



Fig 1.

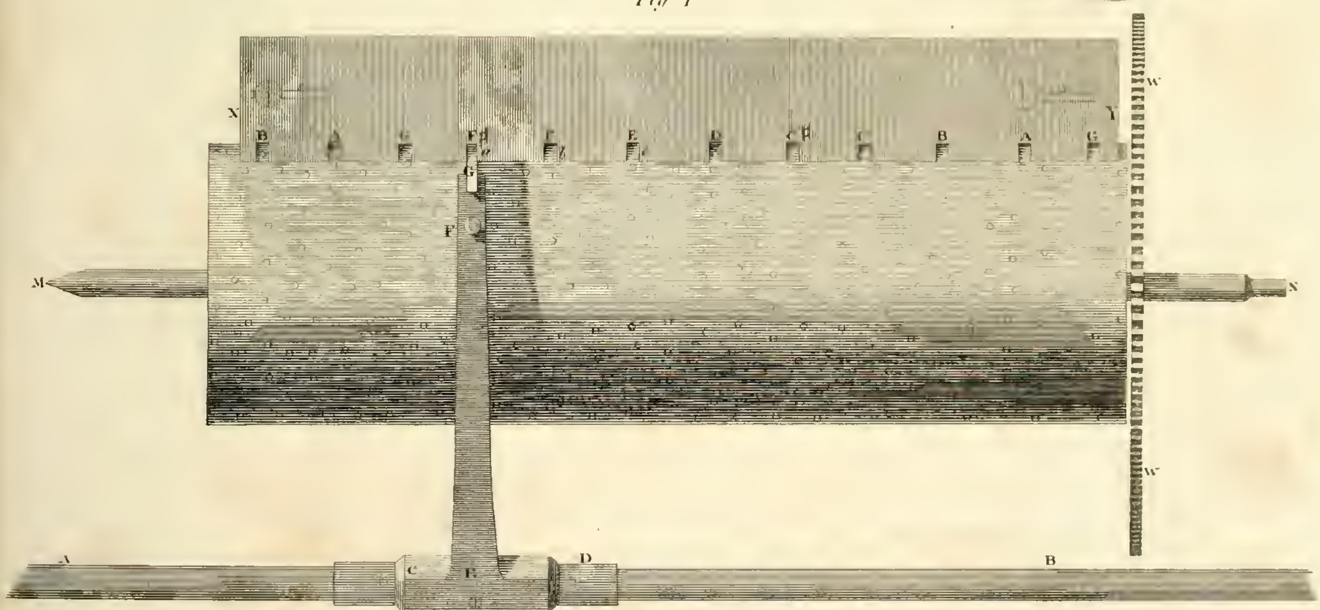
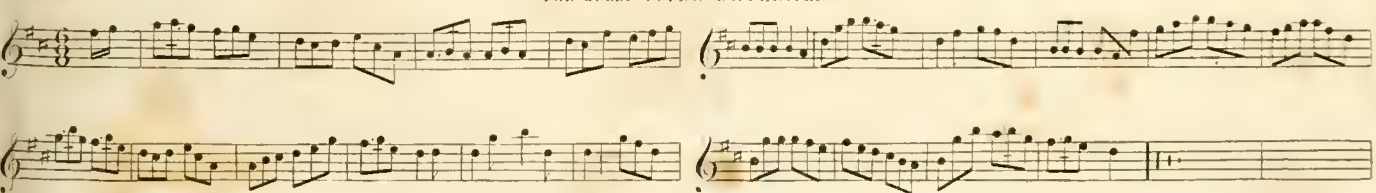



Fig 5.

THE JOLLY YOUNG WATERMAN



J Boyd fc.

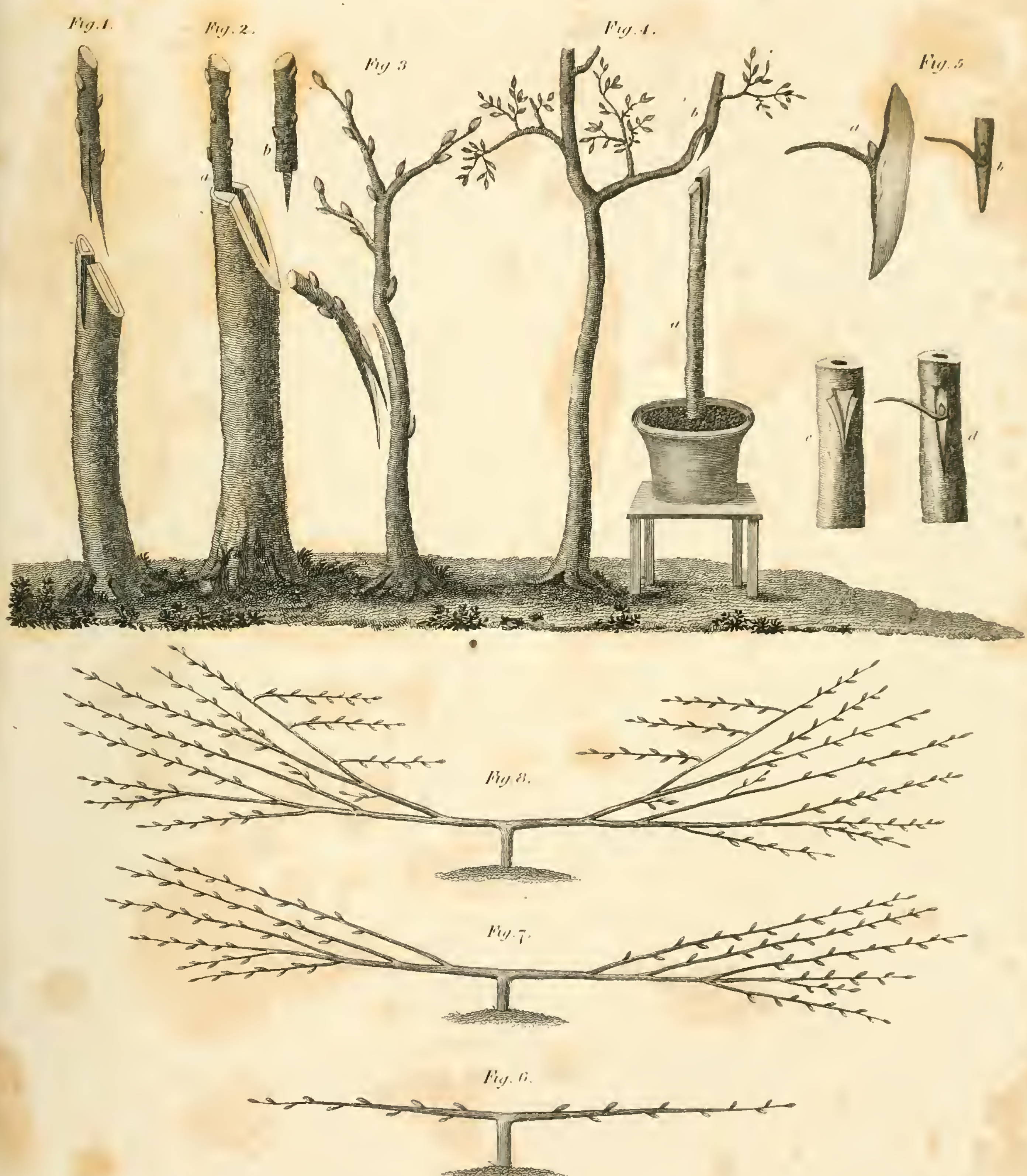
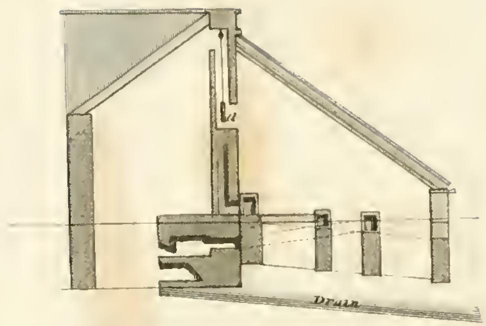


Fig. 1.
Fig. 2.
Fig. 3
Fig. 4.
Fig. 5
Fig. 8.
Fig. 7.
Fig. 6.
Jacob J Plocher Sc

# HORTIC

Fig.


Fig. 3.



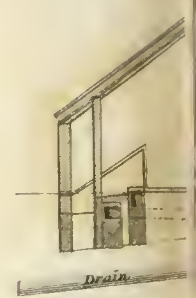
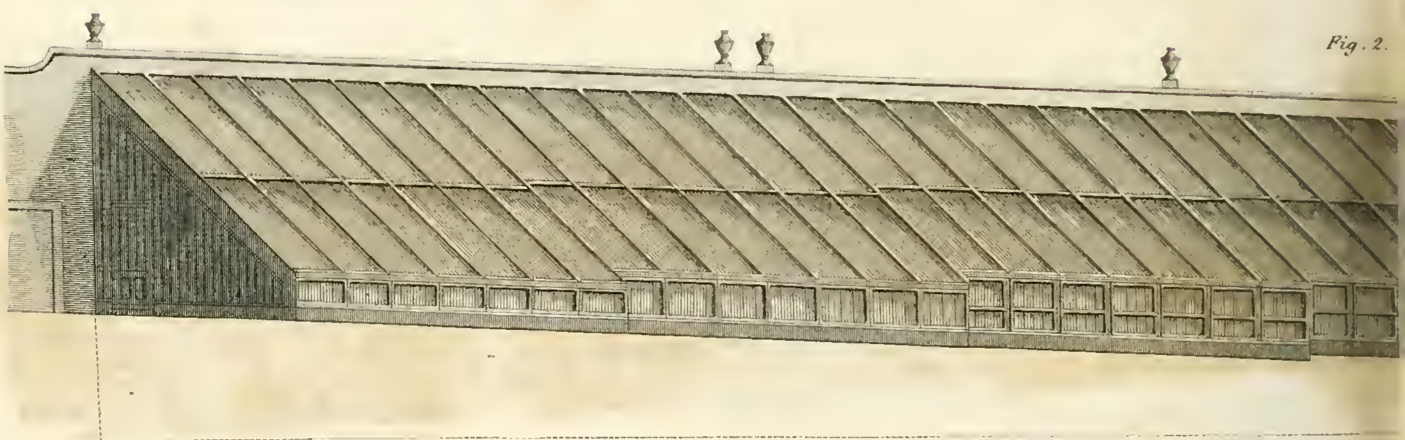
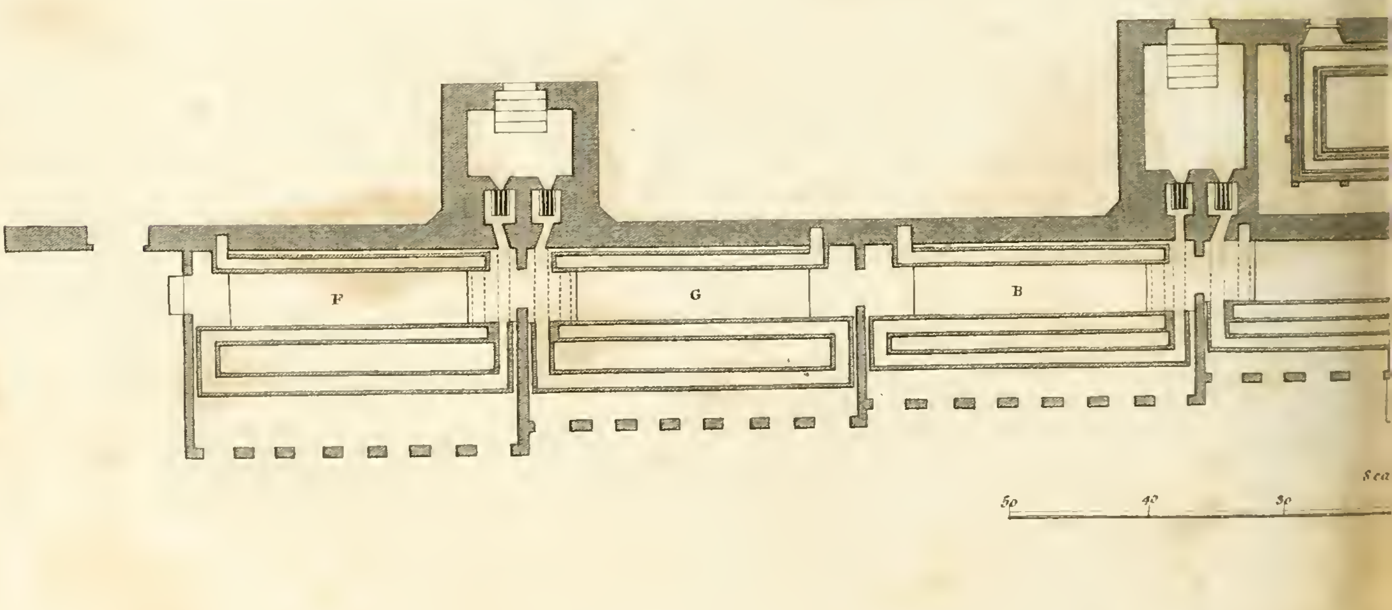




Fig. 2.






Sca

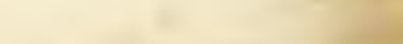


**PLATE CCCX.**


,4.

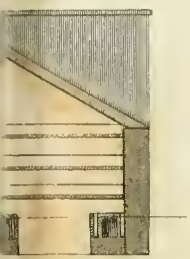
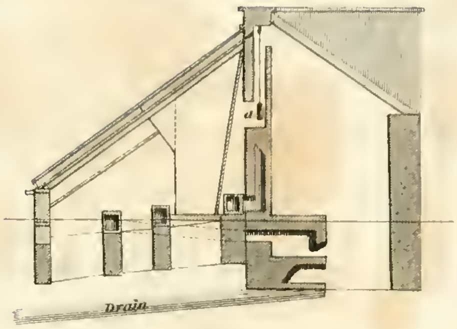
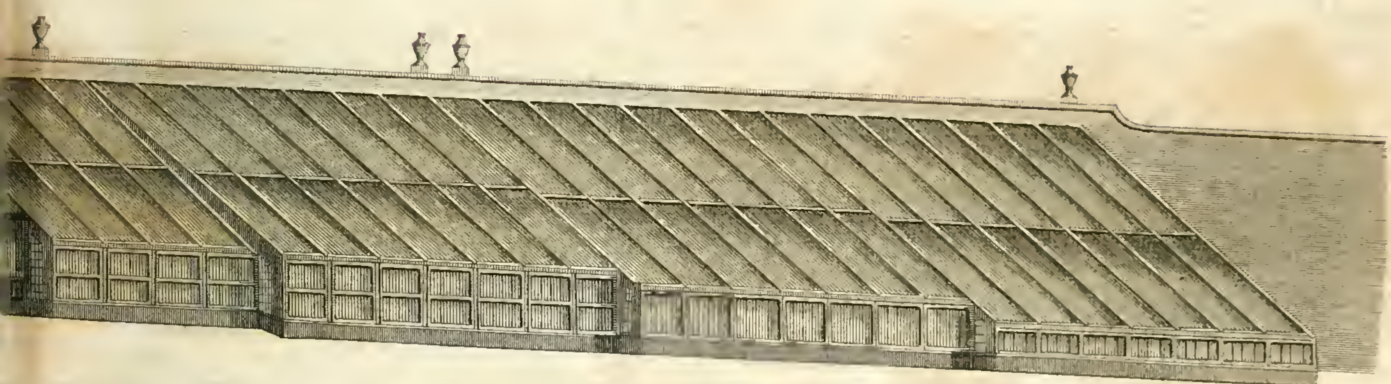
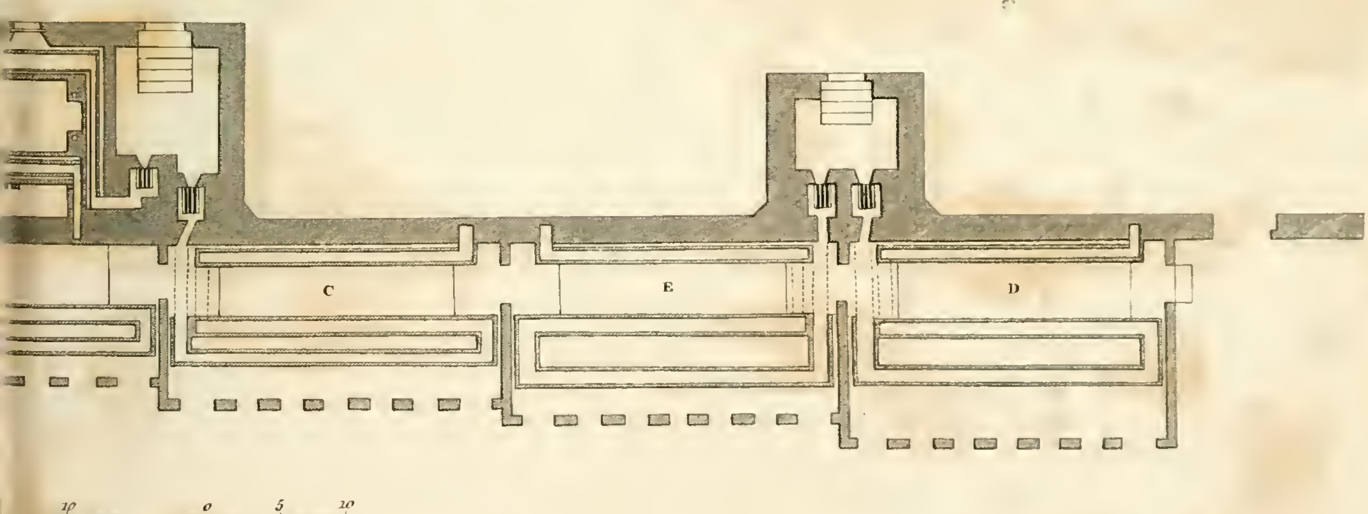


Fig. 5.



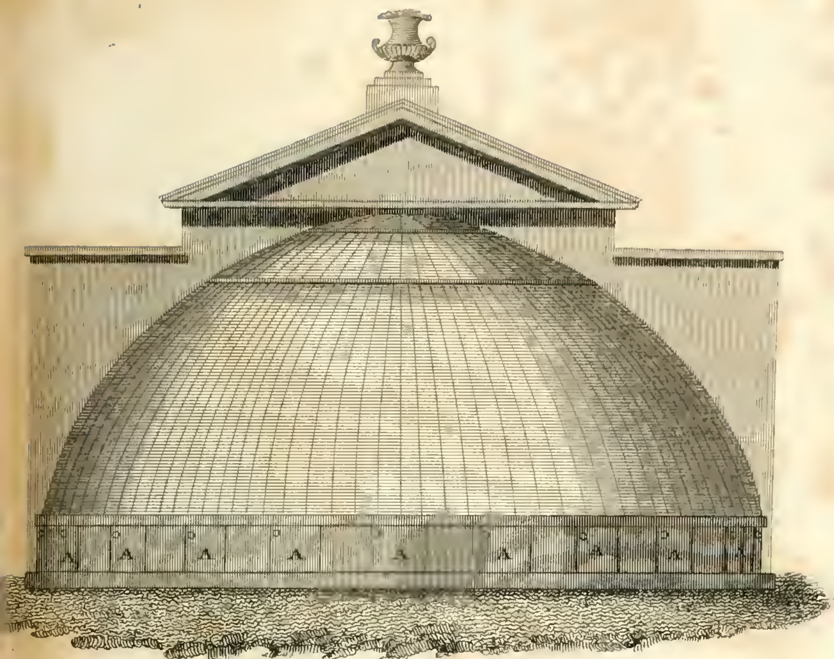






H.Anderson sc.

# HORTICULTURE. PLATE CCCXII.

*Fig. 1.*




*Hot house invented by Sir Geo. Mackenzie Bar.t being a Portion of a Sphere*
*A Segment 34 feet long, 11 high & 13 wide, is recommended as the best size.*

*Fig. 2.*

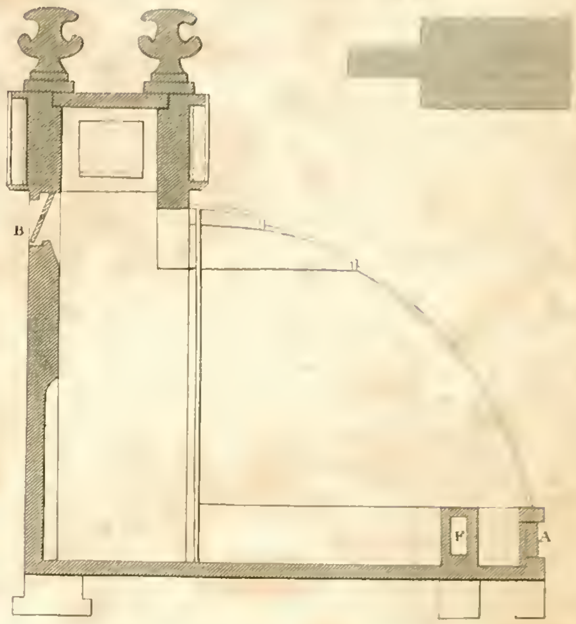
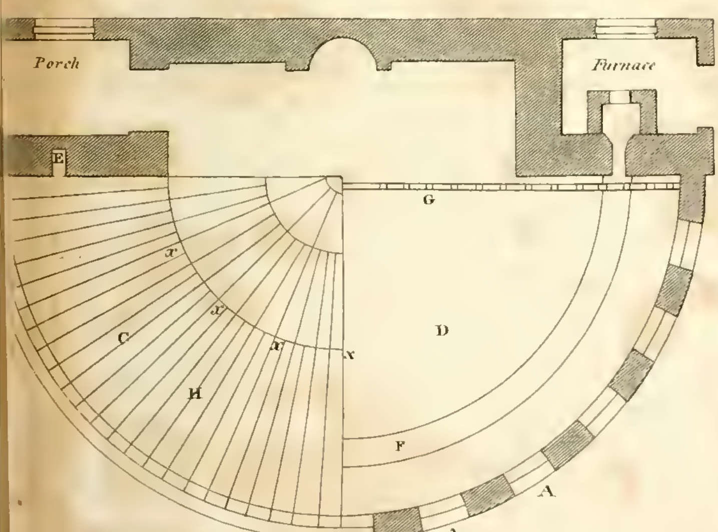
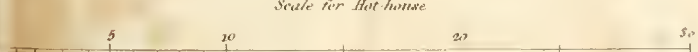



*Fig. 4.*

*Fig. 3.*




*Scale for Hot-house*

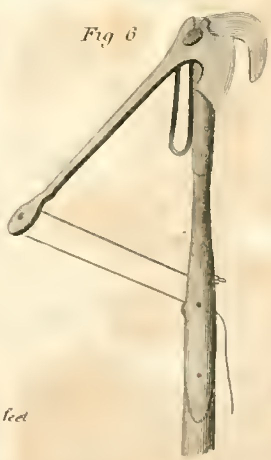



*Sea Kale Blanching Pots*

*Fig. 5.*

*Averuncator*

*Fig. 6*



*Pruning Shears*

*Fig. 7.*

*H. Anderson fc.*

# HYDRODYNAMICS. PLATE CCCXIII.

Fig. 1.

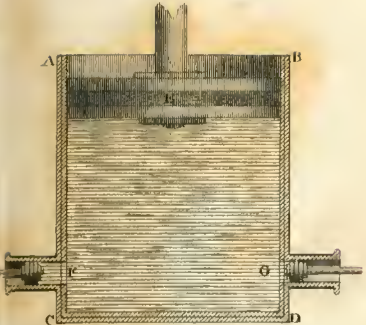



Fig. 2.

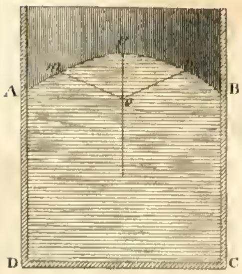



Fig. 3.

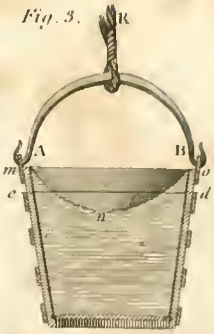



Fig. 4.

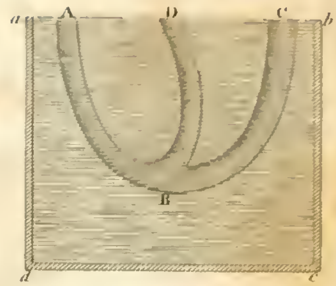



Fig. 5.

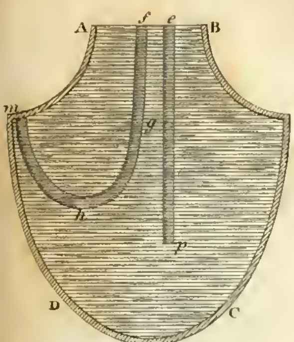



Fig. 6.

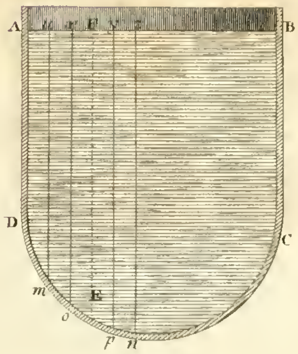



Fig. 7.

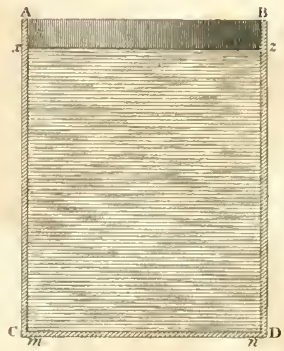



Fig. 8.

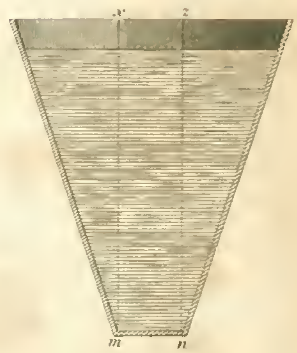



Fig. 12.

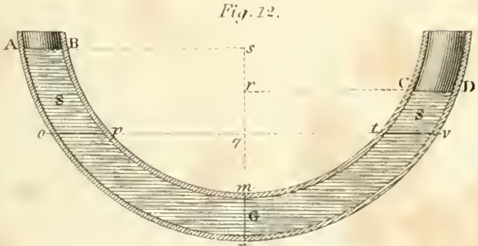



Fig. 13.

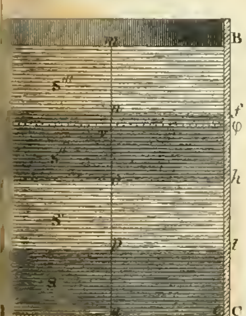



Fig. 9.

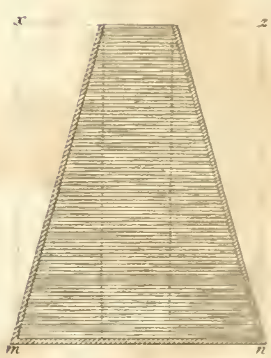



Fig. 11.

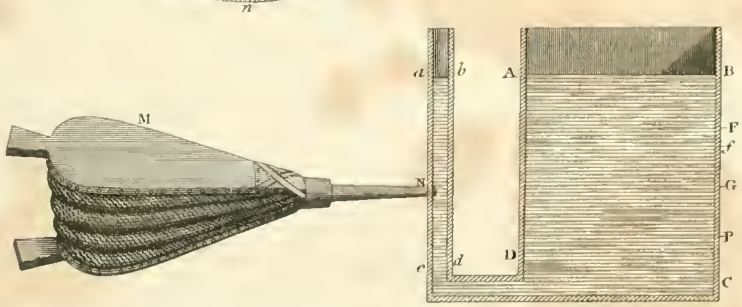



Fig. 10.

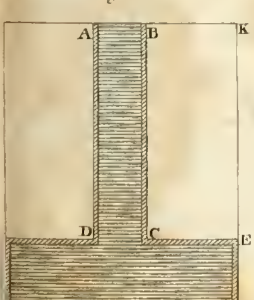
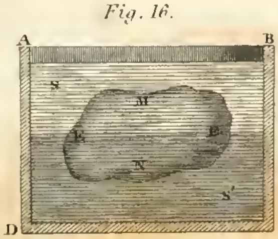



Fig. 16.

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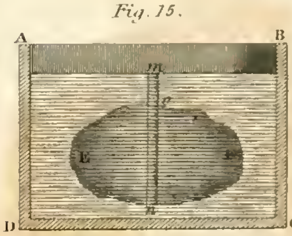
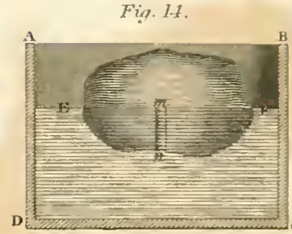



Fig. 14.




H.Anderson sc.

# HYDRODYNAMICS.

PLATE CCCXIII No. 1.

Fig. 2.

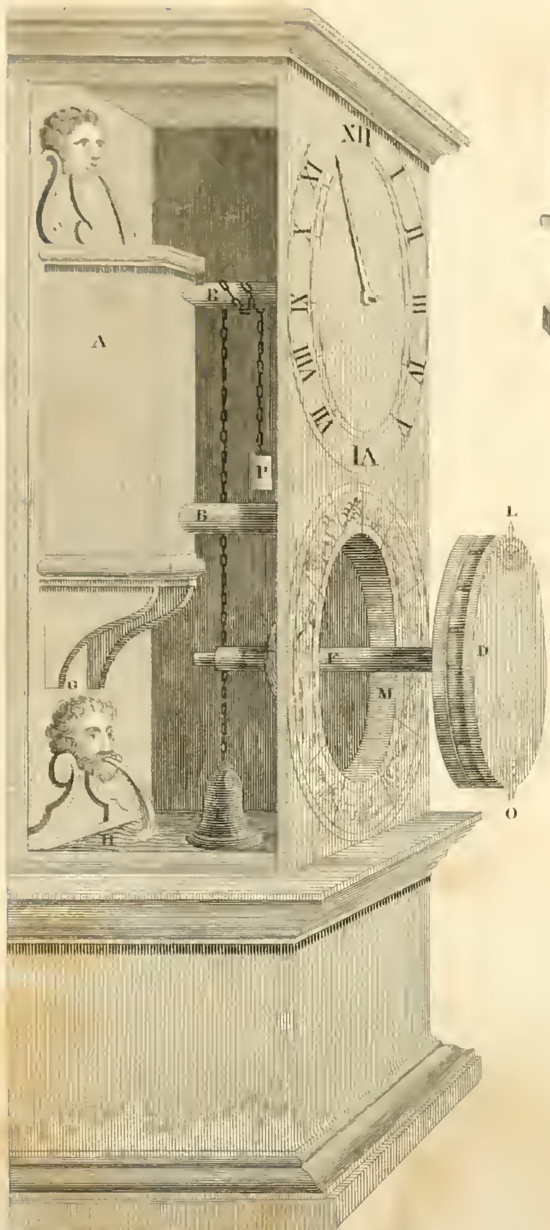



Fig. 1.

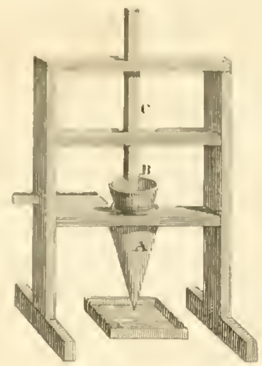



Fig. 4.

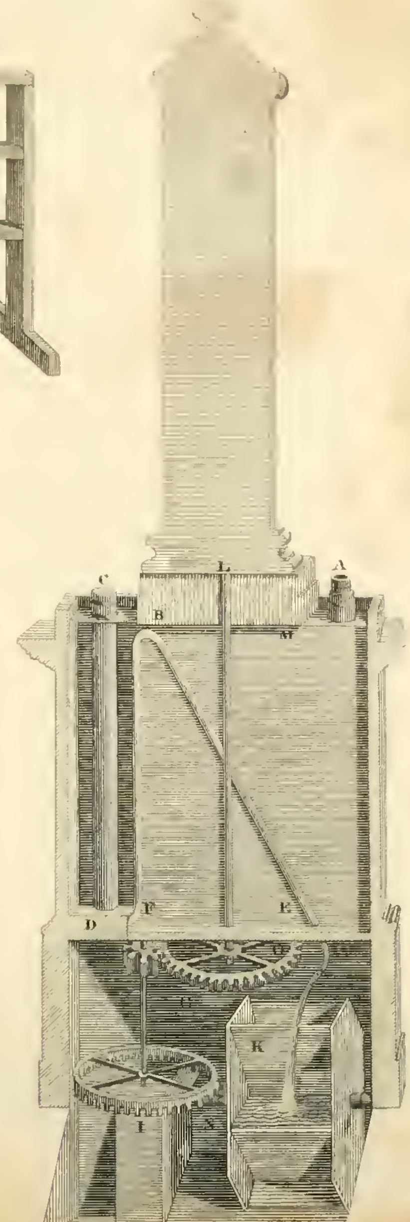
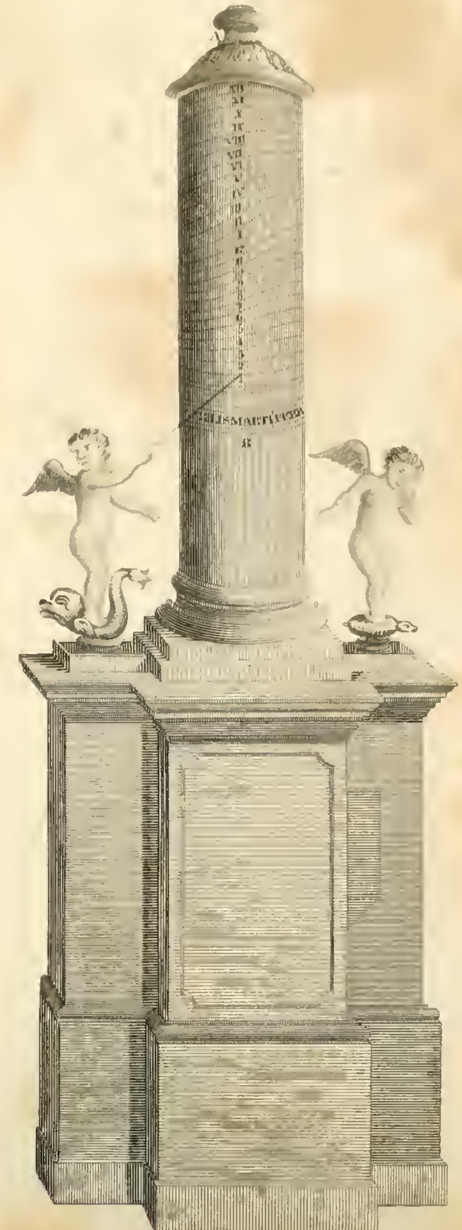


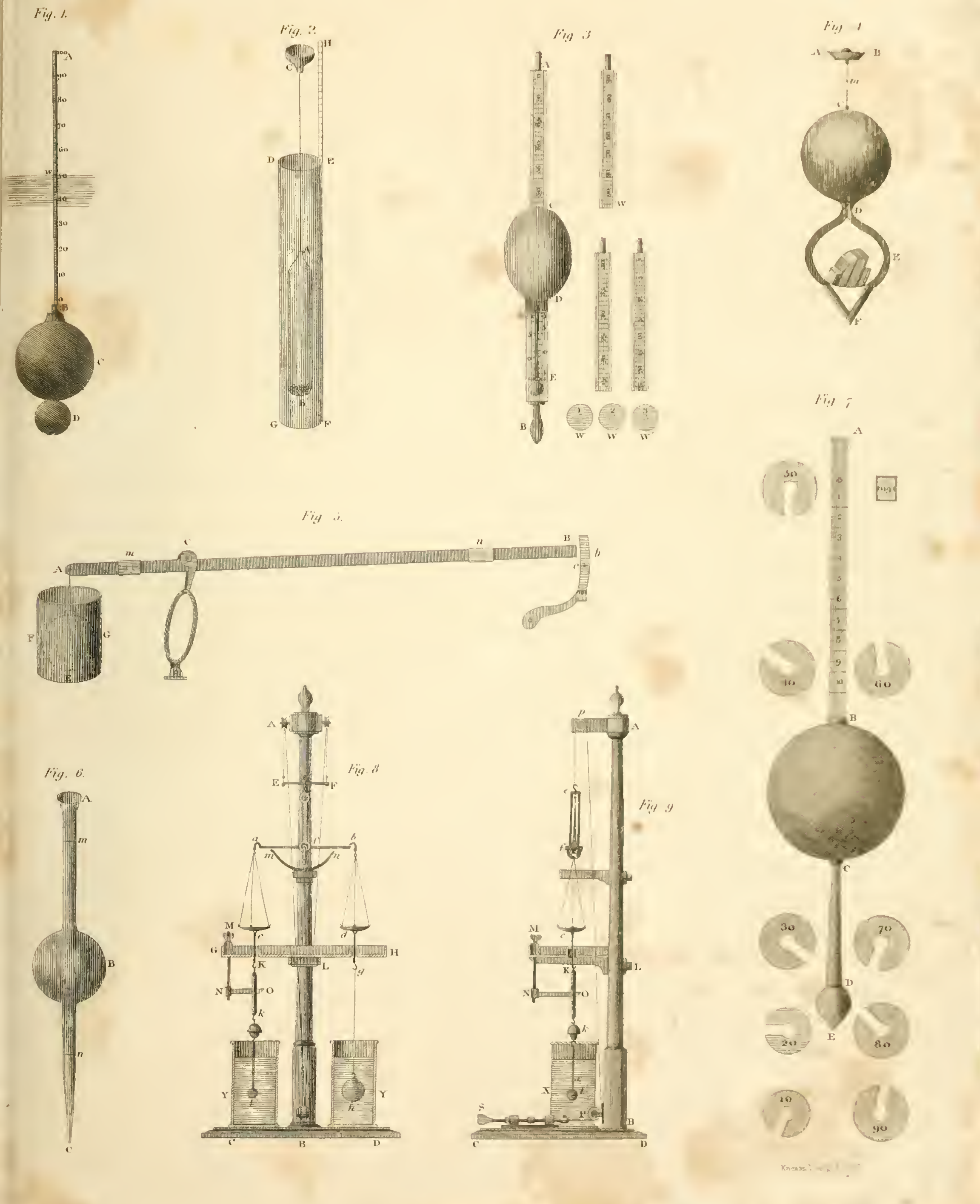

Fig. 3.



Kneass, Young & Co. Sc.

# HYDRODYNAMICS.

*PLATE CCCXIV.*



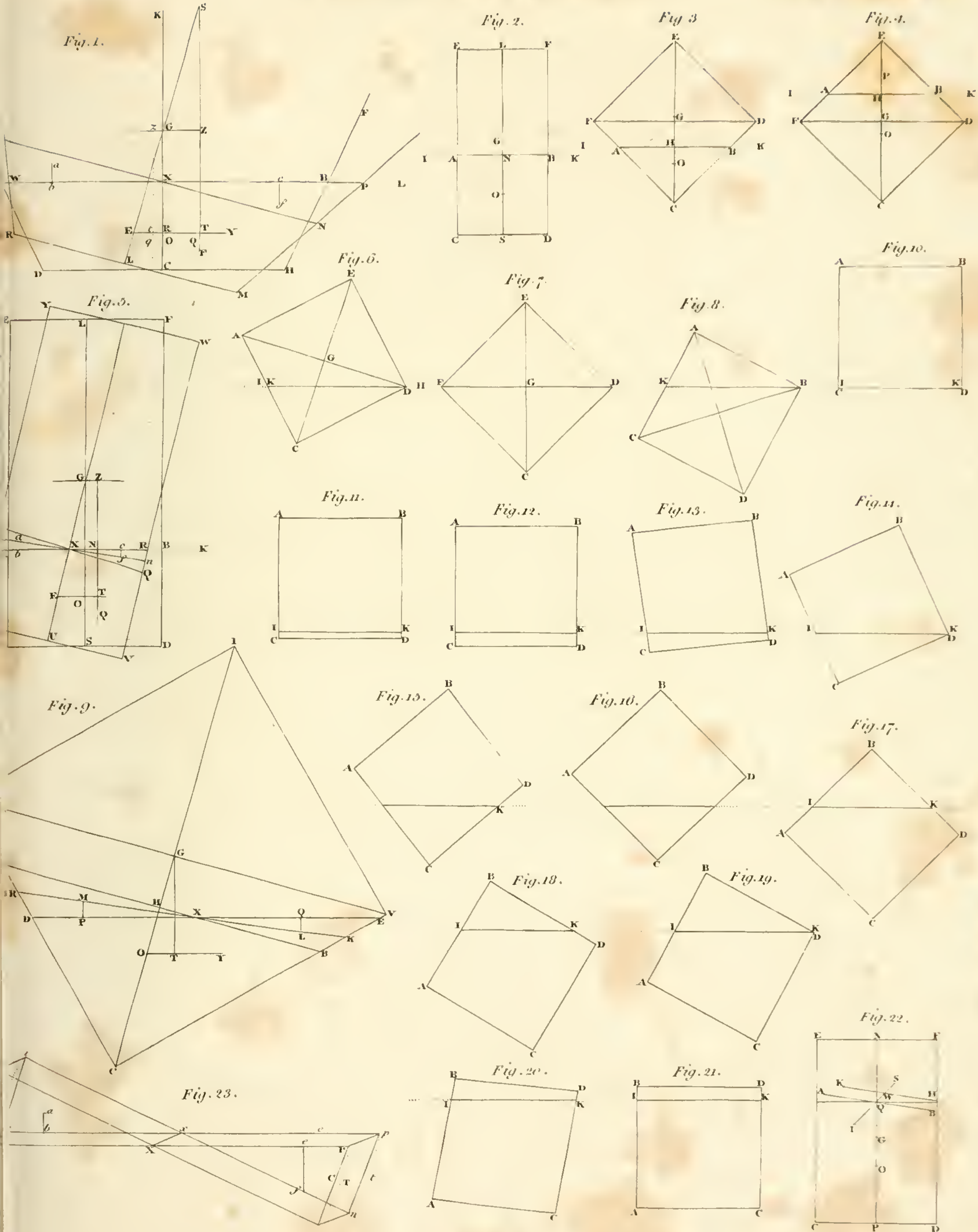


Fig. 1.
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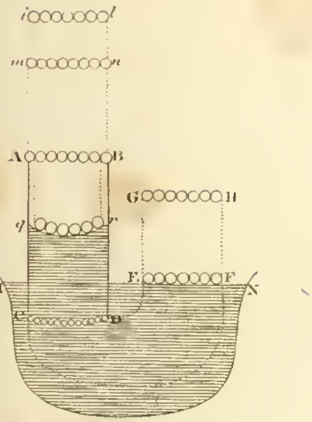
Fig. 20.
Fig. 21.
Fig. 22.
Fig. 23.

Fig. 1.



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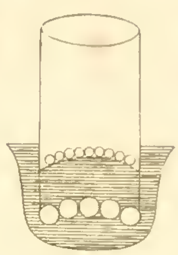
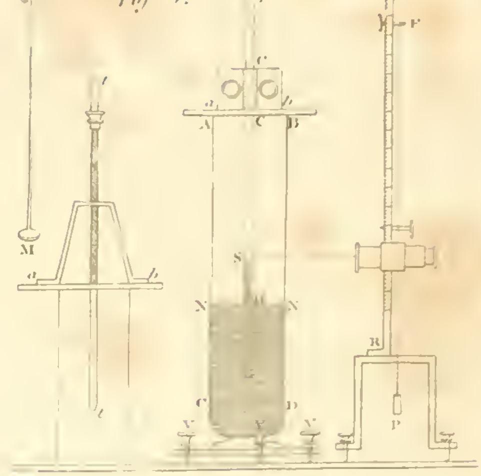


Fig. 3.



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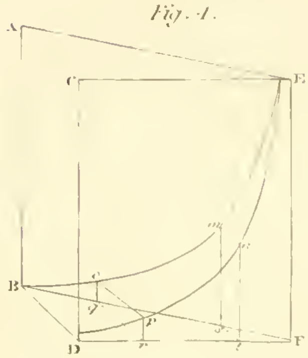

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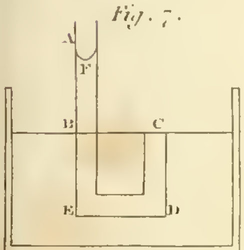
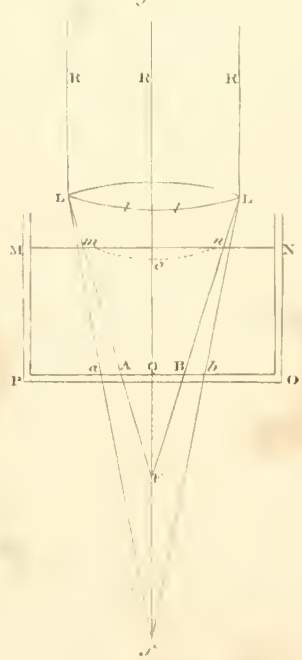


Fig. 5.

Fig. 6.



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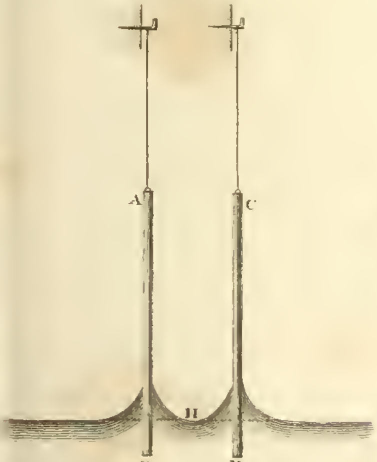

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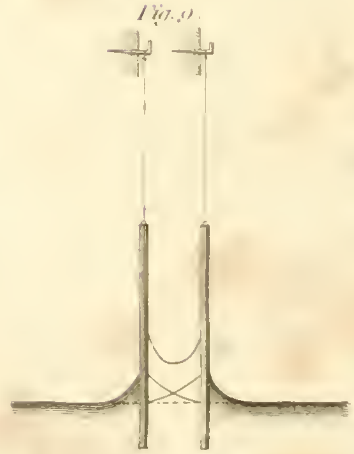

Fig. 10.

Fig. 11

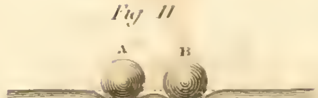

Fig. 12.


Fig. 1.
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...wn by J. Farey.

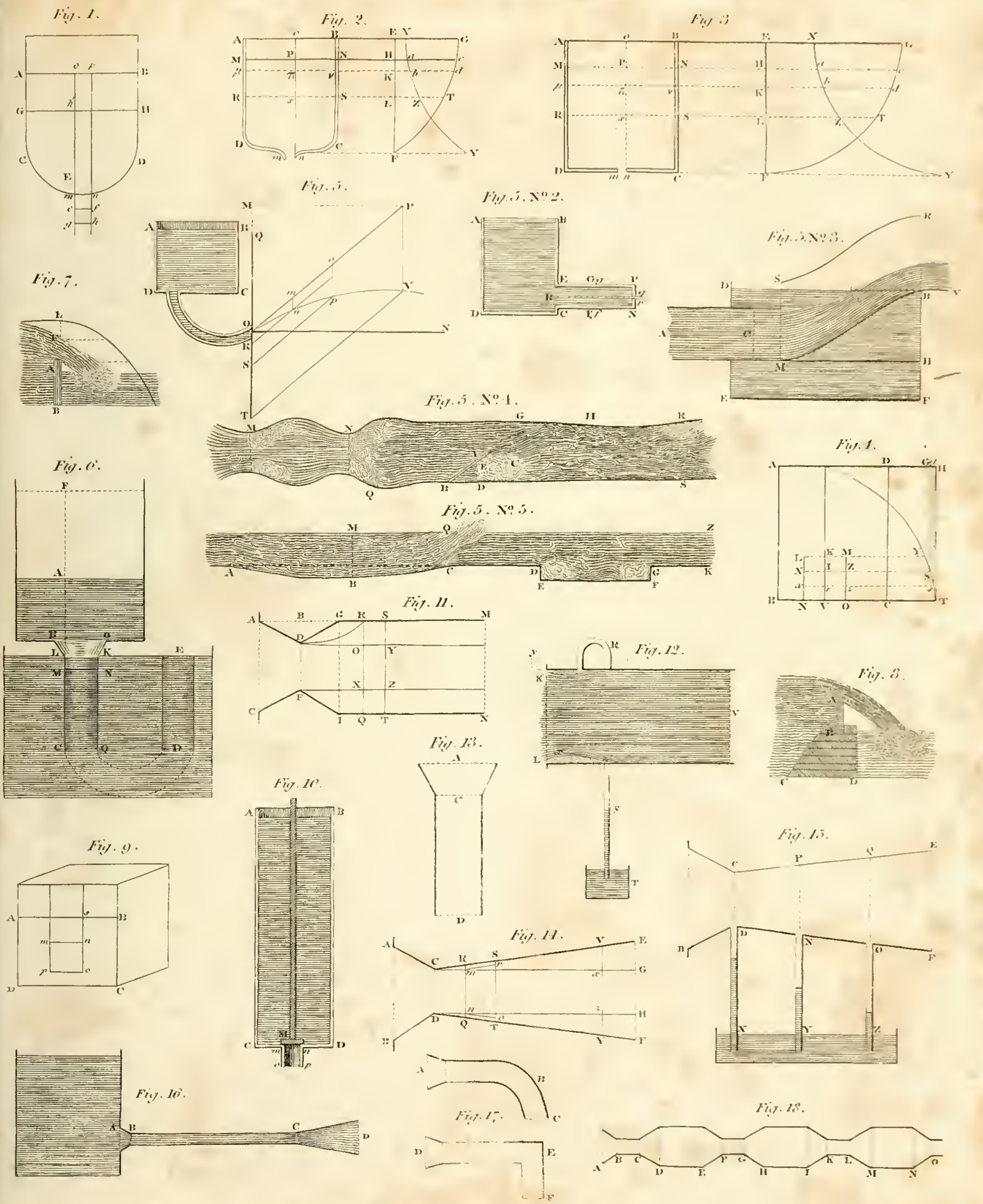
Fig. 1.
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Fig. 5. No. 3.
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Fig. 5. No. 4.
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Fig. 5. No. 5.
Fig. 11.
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Fig. 18.

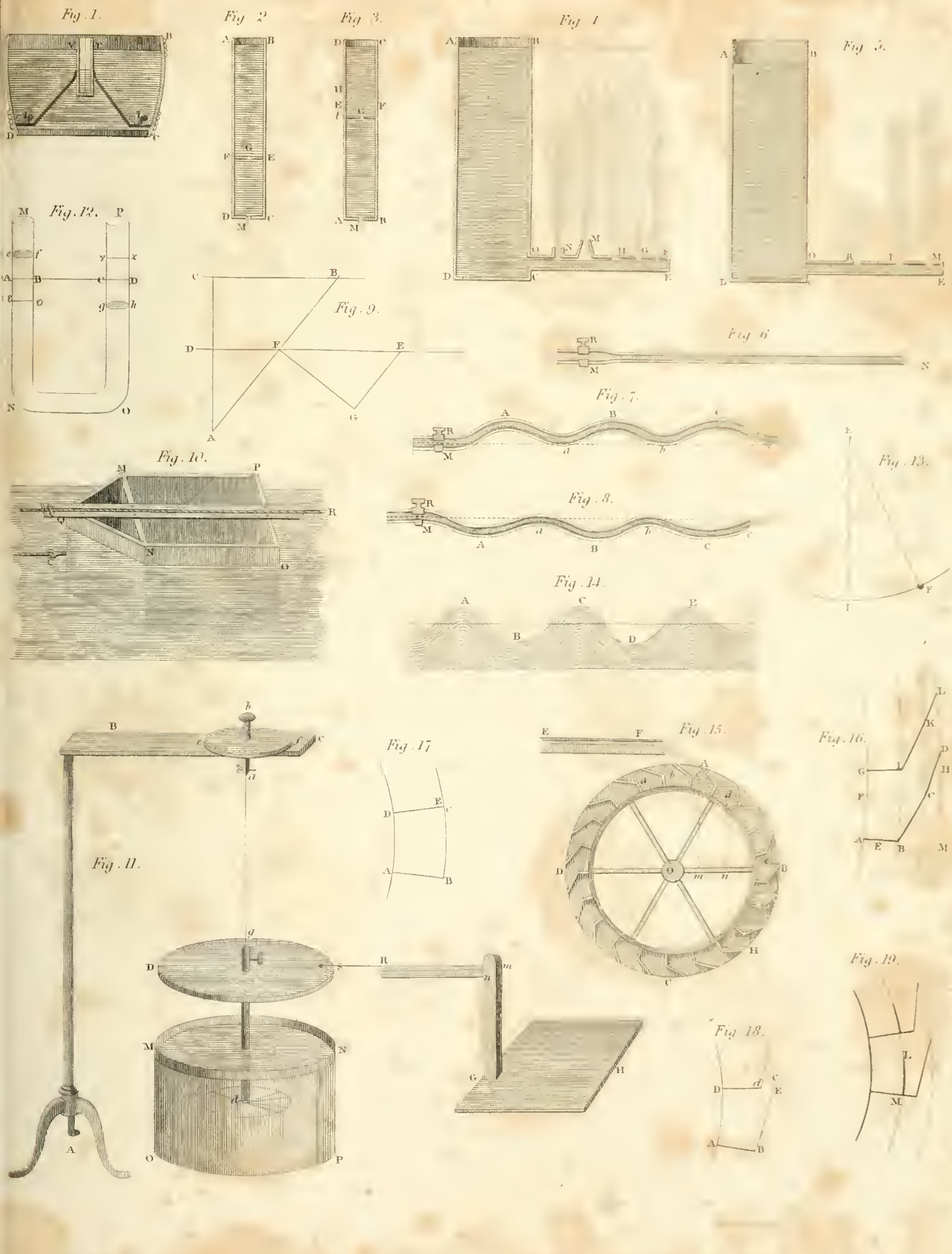
Fig. 1.
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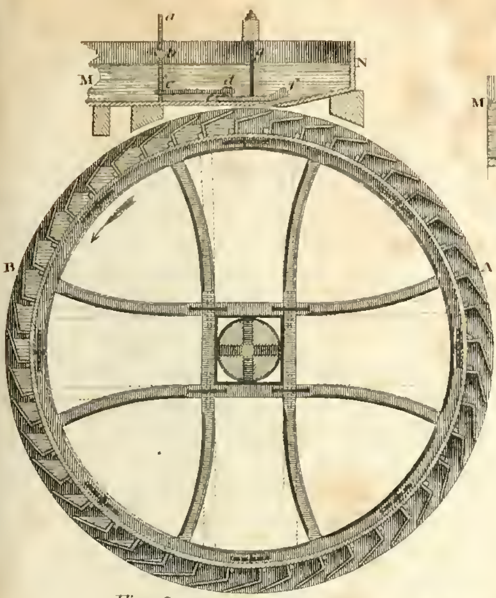
Fig. 19.

*Fig. 1.*



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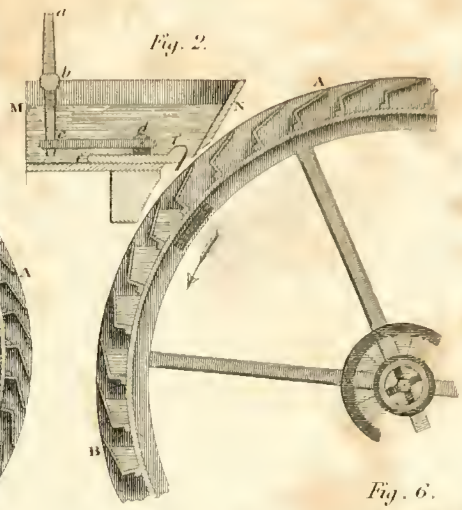
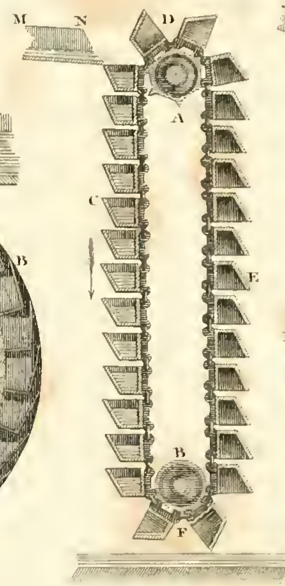


*Fig. 3.*

*Fig. 6.*



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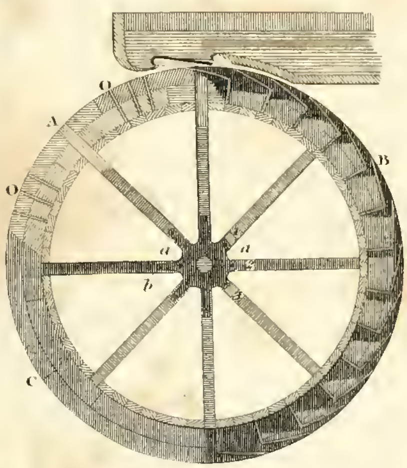


*Fig. 5.*

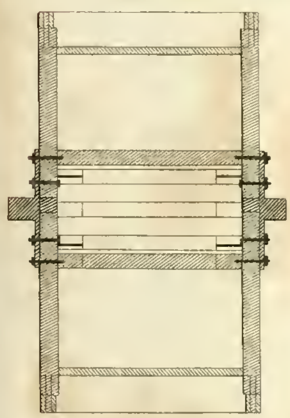
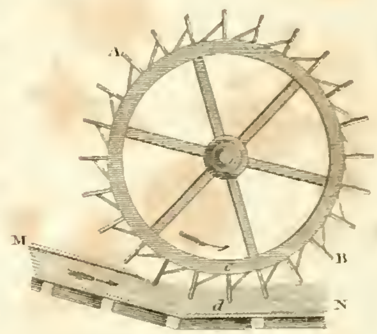


*Fig. 7.*



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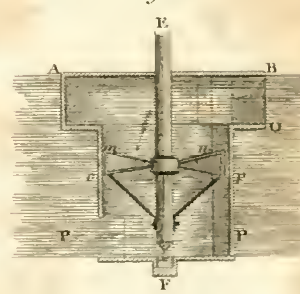


*Fig. 9.*

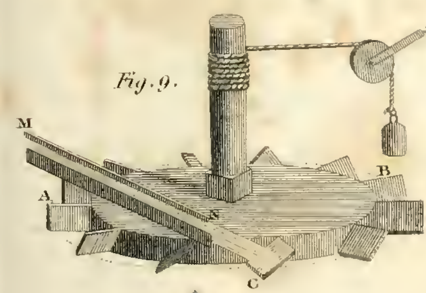


*Fig. 8.*

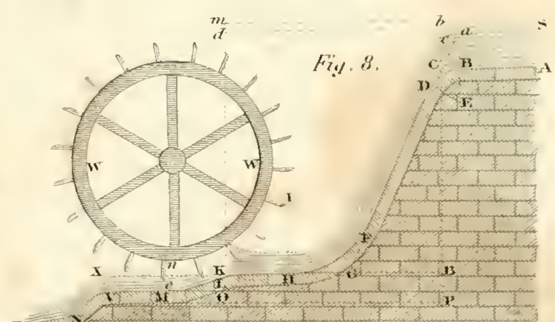


*Fig. 13.*

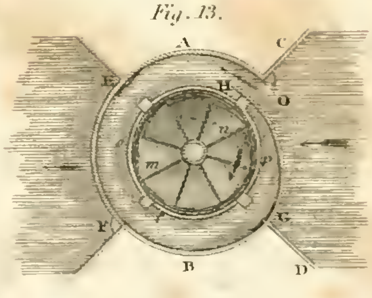


*Fig. 10.*

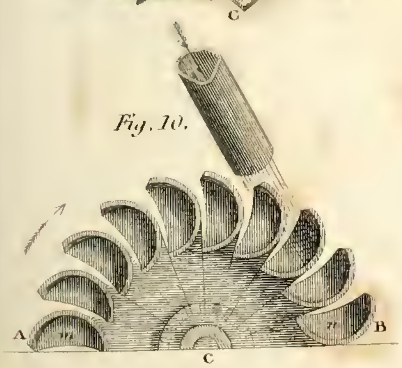


*Fig. 11.*

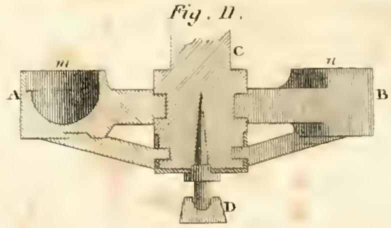


Fig. 1.

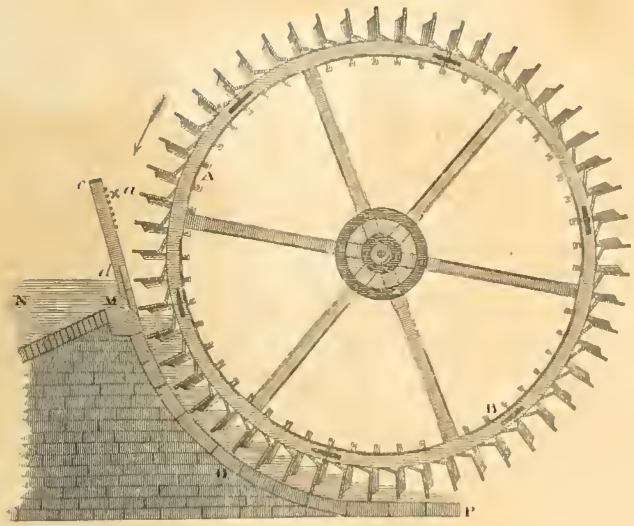


Fig. 5.

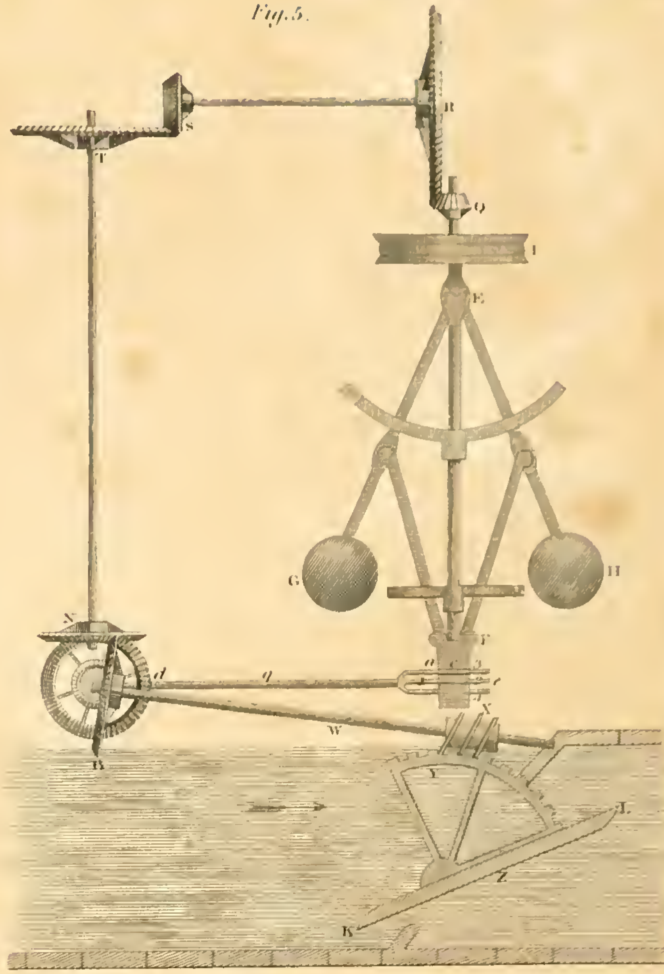


Fig. 2.

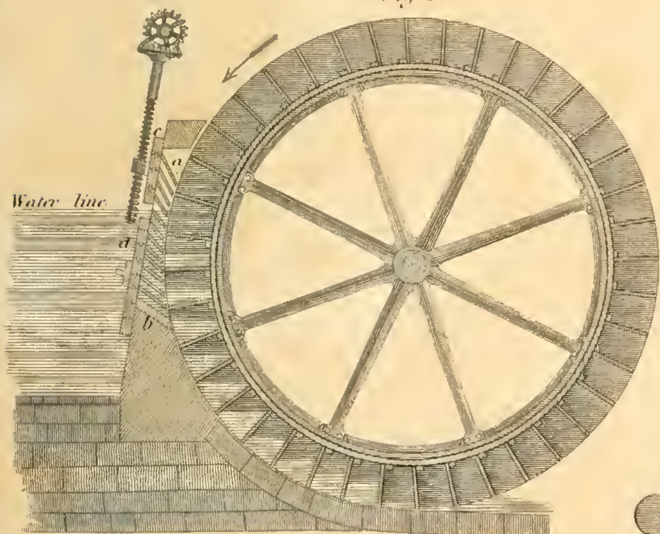
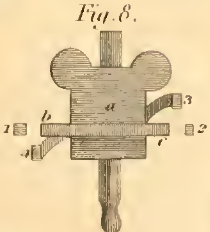



Fig. 8.



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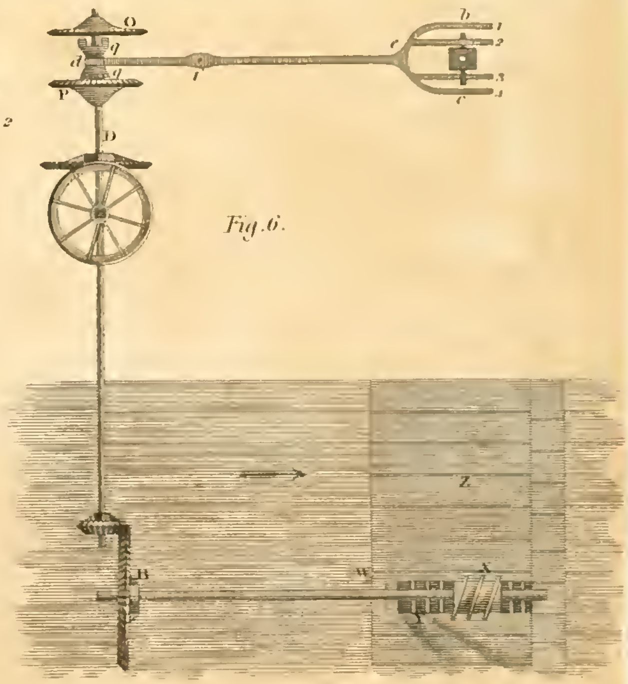


Fig. 7.

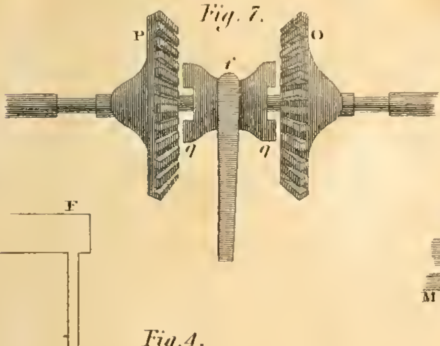
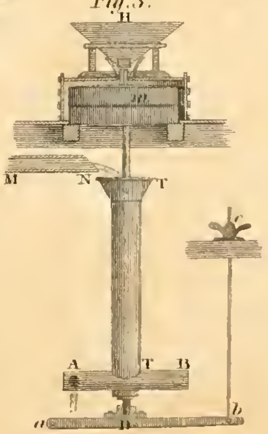


Fig. 3.



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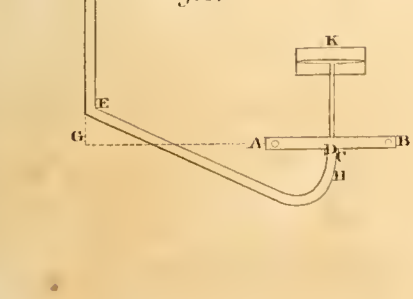
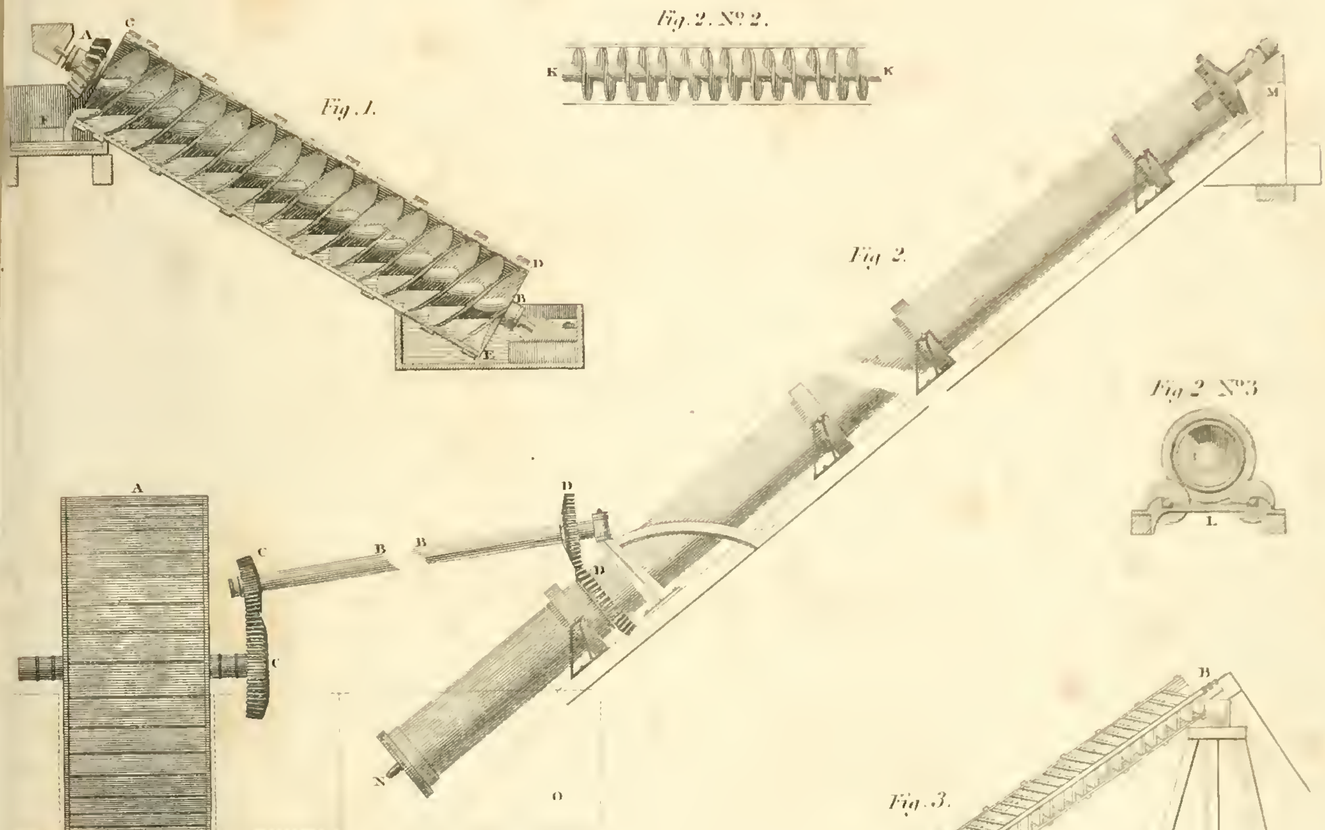
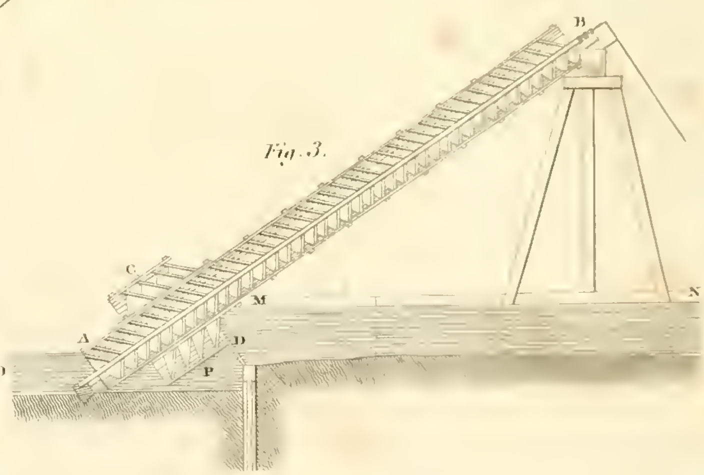




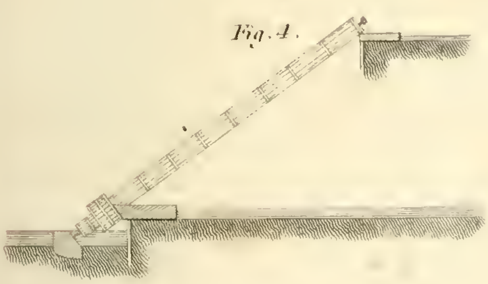



Fig. 4.

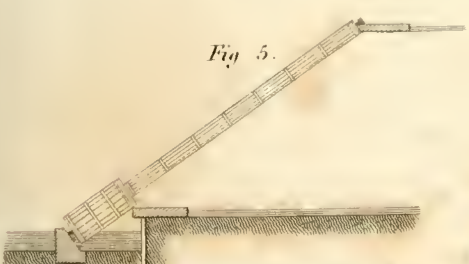


Fig. 5.

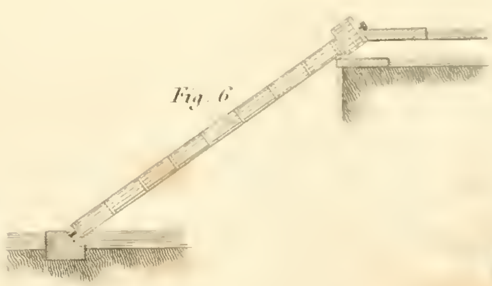
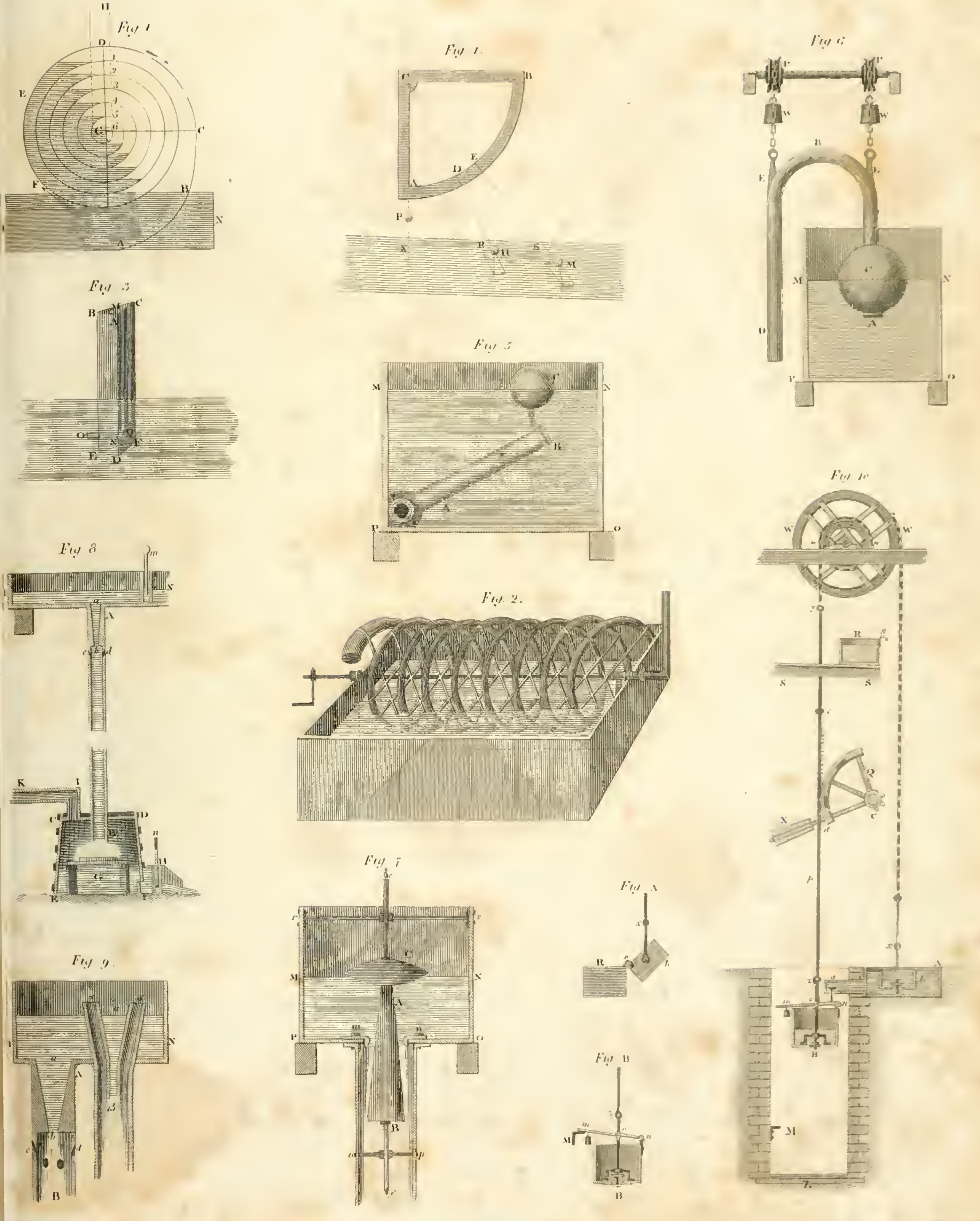


Fig. 6.


Fig. 7.

HYDRODYNAMICS. PLATE CCCXXIII.




Drawn by J.Farey

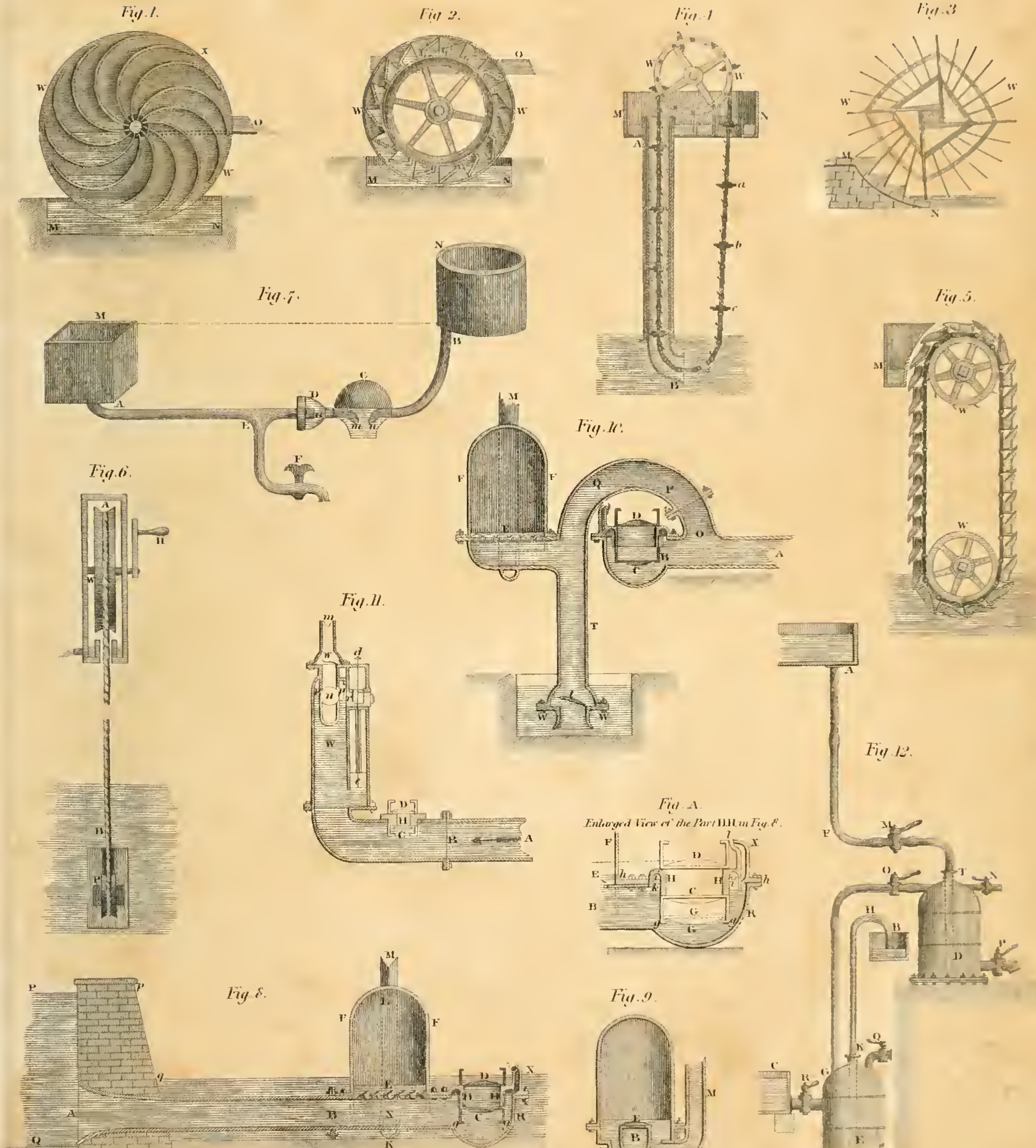


Fig. 1.
Fig. 2.
Fig. 4
Fig. 3
Fig. 7.
Fig. 5.
Fig. 10.
Fig. 6.
Fig. 11.
Fig. 12.
Fig. A.
Enlarged View of the Part H.H. in Fig. 8.
Fig. 8.
Fig. 9.